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Ministry of Science and Higher Education - Ethiopia

MINISTRY OF SCIENCE AND HIGHER EDUCATION

NATIONAL DIGITAL TECHNOLOGIES THEMATIC RESEARCH PRIORITY AREAS

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1. Background

Over the last decades, ‘digital technologies’ which is alternatively described as Information Communication Technologies (ICT) has transformed society through the stride of technological changes. It is fundamentally changing the way people live, work, connect and communicate as the provision of access to information, services, infrastructures, and others has become part of day-to-day life. Digital technology has also been changing the way companies do business, transforming public demand and delivery, and facilitating the development of good governance.

Digital Technologies not only spearheaded the information and communication age but also has been instrumental in today's research and innovation to solve pressing societal problems in areas of agriculture, engineering, health, climate change, tourism, environment, transport, etc. Besides, it has a profound impact on achieving the United Nations’ Sustainable Development Goals (SDGs) whose completion is set to lead to a more equitable, prosperous, and sustainable world. On all aspects of ensuring key digital economy pillars, Ethiopia is in the process of setting the main foundations for the growth, expansion, and inclusivity of its digital economy. In particular, in the areas of coverage and connectivity, costs and affordability, digital disruptors, funding, policy and regulatory reforms, and market size and outlook.

Until very recently, the enabling conditions for the emergence of a digital economy in Ethiopia were largely absent, given very limited telecom infrastructure, very high costs of network access, lack of conducive policies and very low digital connectivity rates among the general population. The ecosystem needed for a vibrant digital economy is coming into place across multiple dimensions, including infrastructure connectivity, digital platforms, digital financial services, digital skills, appropriate national strategies, etc.

To this end, these national research and innovation priority thematic areas aim at supporting the achievement of the 10 year national strategic plan by identifying researchable areas where Digital Technologies can be used as an enabler in agriculture, mining, industry, tourism, urban planning, healthcare, education, and peace and regional development. Besides, as Digital Technologies evolves rapidly, identifying gaps in emerging technologies and improving them accordingly needs research and innovation.

With this understanding, research priorities in Digital Technologies are expected to lead to:

1. Take the lead in developing a competitive community for Digital Technologies research and development;
2. Improved Digital Technologies usability, productivity, and creativity across all industries;
3. Provision of seamless and cutting-edge Digital Technologies products, solutions, and services that uphold national values;
4. Increased current technology adoption through effective technology and knowledge transfer systems;
5. Fostering start-up businesses and innovators to address societal problems through incubation centers;

2. Major Thematic Areas

This document highlights a brief introduction of each of the seven major thematic areas and lists the sub-thematic areas under each major theme.

- Artificial Intelligence for Social Good (AI4SG)
- Telecommunications
- IT infrastructure
- Digital economy
- Digital inclusion
- Cybersecurity
- Emerging technologies
- Cross-cutting digital technologies

2.1 Artificial Intelligence for Social Good (AI4SG)

The challenges facing our world today have grown in complexity and increasingly require large and coordinated efforts with the important role of technology. Artificial Intelligence (AI), the science and engineering of making intelligent machines, presents an opportunity to build smart tools and solutions that address the world's most pressing challenges, and deliver positive social impact following the priorities outlined in the UNs' SDG goals. AI is thought to have a huge influence on our country's economy and companies, as well as the ability to change society by changing people's way of life.

The Artificial Intelligence (AI) sector has been a growing phenomenon in Ethiopia over the last few years. Different start-ups are booming in the area of AI where some have been identified with their pioneer and successful products and solutions. Besides, recently the country's first Artificial Intelligence Center has been established by giving the Center key powers and responsibilities with a major focus on producing research-based artificial intelligence services and products ranging from AI-enabled applications and services to the development of AI-powered robots.

Despite the opportunities AI technologies may offer in our country's context, it can be seen that there is a real gap in utilizing AI interventions to yield structural, economic, social, and political stabilities and balances. This remains a major concern for regulators and policymakers in that efforts were made to establish a thriving center for AI research and development, including robotics. The challenge also expands to establishing interdisciplinary partnerships centered around AI applications towards SDGs.

Accordingly, this theme focuses on creating an increasing range of new services, products and value-adds in various sectors through the adoption of AI. It also incorporates the whole range of theoretical and practical aspects of AI applications in the fields of agriculture, health, education, automation, etc.

This theme creates awareness within society of the advantages of including AI and how to tackle the risks involved. This will be realized by bringing together AI researchers, technology companies, industries, policymakers and academia into the same circle to work in collaboration

to advance AI technology. To this end, AI4SG aims to work on the following sub-themes, but is not limited to:

- Intelligent behaviours (optimization, pattern recognition and detection, prediction and hypothesis testing)
- Robotic Process Automation (RPA)
- Machine Learning
- Natural Language Processing (NLP)
- Data Science
- Internet of Things (IoT)
- Computer simulation and modeling
- Computer Graphics, Vision, Animation, and Game Science
- Fair and responsible AI (Fairness, Accountability, Transparency, and Ethics - FATE)
- Smart Communication/Schedule

2.2 Telecommunications

Today, Ethiopia's Internet usage has reached 23 million or around half of the adult population with an Internet coverage growth annual rate of 45% (4). According to UN reports, there were over 52 million telecom subscribers in December 2020, with 45 Million active subscribers and approximately 44 percent of mobile phone owners. Consequently, compared to other African countries, Ethiopia stands fifth in terms of subscribers as a share of the population, and it has the fastest growth rates in mobile phone usage and internet adoption. Nonetheless, the demand for connectivity from the business sector, the government, and citizens has increased significantly, indicating that a lot has to be done for the deployment of affordable access to the internet and digital communication systems.

However, there are several challenges in the provision of telecommunication services like voice and data. This is due to inadequate availability of basic infrastructures such as electricity, transportation, and core connectivity infrastructure that includes fiber optic cables, mobile phone towers, and affordable peripheral devices. On the other hand, there is loose control of regulatory practice in the telecom sector which has contributed to a decrease in performance by the incumbent. Fortunately, Ethiopia has opened up the telecom sector to global competitors,

which could potentially improve the aforementioned issues due to market competition between the new and the incumbent telecom operators.

Thus, this research theme is meant to address the existing problems in telecommunications by indicating ways of increasing access to connectivity, coverage of the infrastructure and affordability and quality of services. Furthermore, the theme focuses on the adoption of current technology trends in telecommunications concerning the national economy and societal aspects. Hence, the telecommunications theme aims to work on the following sub-themes, but is not limited to:

- Design and planning of telecommunication networks and infrastructure (this includes both fixed and wireless; across technologies like 3G, 4G and 5G; broadband and narrowband; subscriber, access, aggregate and core/backbone networks and the like)
- Monitoring of telecommunication key performance indicators (KPIs), service quality indicators, quality of experience (QoE) indicators (huge data is already available with operators and state-of-the-art machine learning algorithms can be used to analyse the data).
- Optimization of telecommunication networks and service
- Telecommunication services design (like cloud service, virtual services..).
- Rural telecommunication/connecting the unconnected (access to affordable telecom infrastructure)
- Ensuring broadband connectivity - Mobile and wireless broadband, satellite communication, optical and photonic communications
- Uptake of emerging telecommunication technologies (5G and beyond, software-defined networks, internet of things (IoT), machine to machine communication, machine learning and AI for telecommunication, ...)
- Services by Internet Service Providers (ISP)
- Basics of digital and telecommunication systems– Digital communication, communication channels (wired and wireless), signal processing for telecommunication
- Telecommunications law and regulations– spectrum planning, monitoring and management; operators business

- Data analytics for customer management and care– customer handling, customer segmentation
- Data monetization– telecom data analysis to improve the sector’s and different sectors business
- Techno economic analysis
- Energy and environmental issues in telecommunication systems – energy consideration from design, planning, operation and using alternative energy sources

2.3 IT Infrastructure

The IT infrastructure is a critical foundation and the backbone for increasing the access and utilization of reliable IT services. Ethiopia has long been successful in providing connectivity to different sectors across the country. For instance, the Ethiopian Education and Research Network (EthERNet) has enabled the interconnection of higher education institutes in the country. Similarly, WoredaNet has also interconnected different public service institutes in the country. In addition to this, the efforts made on SchoolNet is also worth mentioning. These efforts have created several opportunities for both the private and government sectors though it was not entirely efficient due to lack of collaboration and coordination among different stakeholders.

Building IT infrastructure requires a sufficient capital budget and human power. Lack of appropriate funding from the government and elsewhere is observed to be among the challenges. On the other hand, lack of collaboration and duplication of efforts are being observed across the country. For example, the absence of nationally available state-of-the-art data centers and individual efforts to build data centers is one to mention. Besides, the absence of IT infrastructure standards, policy and guidelines are also among the challenges in the area.

This research theme focuses on assessment regarding use, management and provision of IT infrastructure; adoption of current trends towards construction and development of IT infrastructure; identification of service priorities and means of access. These thematic areas will also point to methods for seamless collaboration and coordination, resource mapping and IT infrastructure service provision between public and private sectors. Hence, the IT Infrastructures theme aims to work on the following sub-themes, but is not limited to:

- Computing for Development (cloud, mobile and pervasive, edge, fog computing, etc.)

- High-performance computing (high-performance cloud computing, etc.)
- Software-defined storage
- Service-centric networking
- Storage area networks (SAN)
- LAN (Wired/Wireless)
- Resource allocation for cloud services
- Application of clustering technologies
- Application of virtualization technologies
- Web operating systems and computing on the web
- Analysis of networks (social networks, complex networks)
- Information System Audit
- Network Traffic Analysis (NTA)
- Network Administration and Management
- Data center infrastructure management (DCIM)
- Video conferencing
- Infrastructure laws and regulations
- Digital preservation facilities and management

2.4 Digital Economy

Digital transformations have been the contemporary agenda in Ethiopia to realize digital interaction between the government, private sectors, and citizens. Delivery of public services at high standards via electronic channels, prioritizing services of high usage and return, and reengineering business processes is a critical issue. Digital technology adoption can also improve the productivity of various sectors, especially agriculture, service and manufacturing sectors, as well as the transparency, efficiency and accountability of government services. Ethiopia is currently progressing in E-Governance despite the lack of human capital and infrastructure. Commitments are being undertaken to digitize government operations, government services and develop better service delivery channels.

Creating a vibrant, inclusive and safe digital economy in Ethiopia is complicated by multifaceted challenges which include gaps in infrastructure and human talent, inability to follow state-of-the-

art development technologies and lack of seamless coordination between inter-public entities and those of private industries. These gaps further affect Ethiopia's Ease of Doing Business (EoDB) rank, which strives for strengthening the analog foundations of the digital economy, in particular policy-making, regulation and skills to adverse the stated problems.

In this regard, this theme focuses on addressing critical gaps which are exhibited in creating a vibrant digital economy by recommending products, solutions, services to be designed with stronger coordination across government and leveraging digital technology to ensure citizens' quality of life. The theme also focuses on developing, customizing, implementing, and improving digital platforms, services and applications in both the public and private spheres, to enable the efficient functioning of the economy. Hence, Digital Economy aims to work on the following sub-themes, but is not limited to:

- e-government (e-procurement, e-taxation, e-office, e-customs, e-visa, e-health, e-trade)
- Digitization and enterprise business automation
- programming languages and software engineering
- Development Operations (DevOps)
- Central repositories, directories
- Management of information systems
- IT Management
- Software quality assurance
- System verification (system element, system, document, service, etc...)
- Data Management and Visualization
- Human-Computer Interaction
- Business process re-engineering (by adopting a variety of IT frameworks)
- Web and Mobile Applications
- E-commerce, M-commerce
- Digital financial services
- Knowledge Management (KM)
- Digital marketing and entrepreneurship
- Public Private Partnerships (PPP)

2.5 Digital Inclusion

Countries that can compete effectively in the digital age will enable their citizens, businesses and governments to reap digital dividends in the form of faster growth, lower transaction costs, and more and better jobs. According to the Internet World Status as of March 2021, in Africa, only 43.2% of its inhabitants had Internet access, compared to 88.2% of Europeans and 93.9% of Americans (Internet World Stats, 2021).

In Ethiopia, over 2 million job seekers enter the job market every year. The government will need to create new sources of job creation since this young workforce (median age of 17.9) cannot be fully absorbed by traditional sectors such as agriculture and manufacturing. The digital economy in Ethiopia has an untapped potential to increase exports, enhance incomes, create employment, especially for women and youth, and reap other social benefits.

Digital inclusion in Ethiopia is at a lower stage and requires vigorous digital inclusion programs. This is due to the high cost of technology, lack of technology access for disabled people, poor skills, lack of proper education and awareness, and the inadequate and absence of high-end devices and accessories. The challenges also extend to utilizing digital technologies in Ethiopia and ensuring inclusivity in the utilization of IT infrastructure (phone line and internet access) and human capital (low rural literacy levels).

This theme focuses on nurturing a healthy pipeline of digital entrepreneurs in Ethiopia and lays the foundations for high-growth digital industries. It also identifies and documents the key policy and regulatory constraints that prevent the healthy growth of digital entrepreneurs and businesses. Hence, the following are the sub-thematic areas on digital inclusion but is not limited to:

- Digital skills for a digital nation
- Digital Technologies for inclusive education
- Digital Technology tools for people with special needs
- The effects of Digital Technologies on Digital Inclusion
- Frameworks towards Digital Inclusion
- Digital Inclusion for Research and Development
- Digital Inclusion Awareness and Motivation
- Access to Digital Technologies addressing digital divides

2.6 Cybersecurity

Nowadays, as the number of connected users, devices, and programs increases, it is important to protect information and other assets from cyberthreats. In cybersecurity, the process of keeping up with new technologies, security trends and threat intelligence is a challenging task.

Though a lot has been done in telecom and IT infrastructure, cybersecurity, which is equally important, has not matured in Ethiopia compared to other Digital Technologies services. Cyber security is essential for a country like Ethiopia preparing to introduce digital services across all its sectors. In 2019/20, the Information Network Security Agency (INSA) thwarted 787 major cyber-attacks.

As new technologies emerge, different and new attack avenues are developed. Keeping up with these frequent changes and advances in attacks, as well as updating practices to protect against them, can be challenging. Furthermore, the increasing volume and complexity of cyber attackers and their attack methods exacerbates the problem.

Another challenge to cybersecurity in Ethiopia is the shortage of qualified cybersecurity personnel due to the need for cybersecurity staff to analyze, manage and respond to incidents has increased enormously.

This thematic research area focuses on identifying proper and viable security products, systems and services to assure security and normal operation of IT infrastructure services. The additional focus area of this thematic area is to recommend trends in cybersecurity technologies which can be adopted immediately to protect against privacy and data loss. Hence, cybersecurity aims to work on the following sub-themes, but is not limited to:

- Cyber autonomy and automation
- IoT and cyber-physical security
- Information security
- Hardware security
- Database security
- Network security (Intrusion Detection and Prevention System)
- Secure Software Engineering

- Data privacy and user data control
- Security and Human Trust in Social Networks
- National security and cyber policies
- Cyberlaw and ethics
- Cyber criminology
- Disaster management and recovery
- Security of Mission Critical Infrastructure and Systems

2.7 Emerging Technologies

Emerging technologies are generally new technologies whose development, practical applications, or both are still largely unrealized, but are figuratively coming into prominence and are often perceived as capable of changing the status quo. Several emerging digital technologies have great potential for the future of many sectors around the world and are already contributing to higher productivity and quality in developing countries today. Analysis and investigation of emerging technologies in Digital Technologies as well as identification, development, and use of the technologies to drive the competitiveness and sustainable growth in agriculture, manufacturing, tourism, health, education, etc., sectors of the country are very crucial.

Continuous innovation is critical to survival in the digital economy as emerging technologies change the way we live and work. Despite the considerable and growing interest in these technologies, there is a lack of formulating research that helps to make systematic inquiries involving the practical application of the technologies and of strong research designs that operationalize central theoretical concepts. Ethiopia must embrace the contemporary industrial revolution the world is having to ensure communities benefit and to build a more prosperous society. Hence, to achieve the development goals of the country, sub-thematic areas where due attention is required in the Emerging Technologies theme but is not limited to are:

- Internet of Things (IoT)
- Data Science
- Data Engineering
- Big Data
- Cloud/edge/fog/mobile and pervasive computing

- Embedded Systems
- Blockchain
- Virtual/Augmented/Mixed Reality
- Unmanned Aerial Vehicles (UAVs)
- Autonomous Driving
- Wearable technologies
- 3D printing, 3D scanning
- Spatial computing
- Intelligent apparatus to guide disabled persons
- 3D guiding systems in complex buildings
- Integration of various emerging technologies

2.8 Cross-cutting Technologies

Digital Technologies does not only solve its own domain areas but serves as a critical cross cutting component in all other disciplines. Hence, to achieve the development goals of the country, sub-thematic areas where due attention is required in the Cross-cutting Technologies theme but is not limited to are:

- Digital Technologies enabled Agriculture
- Digital Technologies enabled Healthcare
- Digital Technologies enabled Tourism
- Digital Technologies enabled Industry (Industry 4.0)
- Digital Technologies enabled Mining
- Digital Technologies enabled Education
- Digital Technologies enabled Home
- Digital Technologies enabled City
- Digital Technologies enabled Services
- Healthcare technologies and management
- Biomedical engineering and healthcare technologies

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