

The Need for Internet of Things in African Societies Owing to Advances in Ict

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ABSTRACT- This paper aims at identifying major advances in African countries that, if harnessed and implemented, could lead to a nation connected through a well-advanced Internet of Things (IoT). This is properly argued by enumerating the ways Information Communication Technology (ICT) has influenced the civilization's key structures as well as day-to-day activities. From the information obtained from peer-reviewed publications, documents and records, we were able to ascertain that, without a doubt, ICT innovations were one of the key elements behind the socio-economic development of these societies. This is useful in guiding stakeholders and policy makers, giving governments an edge over one another to help them multiply the economic opportunities of such societies.

Keywords- *Internet of Things, Information Communication Technology, Industries in Africa, Effects of ICT in African societies, Future of ICT*

I. BACKGROUND

“Anything that can be connected will be connected” (Morgan, 2014). This rule succinctly sums up the concept of Internet of Things (IoT). People have become highly interconnected due to the advent of the internet, leading to increased volume of production, transactions, profits, and wealth (Bianchi and Matthews, 2015). As products were exchanged, things became more interlinked as well. This connection between things-things, people-things, and people-people is called IoT. Any device connected to the internet and/or other devices with an on/off switch that capture and transmit data is part of the IoT. There are many benefits to the adoption of IoT. It is supposed to facilitate wealth growth and push resource economics to reduce waste and encourage productivity, in the same way that people's interconnectedness drives economic activity, raises transaction volume, and increases wealth. The adoption of IoT would be supported by Information and Communicative Technologies (ICT). ICT is described by United Nations Educational, Scientific and Cultural Organization (UNESCO, 2011) as a scientific, technological, and engineering discipline and management methodology for managing information, its implementation, and its relationship to social, economic, and

cultural issues. ICT is the main enabler of globalization, according to Oladele (2015), as it allows for efficient and cost-effective movement of knowledge, goods, persons, and capital across national and regional borders. It has already brought about remarkable developments in Africa over the past 20 years. Indeed, ICT has become a core part of modern life in Nigeria and the entire globe because we talk, text, email, and tweet on mobile phones; we work, educate, read, study, buy, and entertain ourselves on the internet; and we eagerly await the next breakthrough from the world of ICT. The topic of how to recognize and assess emerging economies' readiness to implement IoT remains to be explored. Therefore, an overview of relevant factors and technological advances is needed to be considered in order to examine IoT adoption in this part of the world. This will be accomplished by delving deeper into related indices and details that cover key IoT components. These include the impact of ICT on: Agriculture, Broadcasting and Advertising, Commerce and Industry, Banking Sector, phone Usage and Necessities, and Transportation.

II. LITERATURE REVIEW

A. *Impact of ICT on Agriculture*

Agriculture is a key player in nearly all African countries and it occupies a pivotal role in the improvement of the continent. Based on the National Bureau of Statistics (2017), Agriculture contributes to 29.15 % of Real Gross Domestic Product (GDP). Moreover, based on the World Bank collection of development indicators, Agricultural land in Nigeria was found to be 77.7% in 2016 as well as employment in agriculture to be 36.55 % in 2017. Thus, this makes agriculture an important sector in Nigeria. Munyua (2008) states that Africa has a collective body of agricultural information and understanding, know-how and methods that have to be discussed continent-wide and applied for improved sustainable development and livelihoods. Even though there is a large amount of information applicable to small scale farmers, this is difficult to find. The majority of the institutions using initiatives on small-scale agriculture and ICTs

in Africa have developed regional agricultural information in English and neighborhood languages. The simplicity of access to the web through mobile phones has been of great benefit. Many authors have exploited the launch of cell phone coverage in developing nations to estimate the effect of cell phones on agricultural marketplaces in those nations. For example, evaluating the effect of mobile phones on grain market segments within Niger, Aker (2010) finds that using mobile phones brings down the dispersion of grain charges across markets by ten percent. The impact is actually stronger for those market pairs with higher transport expenses, specifically, the ones that are farther apart and also linked by poor quality roads. The influence is stronger over time, which hints that you will find networks effects much like those discovered by Brown and Goolsbee (2002). A study carried out by Syed et al (2016), on the effect of ICTs on agricultural production was optimistic. Other studies giving positive feedback also reveal the age group of agricultural extension officers. Agwu, Akinnagbe and Uche-Mba (2008) observed that in Enugu and Abia States in Nigeria, the bulk of the extension workers are male. The age of extension officers ranged from twenty-two to sixty-five years, with forty-three percent between forty-one and fifty years and a mean age of 44.6 years, according to the study. This means that the overwhelming majority of the respondents were in their forties and fifties. This trend might have considerable implications for ICTs use since the elders may be less keen on utilizing hi-tech communication equipment and prefer oral and printed information mediums of which these are less efficient. Therefore, the younger extension officers are expected to have a higher knowledge of ICT consciousness and utilization.

Majority of these extension officers in the analysis were married (seventy-nine percent); seventy-three percent of the respondents had not up to 3 kids. Mabe and Oladele (2010) and Oladele and Moilwa (2010) reported findings that are similar among extension officers in South Africa and Botswana respectively. Adebayo and Adesope (2007) found that 70.4% of the extension officers in South Eastern Nigeria were married. The outcomes by Adesope et al (2007) confirmed the findings again that the majority of extension officers within Niger Delta, Nigeria were married. Seventy-one percent of extension officers had a family size of less than five individuals. This finding is the same with that of Oladele and Mabe (2010), which says that they had a mean of 4.2 individuals per home of extension officers within the North West province. A diploma in Agriculture as an educational qualification was what the majority of 41% of respondents had, 10% had M. Inst Agrar, M. Tech and D. Tech, 20% had B. Tech, 15% had degrees, 11% had honours qualification and the remaining 3% had certificates which imply a high degree

of literacy among farmer. Furthermore, 41% of the respondents suggested they were studying for a higher degree. This means that extension workers with a greater level of training must be in a position to value the usage of ICTs within their agricultural study as well as extension work.

Table 1 is from Oladele O.I. 2015's study on agricultural knowledge access among extension officers in the North Western Province of South Africa's. On a three-point-scale, with (3) being high and (1) being low, the impact of using ICT tools for extension officers rated high. Out of the 29 statements on effect of ICT on improving information access, 14 statement were perceived highly positive by extension officers in the study area which included: increase information availability(66.9%), increase knowledge on farming activities (60.9%), improve quality of information and record keeping respectively (60.4%), improves knowledge of agricultural activities, news, and information flow (58 %), improves information accuracy (55.6 %), improves capacity building (55 %), promotes data exchange, distribution, and increase access to agricultural inputs (54.4 %), and strengthens partnerships with research and extension (55 %) (53.8 %), improved access to agricultural markets (52.7%), enhances timeliness of information and improve the relevance of research respectively (50.3%). The mean for most of these statements was above 2.00.

Since knowledge is a critical component of agricultural extension, the above findings imply that extension officers are well aware of the importance of ICT in agricultural production and agree that ICTs should be inculcated in every aspect of agriculture, including extension work. From the regression results provided in Table 2 (Oladele 2015). It is mentioned that 4 out of the 21 variables were significant 10% and 5% respectively. The variable that had a 10% significance level were highest education qualification ($t = 2.61, p = 0.11$); constraints to ICT tools ($t = 2.60, p = .010$) and variables with the significance level of 5% were use of ICT tools ($t = 4.67, p = .000$) and e-readiness of extension officers ($t = -3.01, p = .003$). Probably the highest amount of training had a major beneficial effect on the impact of information access by extension officers within the North West Province. This implies that as respondents obtain increased educational qualification level the outcome of ICT on agricultural information access is actually improved. What this means is that access to agricultural information through ICT is going to continue to greatly improve once the informative qualification increases.

Table 1: Effects of Information Communication Technology on improving information access

Effects	High	Medium	Low	Mean	SD
Increase knowledge on farming activities	103[60.9]	54[32.0]	12[7.1]	2.52	.68
Increase information availability	113[66.9]	40[23.7]	16[9.5]	2.54	.74
Increase information flow	98[58.0]	51[30.2]	20[11.9]	2.42	.79
Improve information seeking behaviour	75[44.4]	72[42.6]	22[13.1]	2.28	.76
Enhances accuracy of information	94[55.6]	51[30.2]	24[14.2]	2.34	.88
Enhances timeliness of information	85[50.3]	72[42.6]	27[16.0]	2.44	2.45
Encourages data sharing and dissemination	92[54.4]	51[[30.2]	28[16.5]	2.32	.87
Enhances multilingualism of agricultural information	69[40.8]	57[33.7]	43[25.4]	2.10	.90
Improves data management	78[46.2]	49[29.0]	24[14.2]	2.27	.82
Improve quality of information	102[60.4]	57[33.7]	17[10.1]	2.46	.77
Improve the relevance of research	85[50.3]	67[39.6]	27[15.9]	2.30	.83
Improve the timeliness of research	77[45.6]	50[29.6]	36[21.3]	2.17	.92
Improve access to agricultural inputs	92[54.4]	57[33.7]	19[11.3]	2.39	.78
Improved access to agricultural markets	89[52.7]	56[33.1]	28[16.5]	2.31	.86
Improved access to credit institutions	53[31.4]	58[34.3]	49[29.0]	1.95	.90
Improved awareness of agricultural events and news	98[58.0]	52[30.8]	21[12.4]	2.41	.81
Enhance decision making	76[45.0]	67[39.6]	29[17.1]	2.23	.84
Give voice to the voiceless	59[34.9]	50[29.6]	47[27.8]	2.02	.86
Reduce rural urban digital divide	47[27.8]	64[37.9]	58[34.3]	1.88	.86
Reduce rich-poor digital divide	37[21.9]	60[35.5]	72[42.6]	1.74	.85
Reduce male-female digital divide	37[21.9]	67[39.6]	65[38.5]	1.74	.89
Improved cultural compatibility of agricultural issues	50[29.6]	78[46.2]	41[24.3]	1.95	.91
Improved social acceptability of agricultural issues	65[38.5]	65[38.5]	39[23.1]	2.07	.92
Improves record keeping	102[60.4]	44[26.0]	23[13.7]	2.43	.80
Reduces cost of interaction among stake holders	72[42.6]	61[36.1]	36[21.3]	2.14	.90
Enhances capacity building	93[55.0]	61[36.1]	15[8.9]	2.43	.73
Changes the function of extension services	8248.5]	59[34.9]	28[16.5]	2.26	.862
Strengthening partnership with research and extension	91[53.8]	48[28.4]	30[17.7]	2.30	.89
Enhances timely feedback from farmers/research	84[49.7]	49[29.0]	36[21.3]	2.23	.89

Table 2: Multiple regression of effect of information access in using ICT tools and socio-economic characteristics of extension officers

Variables	B	SE	Beta	t	p
(Constant)	26.664	11.794		2.261	.025
Gender	4.264	3.042	.113	1.402	.163
Age	-.097	.206	-.053	-4.469	.640
Marital Status	-.077	1.007	.006	.077	.939
Number of children	.790	1.102	.067	.716	.475
Religion	1.671	1.742	.070	.959	.339
Educational qualification	1.971	.764	.180	2.581	.011
Studying for a higher degree	-1.036	2.331	-.031	-4.444	.657
Household size	-.322	.607	-.041	-.530	.597
Working experience	-.180	.162	-.117	-1.110	.269
Living in job location	-4.597	2.888	-.112	-1.592	.114
Place of residence	.184	2.119	.006	.087	.931
Number of farmers covered	.002	.002	.064	.879	.381
Distance to farmers	-.001	.002	-.045	-.627	.532
Awareness of ICT	.056	.107	.071	.520	.604
Availability of ICT	.276	.168	.316	1.646	.102
Accessibility to ICT	-.204	.204	-.240	-.996	.321
Importance of ICT	-.082	.164	-.106	-.501	.617
Use of ICT	.108	.115	.146	.938	.350
Constraints to ICT use	.841	.184	.444	4.566	.000
Effect on officers e –readiness	-.781	.301	-.250	-2.599	.010
Competence on ICT use	.903	.300	.239	3.009	.003
F	3.722				
P	.000				
R	.589				
R square	.347				
Adjusted R	.254				

This is supported by the results of Oladele (2011) indicated a significant difference in the effect of ICT on agricultural information access among researchers, extension agents, and farmers in South Western Nigeria was observed. This means that as educational qualifications increase, access to agricultural knowledge through ICT will improve as well. Furthermore, Lynch (2001) believes that extension experts' attitudes, expertise, and awareness have a significant impact on ICT use. The limitations on extension officers' use of ICT tools had a substantial influence on the impact of ICT on knowledge access.

B. Impact of ICT on Broadcasting and Advertising

The world has come to a new global era from tangible flows of physical products to intangible flows of information and data, from information flows primarily between advanced countries to higher participation of emerging economies, from capital and labour intensive flows to more information-intensive flows, from when multinational companies drive the flow to a moment when small firms and individuals are able to play crucial roles as well, from flows of primarily monetized transactions to a lot more exchange of free contents and services and from a moment when innovations moved from advanced to emerging economies to a period when innovative developments run in both directions (McKinsey Global Institute, 2016). In today's media system, this change is manifested by the innovative and formidable ways in which information is processed and distributed. The established mass news media, having clearly found themselves in uncharted waters, have quickly devised impressive and fruitful tactics to deal with such a dramatic change: they have adapted to the modern age with certain trepidation. Television and radio programs have for example created blogs, Facebook pages as well as webcasting as complementary forms or elongations of classical transmitted exercises; meanwhile, newsprints which hitherto existed solely on paper, today are available in both paper format as well as digital form.



Figure 1: McKinsey Global Institute, Digital Globalization: The New Era of Global Flows, 2016

Magazines and newspaper now intensify their presence on the Internet from the development of informative and entertaining sites. Likewise, music and movies which were earlier

distributed solely on disks or tapes and video cassettes, are now available in form of downloads on the world wide web, bypassing the different recording businesses and usually violating copyright laws (Endong 2015). The incorporation of ICTs into media communication has fully changed Nigeria's communication industry, allowing for quicker, simpler, and more affordable information collection, distribution, and dissemination (Joseph Oluchukwu et al, 2018). The internet and new technologies were mostly responsible for the emerging digital transformation in the international media environment.

In recent context, Nigerian migrant networks make use of ICT, social media and the internet as a way to create global consciousness on the problems emerging from their native homeland. By posting articles on personal blogs, political commentaries on social media handles, and broadcasting audio-visual images of material emerging during protests, such networks have forced issues into both local and global media agenda through their innovative uses of online media. This activity leaves both national and international media no option but to report the events since they are public knowledge (Shola A. Olabode, 2016). According to Joseph Oluchukwu et al., 2016, ICT has also resulted in a significant shift in Nigerian beliefs. They went on to say using Moor (2005) observation that as technological revolutions grow in social influence, ethical issues will grow as well, and revolutionary technology opens up a slew of potential possibilities for action on which no well-thought-out ethical strategies will exist.

They then summarized, saying that the quest to catch up with the globalization of international development agenda and socio-economic and political transformations generated by technological advances in the field of Information and communication propelled Nigeria to adopt an information policy in 1992. The policy, which was progressively modified to take care of some national development requirements, and evolving problems in the communication industry led ICTs integration into media communication. The integration led to remarkable national economic growth, job creation, Nigeria's switchover from analogue to a digital system and subsequent integration into the global socio-economic and communication systems. Media communication has become not only easier, faster, democratized, cheaper, and accessible but also enjoys greater geographical coverage and internationalization.

C. Impact of ICT on Commerce and Industry

According to Yoshimoto and Nemoto (2005), the use of ICT and technology has impacted many areas of trade, transforming not just how enterprises are run but also spawning new industries and employment. ICT has since been used to reduce prices by eliminating the use of energy-related materials such as petrol. As a result, it is possible that ICT has an effect on the environment. According to Falch et al. (2009),

changes in the organization of transportation operations by ICT result in significant reductions in energy use by the shipping industry. However, the authors note that ICT usage affects not only manufacturing costs but also administration costs, and because administration is all about coordination and information, these management costs are likely to be affected as well (Selvi, 2018).

Recently, many conventional enterprises are turning towards more digitalized and technology-oriented ways of doing industry. The trading landscape has been fundamentally altered and reshaped by ICT-based technologies that offer companies access to wider markets, enabling them to extend their customer base, size, and profitability in an increasingly globalized world. It also puts companies in direct competition with world-class rivals, introduces them to fresh technologies and innovations, and helps them to keep up with industry demands. (Clarke and Wallsten 2006; Freund and Weinhold 2002, 2004). Nigeria is said to have the highest online users in Africa with over 203 million online users as of December 2020. Egypt, with 54.74 million subscribers, was in second place. Active mobile devices are responsible for the bulk of online traffic in Africa's top digital markets (Johnson, 2021). International e-commerce, in its broadest sense, entails cross-border and/or cross-country online transactions that result in significant change. The reduction in travel, administration, correspondence, and business quest costs is the most significant cost-saving feature of e-commerce (Zhongwei 2017). In the global south, e-commerce is being encouraged because it allows manufacturers and exporters to address conventional disadvantages such as limited access to knowledge, higher market entry costs, and distance from potential customers. (Aw and Hwang 1995). It also encourages entrepreneurship by assisting small and medium-sized businesses (SMEs) in identifying emerging opportunities, achieving economies of scale through operations management, and coordinating supply chains across boundaries. (Panagariya 2000). Lastly, industries are hugely benefiting from the use of ICT in the employment sector. It is way cheaper to hire workers online than having them employed permanently and then enrolling them under a pension scheme. Industries also have an added advantage of accessing top professionals from anywhere in the world via teleworking as opposed to when they would be restricted to their geographical area.

D. Impact of ICT on Banking Sector

In terms of growth and profitability, Africa is the world's second-largest banking market (Moses, 2020). The banking sector today is dynamic and undergoes changes as a result of technological innovations, increased awareness and demand from customers (Ekwonwune et al, 2017). Business organizations, especially the banking industry, operate in a

complex and competitive environment characterized by these changing conditions and highly unpredictable economic climates (Ekwonwune and Dike, 2006). They believe that Information and Communications Technology (ICT) is at the heart of this global shift. The introduction of ICT principles, methods, regulations, and delivery strategies to banking services has become a subject of critical importance and interest for all banks, as well as a need for local and global competitiveness. In the banking sector, ICT has a strong impact on how management make decisions, prepare, and deliver goods and services. Ekwonwune and Dike insist that information technology has changed the way banks and their business partnerships are structured around the world, as well as the number of creative devices available to improve service delivery speed and efficiency.

Nweke Remmy (2008) pointed out that our conventional payment model in Nigeria was the "brick and mortar" scheme, which was the same as the extension of bank branch networks necessitated by customers' forced presence in banks to complete transactions. Nigeria's conventional payment model, known as "brick and mortar," was distinguished by a large branch network and long lines of customers for transactional purposes. Insecurity, inconveniences, high processing costs, cumbersomeness, and high market risk were some of the obstacles he noticed. He was pleased that the use of ICT in today's banking activities has minimized such issues by lowering transaction costs and rising service level. Indeed, information technology has altered the way financial systems and services are processed and delivered around the world (Frederick 2012). It also aided in the reduction of overhead costs, the enhancement of customer relations, and the enhancement of service efficiency (Boateng et al 2006). Electronic banking is a modern way for banks to offer products and services. In the last three decades, electronic banking products and services have grown in popularity (Oladejo 2012). The banking sector, which operates in a diverse and dynamic climate, has realized the importance of providing electronic services to its customers (Shittu 2010). In reality, thanks to electronic banking, bank employees' efficiency and customer loyalty have also improved significantly (Yunus et al, 2011). Most researchers believe that ATMs are essential for the banking industry's future growth, some have discovered a lack of proportionality between the size of technology adoption and the increase in bank profitability. According to Okoro (2014), Customers in Nigeria use automated teller machines (ATMs), Point-Of-Sale terminals (POS), and the Internet services to deposit money. Following the initial cornerstones of electronic finance, electronic banking and internet automated teller machines (ATMs), expanded proliferation and integration of mobile banking and Internet banking has brought a new delivery platform to retail banking: Internet/Online-banking (Peter et Al, 2016). After Asia-Pacific, Africa has become the world's second-fastest-growing market for electronic payments.

Furthermore, about 40% of Africans now choose to conduct banking transactions via digital platforms (Moses, 2020). According to a report conducted by McKinsey and released in February 2018, the growth in mobile and digital banking is likely to exceed the banking sector's revenue forecasts on a continental scale, which were forecast to grow from \$86 billion in 2017 to \$129 billion in 2022 (Moses, 2020).

E. Impact of ICT on Transportation

When talking about the impact of ICT on transportation, we can consider two aspects. First, ICT can be used in transportation to optimize and boost operations. Second, widespread ICT usage may have an effect on transportation and mobility demand, both in terms of volume, spatial and temporal distribution. ICT has a major impact on current and future mobility. When consumers switch between regions and states, ICT applications such as wireless technology may be accessible to them as electronic networks. ICT often affect the real flow of goods and persons, giving the mobility issue a clear, physical component in the context of transportation and logistics. Cities are spreading more widely as decentralization occurs. Innovation and upgrade in transportation, may be a key element in making this phase go more smoothly. Public transportation and private transportation planning are more concerned with the effects on transportation activities than with transportation itself. In both cases, the aim is to improve the system's reliability. This is especially important in the case of public transportation, as the infrastructure must be seen as a unified collection of multimodal options with seamless transitions between modes of transportation. This criterion applies to not only the services rendered, but also information, schedules, and ticketing. Technology allows for a "seamless" transportation infrastructure if the user interface discussed here is paired with other efforts to prioritize public transportation within the system. (Wagner et al, 2003).

ICT can be used in the implementation of policies aimed at lowering travel demand, such as road pricing, as well as policies aimed at allowing more use of existing power, such as control technology. Many optional devices are also available for cars to provide the driver with updates on suggested routes to reduce delays and advance notice about road hazards. The aim was to offer direct incentives to the driver in the form of privileged information that was paid for in order to shorten journey times.

F. Impact of ICT on Phone Usage and Necessities

Over the last decade, mobile phone penetration in Africa has increased at breakneck speed. Less than 10% of Africans had access to cell phones in 1999, mostly in North Africa (Algeria, Egypt, Libya, Morocco, and Tunisia) and South Africa (GSMA, 2012). By 2008, 60 percent of the world (477 million people) had access to a signal, and cell phone coverage covered an area of 11.2 million square kilometers—equivalent

to the United States and Argentina combined (ITU 2009). Jenny and Isaac (2010) stated that the widespread growth of cell phones has sparked a lot of excitement and hope about their effect on Africa's economic progress. Along the same vein, an article in *The Economist* (2008) reported: "A computer that was once a yuppie toy has now become a formidable force for economic growth in the world's poorest countries". Nigeria has one of the largest populations of internet users in the country, with smartphones accounting for 74% of online traffic and PCs accounting for 24%. This is due to the fact that smartphones are much more affordable and comfortable than PCs, and with the advent of 4G/5G networks, they provide almost the same internet speed (Johnson, 2021). In rural Africa, where cell phones were often the first digital telecommunications networks of any sort, these results may be especially drastic. Mobile phones have significantly lowered contact costs, enabling individuals and businesses to send and receive information on a range of economic, social, and political issues easily and cheaply. In particular situations and nations, a growing body of research suggests that the decrease in connectivity costs associated with cell phones has real economic benefits, improving agricultural and labour market productivity, as well as producer and consumer welfare. (Aker, 2008; Aker, 2010; Klöner and Nolen, 2008).

Mobile phones can increase information access and usage, lowering search costs, enhancing agent teamwork, and increasing business performance. Second, by helping companies to properly control their supply chains, improved collaboration could boost their productivity. Third, cell phones generate new employment in rural and urban areas to meet the need for mobile-related utilities, resulting in income-generating opportunities. Fourth, cell phones will make it easier for social networks to communicate in the event of a disaster, lowering household danger. Finally, cell phone-based apps and development programs, dubbed "m-development" by others, have the ability to make banking, agricultural, health, and educational resources more available.

III. DISCUSSION

A. The Future ICTs – Internet of Things

ICT futurists find it difficult to foresee what we might face in the future because the future of ICT and its effect on our culture is too vast. This can be due to the fact that technology evolves at a rapid pace. The impact of futurists like Gordon Moore, the creator of Moore's law, is now being felt. A lot of engagement can be anticipated with how ICT affects everyone socially, ethically, and economically in areas such as education, entertainment, growth, governance/politics, and industries, among others. Green computing, cloud computing, ubiquitous computing, and the Internet of Things (i.e. the future internet) are examples of emerging ICT technology that will drive our world forward. Over the next five years, almost

\$6 trillion will be spent on IoT solutions. The Internet of Things has the power to change the way we work and live. The IoT's universal adoption will take time, but the clock is ticking. According to another recent projection, up to 28 billion devices will be connected to the Internet, with two-thirds of those being other "devices" – cameras, terminals, home appliances, thermostats, televisions, cars, construction machines, urban networks, and a variety of other "things" that have not previously been connected to the Internet. (Banafa, 2016).

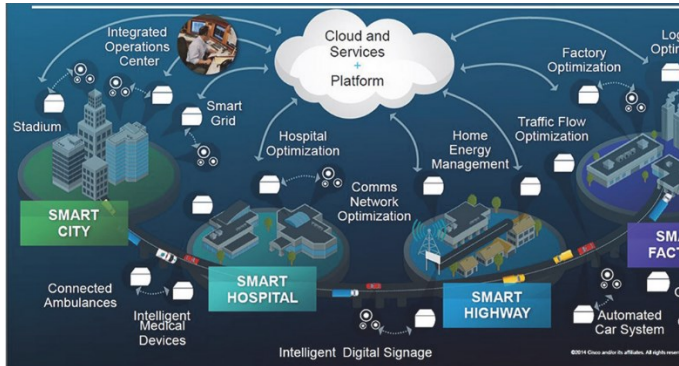


Figure 2: Use of IoT in Everyday Applications Source: Cisco

Although the Internet of Things is still in its infancy, its applications will expand rapidly in the coming years as more and more sensors become linked, opening up new possibilities for smart product innovation. Many innovations, such as Augmented Reality (AR), Industrial IoT (IIoT), Edge computing, and Low Power Wide-Area (LPWA), have been launched in the last few years, and they will form the next stages in IoT growth. AR allows IoT data to be visualized as text, graphs, photographs, and videos on a smartphone, tablet, or smart glasses. The majority of AR applications today are aimed at consumers. When AR technologies are combined with IoT and other device data, the system will be used in business markets in the near future. (Mohsen, 2017).

B. *IoT and African Societies*

Areej (2018) pointed out that IoT adoption could lead to multiple privacy and security issues and majority of the top 10 countries with the world's worst internet access belong to the African continent, Africa faces major barriers to the adoption of IoT. Despite having an internet penetration rate of 16%, there is high potential for development. According to McKinsey, by 2025, Africa's internet penetration would have tripled to over 50%, or about 600 million citizens. Although Africa is comparatively slow in adoption of technology, this lack of infrastructure enables its cities to adopt IoT more easily. (Maryleen et al, 2015). Taking these hurdles into consideration, Africa will need to first pursue an enabling policy and take advantage of IoT applications tailored to the continent's unique needs. First, there can be no IoT without data. Therefore, stakeholders and policy makers should intervene in the cost of data purchase, reducing them to a bare

minimum in order to maximize IoT adoption, as India has done (BBC, 2019). There are several indications that a major rollout of IoT in Africa would be successful, mainly revolving around the changing cost of devices and the introduction of emerging technologies to manage the connectivity and data processing elements of IoT. These include the advent of big data analytics, lower computing costs, lower sensor bandwidth costs, widespread mobile use, clean energy, ultra-low power technologies, and wireless networks (such as Wi-Fi) being less expensive and more available (Anish et al, 2020).

C. *Effects of IoT Across Industries in Africa*

The Internet of Things shows promise of improving people's lives and society as a whole. In the transportation industry, it could lead to a reduction in the number of deaths caused by driving. Sensors can be used to remotely identify collisions, support requests, and provide emergency responders with the location of the vehicle (Chris et al, 2010). Users' mobile phones can be used to track traffic congestion, and surveillance reports such as live highway robbery sensors and safe zone coordinates can be used to make goods and people transportation secure (Nomusa, 2016). If containers can self-scan and weigh themselves, transportation firms can become more effective in packaging containers. The use of IoT technology in airports and airline operations would allow for automated monitoring and sorting, improved per-bag read rates, and increased protection. Companies in the logistics industry could use traffic signals, road congestion data from cameras and sensors, and early weather forecasts to make regular route changes for their delivery trips. This cross-domain data could be able to assist them in improving transmission efficiencies and lowering total latency costs (Friedemann et al, 2010).

ICT can transform education by increasing student engagement and allow teachers to do their work more efficiently. Instead of sharing information by writing letter by letter on a chalkboard, teachers can share lecture notes very quickly through an IoT device. The same smart device can enable classmates and teachers to work collaboratively and share knowledge from any location. Daily activities such as attendance can be eliminated by the introduction of sensors that identify the presence of students in the school automatically (Kassab et al 2019). In Africa, it is not presently viable to have smart homes in most houses but smart cities are realizable. Cities can conserve electricity by using intelligent street lamps that dim depending on atmospheric conditions. They also collect data including ambient temperature, visibility, rain, GPS location, and traffic densities, which can be fed into applications that control road construction, traffic monitoring, and neighborhood mapping. Travelers can also receive real-time updates via smart devices or display boards. Smart traffic lights, which use cameras at every signal and stage, can increase the city's average speed. Furthermore, the

use of street cameras reduces crime and emergency response times. (Maryleen et al, 2015)

Additionally, although the healthcare sector has already benefited from IoT, areas where IoT can assist continually emerge as technology develops. The use of medical body monitors to track critical body conditions such as pulse, temperature, and sugar levels allows for continuous and remote patient monitoring. Smart pills, ingestible sensors that can monitor a variety of physiological measurements, can send data to the sensor on the body. This data can be used by an application to analyze the actual status of the patient's health for any anomalies and then determine if the patient will have any health complications in the future. Doctors would be able to track, assess, and leverage this information by using their mobile devices. Furthermore, tracking of drugs from manufacturer to patients and of hospital equipment and instruments is feasible. Finally, IoT can expand the wellness program to include lifestyle and fitness monitoring. (Pijush et al, 2018; i-Scoop, 2020). In the defense sector, the use of IoT devices can save lives. African armies can combat terrorist organizations by using linked drones to get photographs of the battlefield without putting their troops at risk. Thousands of photographs of a hazardous area can be sent by a drone with a connected camera over a long distance. Internal monitoring of security threats such as abduction, pipeline theft, armed robbery, hijacked peaceful protests, and so on can all be done from the same drone. (Maryleen et al, 2015). Lastly, IoT can help nomadic communities. For example, a Fulani herder can watch the movement of his cattle in real time via his cell phone, from the safety of his hut. He can use a forecast application to determine the best pasture area for his livestock and where to water them. Agricultural officials can keep track of nomadic groups' movements and make a timely call to community elders if they suspect trouble will arise, such as when herdsmen cross their borders and potentially resulting in clashes between community members.

IV. CONCLUSION

The Internet of Things provides for almost limitless possibilities and connections. Taking part in the Internet of Things revolution will have a significant effect on society and help address some of the world's most pressing issues. In some developing countries in Africa, applications like a smart toaster are neither feasible nor required. Commercial applications like precision irrigation, smart grids, and healthcare are more likely to be realized in Africa, with an emphasis on maximizing the use of finite resources. Furthermore, IoT applications affecting a wide cross-section of the population, such as precision medicine or irrigation and water control are more likely to have a direct socioeconomic effect. In order to enforce these applications, less consumer changes and mobilization are needed and the above implementations should be prioritized. All in all, the advent of IoT in Africa can have rippling effects on the quality of life

and work, propelling Africa to the forefront of the developing nations in terms of GDP and technological advances (Martin and Aminata, 2017).

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