# ICT FOR FOSTERING INDUSTRIALIZATION AND SOCIO-ECONOMIC DEVELOPMENT IN TANZANIA

Eng. Prof. Justinian Anatory
Dean, School of Informatics,
College of Informatics and Virtual Education
**The University of Dodoma**

**Abstract**

*Information and communication technology (ICT) is changing the world towards fourth industrial revolution. The Fourth Industrial Revolution is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. In this paper, the current status of ICT in Tanzania is articulated. Use of ICT in teaching and learning process and ICT as a technological force that drives industrialization are addressed. Positive implications of ICT, issues and challenges and what can be done to address challenges in ICT including lessons from China is articulated. It has been observed that Tanzania optical fiber infrastructure is connected to nine borders and all districts. Mobile phone subscription is approaching 70%. 4% of households have computers. 60% of Tanzanians are using social networks. 3% of Tanzanians are connected to Mobile broadband. 4% of Households are connected to Internet. 0.2% are Subscribing to fixed broadband Internet. Currently environment of ICT (political and regulatory, business and innovation and competition) in Tanzania is about 50%. However, looking at networked readiness index, Tanzania is below average in many aspects which needs some improvement. It has further been observed that ICT is a powerful mechanism in every aspect of education. The arrival of forth industrial revolution has the possibilities of multiple emerging technology breakthroughs in various fields. Finally, there are some possibilities of increasing industries such as telecommunications, software, hardware and IT solutions.*

## 1.0 Introduction

According to the United Nations International Telecommunication Union (ITU), ICT refers to equipment and services related to broadcasting, computing, and telecommunications, all of which capture and display information electronically.

In recent years, the ICT industry has developed intensely worldwide because of a series of new technologies, applications, and equipment that have been invented and marketed rapidly. This development has strengthened ICT's role as an enabler for other industries. Telecoms' over-the-top (OTT) services, gaming, mobile platforms, and social mobile internet cloud (SMIC), wearables, big data, smart cities, e-health, and internet of Things (IoT) concepts now define the industry structure. All of these new paradigms are fundamentally structured around four key technology areas, telecoms, hardware, software, and services. This paper has arranged this broad industry overview along those lines.

This paper will delve on how ICT can foster industrialization and socio-economic development in Tanzania. In section two, current status of ICT sector in Tanzania is narrated. Current implementation of National ICT broadband infrastructure is explained as well as discussing the Current status of ICT Subscription in Tanzania. Use of ICT in teaching and learning process is discussed in section three. Section four explains ICT as a technological force that drives industrialization. Internet of Things (IoT), automation and innovation, big

data' and analytics and advanced robotics are explained. Positive implications of ICT are described in section five. Issues and challenges of ICT are narrated in section six. Section seven is concerned with industrialization in China which is taken as a model.

## 2.0 Status of ICT Sector in Tanzania

### 2.1 National ICT broadband backbone

Telecommunication industry in Tanzania has experienced enormous changes in the past decade. In Tanzania like other developing countries lack of ICT infrastructure in both urban and rural areas attributing limitation of access to ICT services, has necessitated intervention of the Tanzania Government to build the National ICT Broadband Backbone (NICTBB) infrastructure.

Fig. 1 shows optical fibre cable infrastructure. In Tanzania the Optic Fibre Cable has been extended to nine border points of Sirari, Namanga and Horohoro (Kenya); Mtukula (Uganda); Rusumo (Rwanda); Kabanga and Manyovu (Burundi); Kasumulo (Malawi); and Tunduma (Zambia); with a view to fulfill the Government's commitment to connect the landlocked countries to the International submarine cables landing in Dar es Salaam (currently SEACOM and EASSY) and thereby making Tanzania a hub of ICT infrastructure and ICT solutions within the region. Service providers in different countries have already connected to NICTBB.

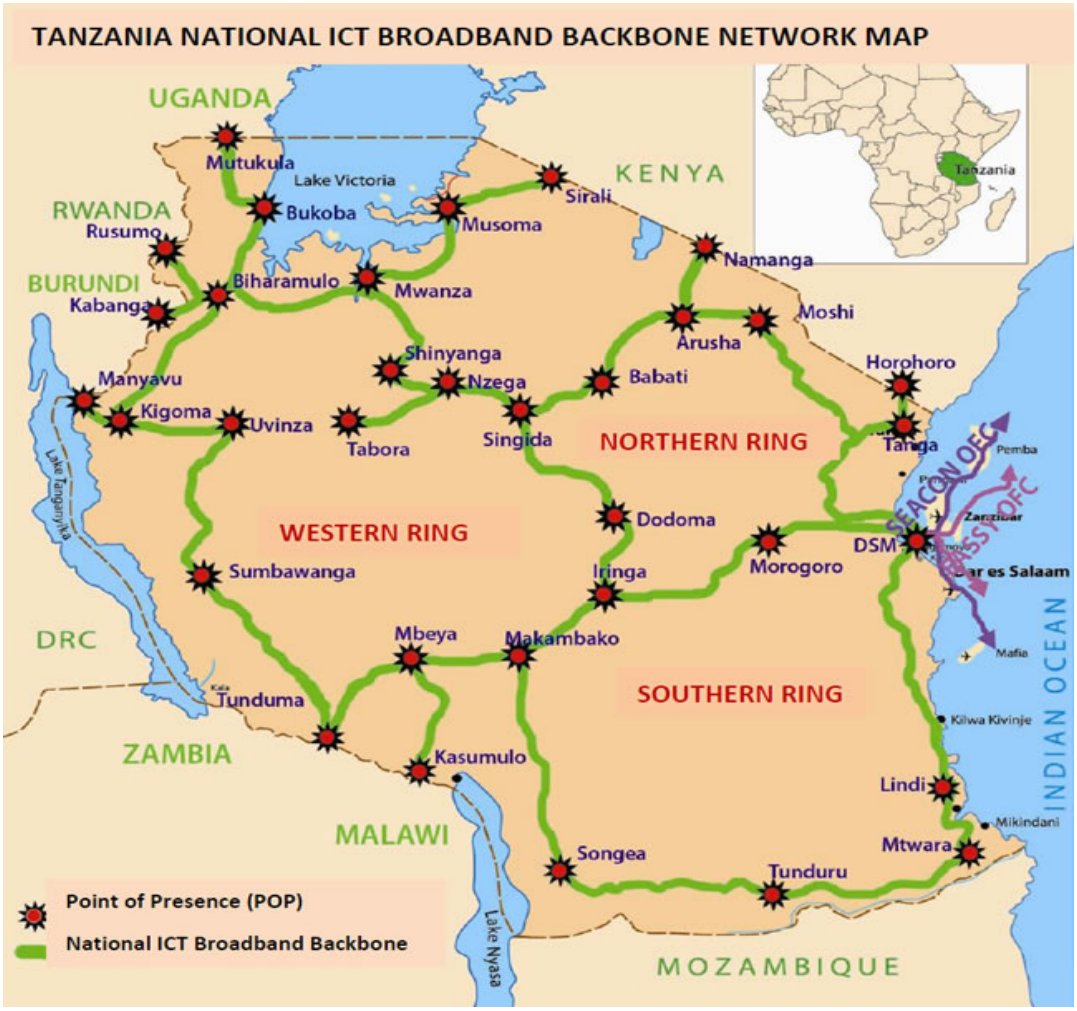



Fig. 1: Tanzania National ICT broadband backbone [1][2]

## 2.2 Current status of ICT Subscription in Tanzania

Fig. 2 shows the mobile subscribers in Tanzania from 2011 to 2016. It can be observed that the mobile subscribers increased from 40% to about 65% from 2011 to 2016 respectively. This increase is attributed to a number of interventions by Government of having a good regulatory framework whereby there is a good competition in the market and penetration of mobile cellular. Also Fig. 3 shows the percentage of households with personal computers. It can be observed that the percentage of households with personal computers in Tanzania increased from 2.5% to 4% from 2011 to 2013 respectively. However percentage of households with personal computers in 2016 is about 3.7%. The use of social networks (twitter, face book, etc) increased from 51% to 62% in 2011 and 2014 respectively decreasing to 60% in 2016. The trends from 2011 to 2016 can be observed in fig. 4. These trends might be attributed to the awareness of technology and penetration of mobile networks in Tanzania. Figures 5, 6 and 7 show the Mobile broadband subscription, households with Internet access and fixed broadband Internet Subscription respectively. It can be observed that the mobile broadband subscription increased from 0.1% in 2012 to 3.7% in 2014 though it decreased to 3% in 2016. Households with Internet access increased from 0.7% in 2012 to 4.5% in 2013 decreasing to 3.3% in 2014. Currently it is about 4.1%. The fixed broadband Internet Subscription increased from 0.1% in 2015 to 0.2% in 2016.

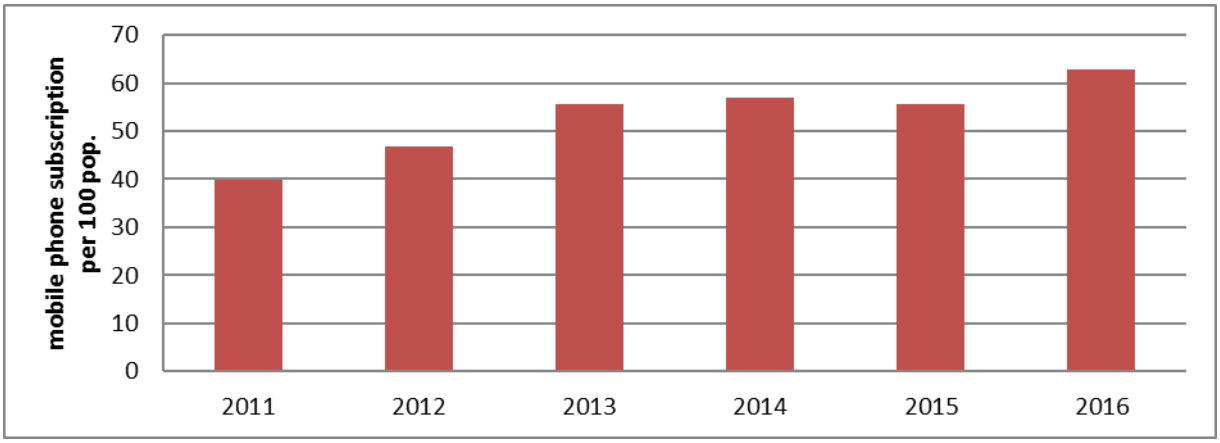



***Fig. 2: Mobile Phone subscription per 100 populations [3-9]***

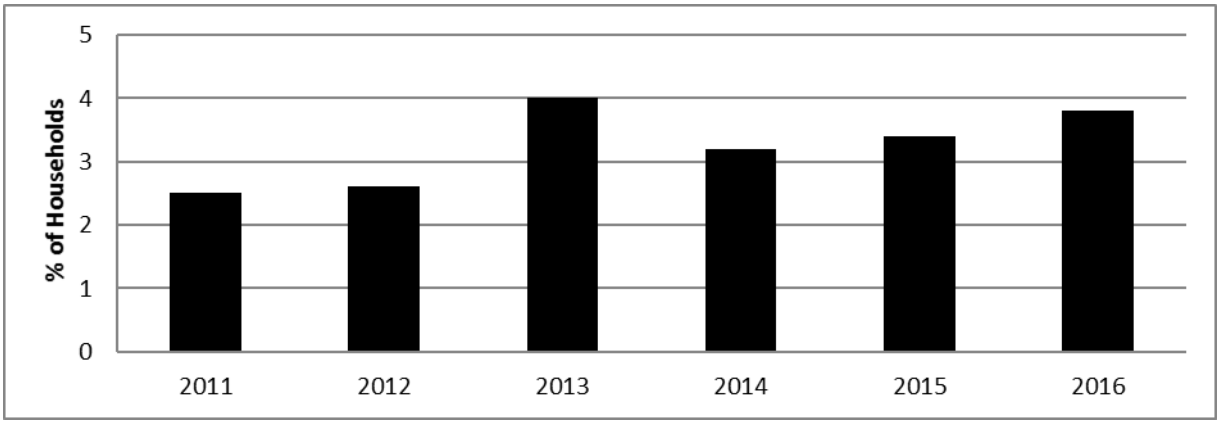



***Fig. 3: Households with personal computer [3-8]***

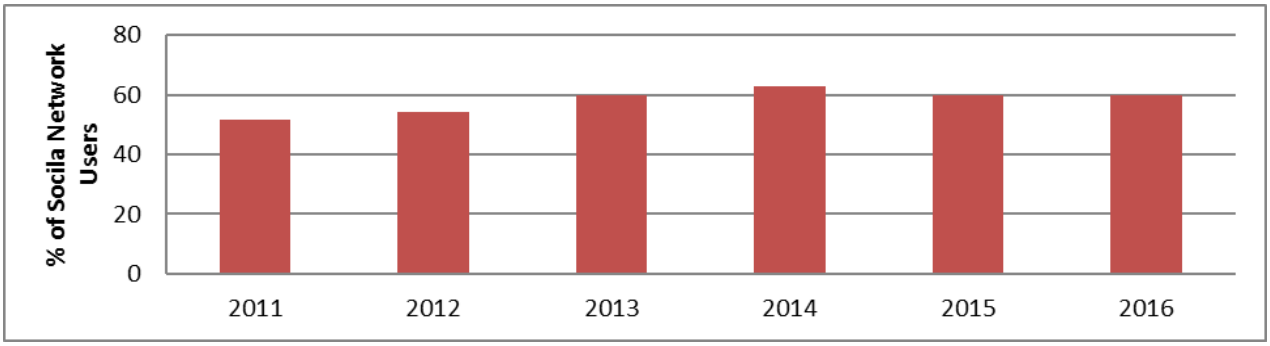



*Fig. 4: Percentage of social network users[3-8]*

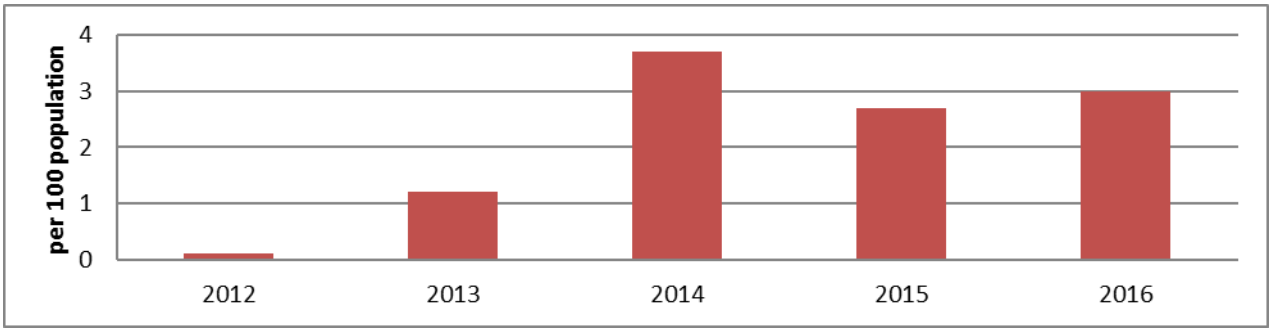



*Fig. 5: Mobile broadband subscription[3-8]*

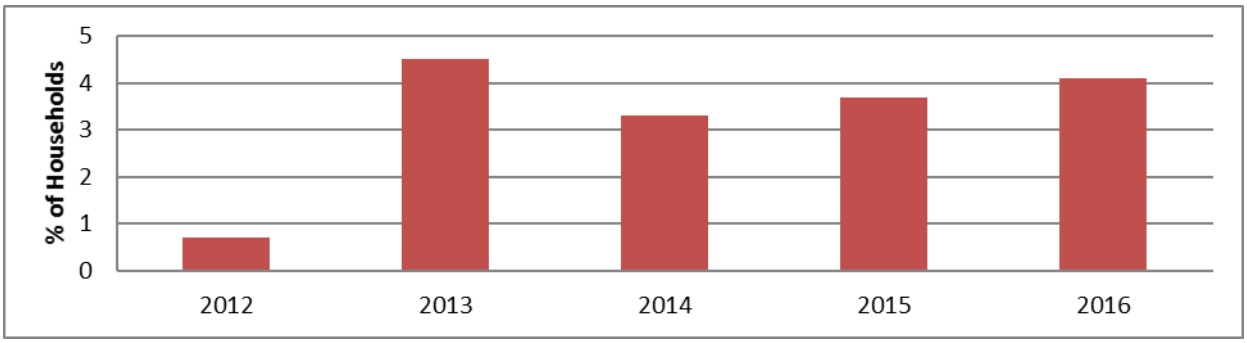



*Fig. 6: Households with Internet access [3-8]*

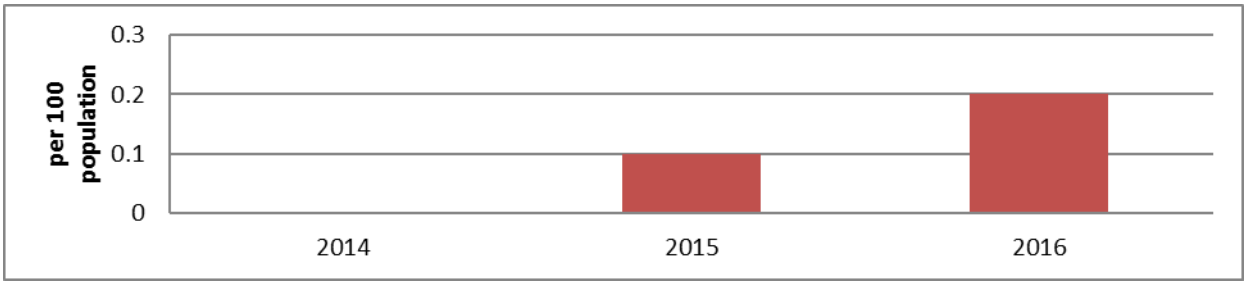
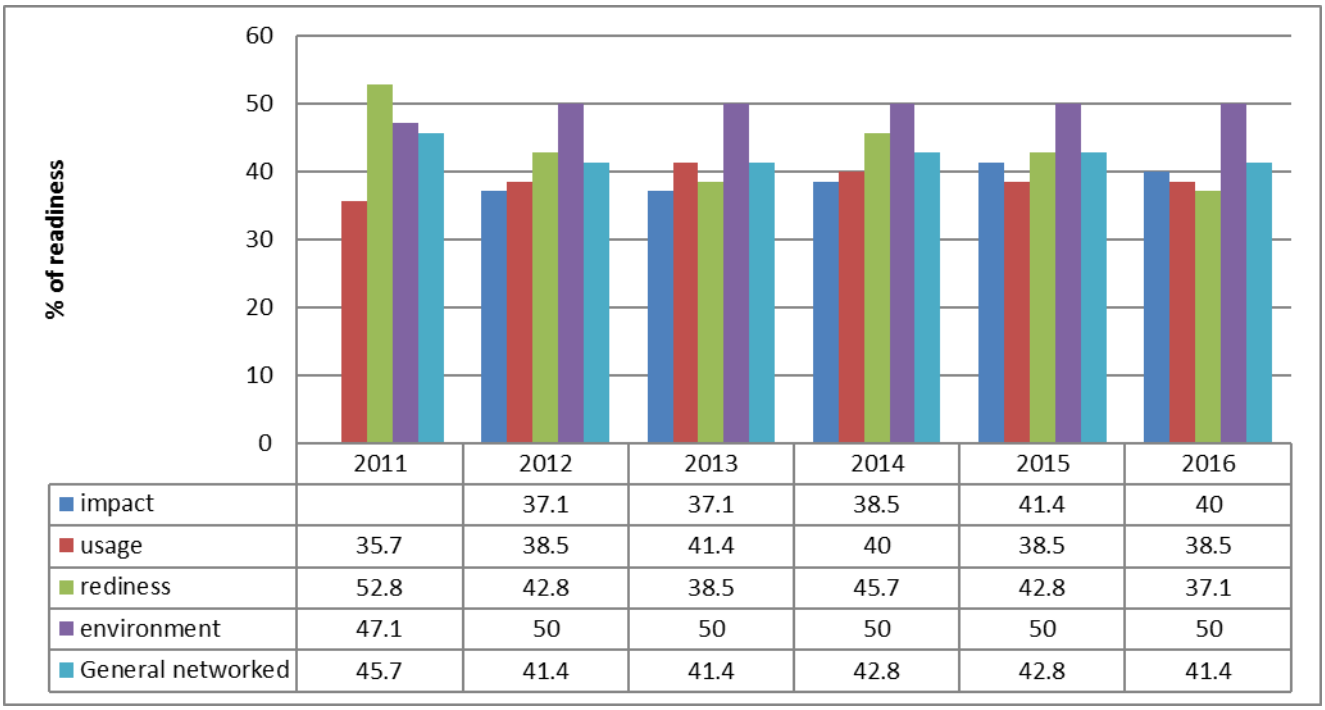



*Fig. 7: Fixed broadband Internet Subscription [6-8]*

General trends of ICT in Tanzania are guided by the networked readiness index (NRI) [3-9]. The NRI framework is guided by five principles which include economic and social impacts of ICTs, enabling environment to determine the capacity of an economy and society to benefit from the use of ICTs and ICT readiness and usage. The networked readiness framework (NRF) normally translates into the NRI comprises four sub

indexes that measure the environment of ICTs; the readiness of the society to use ICTs, the actual usage of all main stakeholders and impacts that ICTs generate in the economy and society. The environment, readiness and usage sub- indexes are regarded as drivers while economic and social are regarded as impact sub index. Figure 8 shows the ICT networked readiness in Tanzania from 2011 to 2016. It can be observed that the environment of ICT in Tanzania is average. Other factors are about 40% and below. This indicates that there is a lot to do to enable the country to benefit and be competitive towards the fourth industrial revolution.




| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| impact | | 37.1 | 37.1 | 38.5 | 41.4 | 40 |
| usage | 35.7 | 38.5 | 41.4 | 40 | 38.5 | 38.5 |
| rediness | 52.8 | 42.8 | 38.5 | 45.7 | 42.8 | 37.1 |
| environment | 47.1 | 50 | 50 | 50 | 50 | 50 |
| General networked | 45.7 | 41.4 | 41.4 | 42.8 | 42.8 | 41.4 |

***Fig. 8: ICT Networked Readiness Index [3-8]***

## 3.0 Use of ICT in teaching and learning Process

ICT is a powerful mechanism in every aspect of education: teacher training, local curricula, local-language instruction, monitoring and assessment of student performance, education-systems management, coaching and mentoring, and preparing students for a world in which ICT is a necessity for successfully navigating their future careers and lives and contributing to their national economies. ICT-based innovation is taking place throughout the education value chain. Recent ICT-based advances for educational systems include ICT for spatial planning, Massive Open Online Courses (MOOCs), and distance training, tutoring, and mentoring. Through ICT, the learning space is no longer limited to a traditional classroom, shifting educational delivery to the palms of every individual. ICT provides an unprecedented, cost-effective platform for governments, schools, teachers, communities and businesses to collaborate effectively. ICT enables delivery of high quality content regardless of location. It provides a mechanism for ongoing teacher pedagogy, professional development and communities of practice. Significantly, it also enables substantial reduction of delivery costs.

Setting pace for exploiting ICT in teaching and learning some universities in Tanzania have already started some programmes such BSc in ICT Mediated Content Development, BSc in

Multimedia technology and Animations and BED ICT (University of Dodoma), BSc in Education with Computer Science (Saint Joseph University) etc. In addition there are some initiative in Open University of Tanzania and Center for Virtual Learning at the University of Dar es Salaam etc. Despite all these initiatives, research on how best this opportunity can be exploited at maximum in Tanzania is lacking. Very little investment is being directed towards ICT for education in Tanzania. Most of these initiatives are fragmented and isolated, there is no national coordination.

## 4.0 ICT as a technological force that drives industrialization

The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres.

There are three reasons why today's transformations represent not merely a continuation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope, and systems impact. The speed of current breakthroughs has no historical precedent. When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country. And the breadth and depth of these changes the transformation of entire systems of production, management, and governance.

The possibilities of billions of people connected by mobile devices, with exceptional processing power, storage capacity, and access to knowledge, are unlimited. And these possibilities will be multiplied by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing.

Already, artificial intelligence is all around us, from self-driving cars and drones to virtual assistants and software that translate. Impressive progress has been made in artificial intelligence in recent years, driven by exponential increases in computing power and by the availability of vast amounts of data, from software used to discover new drugs to algorithms used to predict our cultural interests. Digital fabrication technologies, meanwhile, are interacting with the biological world on a daily basis. Engineers, designers, and architects are combining computational design, additive manufacturing, materials engineering, and synthetic biology to pioneer a symbiosis between microorganisms, our bodies, the products we consume, and even the buildings we inhabit.

**Internet of Things (IoT):** there are already 400 million cellular IoT subscriptions, forecast to reach some 28 billion connected devices worldwide by 2021. The IoT will be a rich platform for innovation and is projected to add around USD 11 trillion of market value globally by 2025 across applications. In the industrialization context this technology will

have industrialization such as process anomaly detection and control of complex equipment and integrated systems; systems optimization; prediction; data capture and analytics; and systems maintenance.

**Automation and innovation**: Next-generation mobile broadband (5G), IoT, artificial intelligence, advanced robotics and 3D printing herald unprecedented advances in healthcare, education, energy services, production, agriculture, and environmental monitoring and protection. But such innovations also raise issues such as privacy and security around protecting the integrity of individual data, and new areas of concern are likely to come to light as technology evolves. In the context of industrialization this area will form products and machines that communicate with each other, enabling the products themselves to control their production.

**Big data' and analytics**: through big data, it will be possible to produce in real time high-quality vital statistics (births, deaths, population), indicators for health (e.g. epidemic out-breaks), education (e.g. learning outcomes) and the environment (e.g. air and water quality). Both public and private sectors are making use of big data analytics and any risks must be balanced against the benefits to society, including the possibility to use big data for social good, such as improving response to disease outbreaks. A core part of any nation's ICT strategy should therefore be upgraded information platforms to harness the flow of big data in the service of public policy.

**Advanced robotics**: an industrial robot 'revolution' is already transforming many industrial and service sectors, with countries like China investing heavily in the R&D and deployment of advanced robotics and a surge in applications. Machine learning algorithms are enabling breakthroughs in robotics pattern recognition, voice recognition, natural language capabilities, and problem-solving capacities. Robots will increasingly be used in the high-tech service economy in legal analysis, medical diagnostics, and other areas of complex problem solving. In a vision of the future of manufacturing, the pervasive networking of people, things, and machines will create completely new production environments.

## 5.0 Positive implications of ICT

The spread of ICT and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies, as it does scientific and technological innovation across areas as diverse as medicine and energy. ICT can bridge institutional gaps by integrating informal trade into formal frameworks, strengthening economic development and reducing trade barriers.

According to the Organization for Economical Cooperation and Development (OECD), "more ubiquitous access to and use of broadband Internet networks, which are available in a competitive market and at affordable prices, will help foster innovation and drive the growth of the Internet Economy and the economy in general. ICT needs to be combined with innovative policies, services and solutions to deliver transformation at unprecedented

speed and scale. It can be a powerful means of implementation in five major ways:

- Accelerated up scaling of critical services in health, education, financial services, smart agriculture and low-carbon energy systems, etc.
- Reduced deployment costs addressing urban and rural realities.
- Enhanced public awareness and engagement.
- Innovation, connectivity, productivity and efficiency across many sectors.
- Faster upgrading in the quality of services and jobs.

**6.0 Issues and challenges**

No technology is without risks, and widespread uptake of ICT raises a number of issues that will need to be addressed and managed. Several issues have been identified which governments, industry and other stakeholders must work together to address:

- **Privacy and surveillance:** The pervasive nature of ICT could result in loss of privacy, growth of surveillance and violations of human rights without adequate oversight and boundaries.
- **Cyber security:** A networked economy is more vulnerable to systemic network failures of the Internet or power grid, which could bring the economy to a grinding halt. Disrupting the networked economy could become the focus of deliberate acts of cyber-warfare and terrorism. Luckily enough this challenge is already being addressed at the University of Dodoma where there are curricula for cyber security at the levels of certificate, diploma, degree, masters up to PhD. Another initiative is computer emergency response team under Tanzania Communications Regulatory Authority (TCRA).
- **Loss of human skills:** The online world will literally reshape brain development, possibly engendering loss of 'human' skills and the 'crowding out' of real communities, undermining social interaction and trust.
- **Possible public concern about health effects:** To protect human health, radio wave exposure levels from products and network solutions must be kept within established safety limits, while sedentary lifestyles could contribute to the growing global burden of Non-Communicable Diseases (NCDs). In Tanzania through TCRA and Tanzania atomic energy (TAEC) already this challenge is implemented. There is a national committee dealing with Electromagnetic Fields (EMF).
- **Electronic waste and carbon emissions**: Growth in global ownership of digital devices, rapid product turnover and inadequate waste processing have led to accumulation of dangerous electronic waste; and while ICT can reduce carbon emissions in other sectors, it must also reduce it own emissions, focusing on energy

performance. Already there is a committee dealing with this issue under National Environment Management Council (NEMC) and TCRA.

- **Digital exclusion:** As well as winners, there will be losers from digital transformation due to age and generation gaps, digital literacy, geography and industry sector. Ensuring no one is left behind is easier said than done.

- **Child protection and the Internet:** *Using the Internet provides children worldwide with opportunities but also risks. The ICT industry has a role to play in protecting child safety in the online world including child sexual abuse.*

**7.0 What can be done to address Challenges in ICT?**

To fulfill its potential as a disruptive, transformative technology for good and deliver, ICT must be integrated into every facet of public policy and economic activity. To achieve this number of hurdles must be overcome:

- Equip the entire public sector including service delivery in finance, education, health, energy and transportation with high quality ICT infrastructure. Currently Public sector regulations do not enable full utilization of ICT.

- Mobile broadband physical infrastructure needs rapid expansion and upgrading, especially to public facilities like schools and clinics.

- Promulgate a national policy to channel funding and efforts on the start-up local initiates particularly on training (UDOM curricula and research) and software development domestication.

- Small, fragmented demonstration projects require national scale-up with business models addressing urban and rural areas.

- ICT-based system components need to be interoperable across competing platforms.

- Significant training of personnel is required to manage ICT systems and international certification.

- Policy and regulation must play catch-up with rapid ICT innovation and deployment to ensure that new challenges, risks and threats are effectively managed.

- Public-Private Partnerships (PPP): New partnerships are needed between government, international organizations and industry in order to find sustainable business models that support wide-scale ICT deployment. For example, to connect the unconnected in areas that are not currently profitable, or to accelerate the creation of innovation hubs to develop new ICT applications especially locally de-signed and targeted ones. Sufficient public and private investment needs to be

actively targeted towards ICT. Business models need to address the needs of urban and rural areas.

- Upgrade STEM: Foster science, technology, engineering and mathematics skills in primary and secondary education to build long-term technology readiness and scale up ICT training programs with universities.

- Harness big data: Create national online and open databases using big data from public service provision and satellites, mobile networks, remote sensors and other connected devices in the Internet of Things.

- Establish a timeline for universal broadband connectivity of public facilities and services.

**8.0 Lessons from other countries**

The ICT industry in China covers a wide range of products and services, including telecommunications, hardware, software, and IT services. China foreseeable that ICT will still be an important sector as the Chinese government realizes that ICT is the key to other industries modernization. China's ICT sector has grown rapidly because of the support of the Chinese government's plans and policies.

In 2006, the Ministry of Industry and Information Technology published the '2006-2020 National Informatisation Development Strategy'. This guideline outlined the overarching goals for the Chinese ICT industry by 2020. China promulgated the outline of National Medium and long term Science and Technology Development Plan. This plan identifies innovation as the new national strategy, placing innovation capability strengthening as the strategic basis for science and technology development and the core of industrial restructuring and growth mode transformation.

The key points were as follows:

- To grow the economy through high technology rather than capital investment by fully utilizing the ICT industry
- To develop indigenous innovative core technologies rather than imitating or introducing them from abroad
- To establish a world-leading, reliable, and safe information system
- To make government and military affairs paperless

A number of policies were also initiated to support the ICT industry's development. The major policies included the following:

- Optimizing administrative processes for ICT companies
- Increasing government procurement of ICT products

- Promoting a chief information officer (CIO) system in companies
- Better financing and taxation for ICT companies in supported sectors
- Improving related laws
- Reinforcing the standardization and protection of intellectual property

In the national level development plans for identified key technologies include: Integrated circuit, High-definition television(HDTV), software, Networked and Information security, new components, Broadband wireless mobile communications, next generation networks, intelligent terminals, intelligent transportation system, automotive engineering computing platform, information industry and information technology services platforms and scientific research platform and service system.

To upgrade overall environment for technology innovation and promote high-tech industrialization, government has implemented a series of actions including: National Science and Technology Industrial Parks, Innovation Fund for Tech-based SMEs, Technology Business Incubators, Specialized Industrial Bases, Software Parks and productivity Promotion Centers to perfect support systems for high-tech industrialization, to promote indigenous innovation, to foster growth of tech-based SMEs and to boost technological innovation in enterprises.

To enhance industrialization in China foreign ownership in telecommunication market has a 49% limit and up to 50% for related value added services. Tariffs for ICT products and services vary depending on the category classification and what level of Chinese indigenous component is included. Certain ICT products exported to china are subject to china compulsory certification. The tariffs of ICT related hardware products ranges from 0% to 35%.

IT market reached EUR 197 billion and that the telecom services market worth EUR 236 billion in 2015. The ICT industry’s revenue has grown by 8% in 2014 to EUR 246 billion.

**9.0 Conclusions**

ICT is changing the world towards fourth industrial revolution. Fourth Industrial Revolution is building on third industrial revolution and characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. Current status of ICT in Tanzania is discussed. Use of ICT in teaching and learning process and ICT as a technological force that drives industrialization are addressed. Positive implications of ICT, issues and challenges and what can be done to address Challenges in ICT including lessons from other china has been discussed. It has been observed that Tanzania optical fiber infrastructure is connected to nine borders and all district covered. In Tanzania, Mobile Phone subscription per 100 populations is approaching 70%. 4% household are connected have computers. 60% of Tanzanian are using social network networks. 3% of Tanzanians are subscribing Mobile broadband. 4% 0f Households are connected to Internet Access. 0.2% are Subscribing fixed broadband Internet. Currently environment of ICT in Tanzania is about 50%. Moreover, looking at networked readiness index, Tanzania is below average in

many aspects which needs some improvement. It has further observed that ICT is a powerful mechanism in every aspect of education, financial and all public sectors. The forth industrial revolution, have a possibilities of multiple emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing. Finally, there are some possibilities of increasing industry such as telecommunications, software, hardware and IT solutions. Different policies and regulations are needed to enable Tanzania move towards ICT industrialization country.

**ACKNOWLEDGEMENT**

The contributions from Eng. Prof. A. N. Mvuma and Prof. L. J. Mselle in the College of Informatics and Virtual Education, the University of Dodoma are highly acknowledged.

**REFERENCES**

[1] ICT in Engineering Practice and social knowledge economy, 11th Annual Engineers Day, September 5-6, 2013, pp. 59-87.

[2] Hon. Prof. Makame Mbarawa, Investment in ICT in Tanzania, the Southern African ICT for Education Summit 2012, Mozambique and Tanzania, Victoria Falls, 26-27 January.

[3] ICT and SDGS, How Information and Communications Technology can accelerate action on sustainable Development goals, 2016.

[4] The Global Information Technology Report 2016

[5] The Global Information Technology Report 2015

[6] The Global Information Technology Report 2014

[7] The Global Information Technology Report 2013

[8] The Global Information Technology Report 2012

[9] The Global Information Technology Report 2011

[10] China Runway: Guide for ICT companies, September, 2010.

[11] The ICT Market in China, 2015