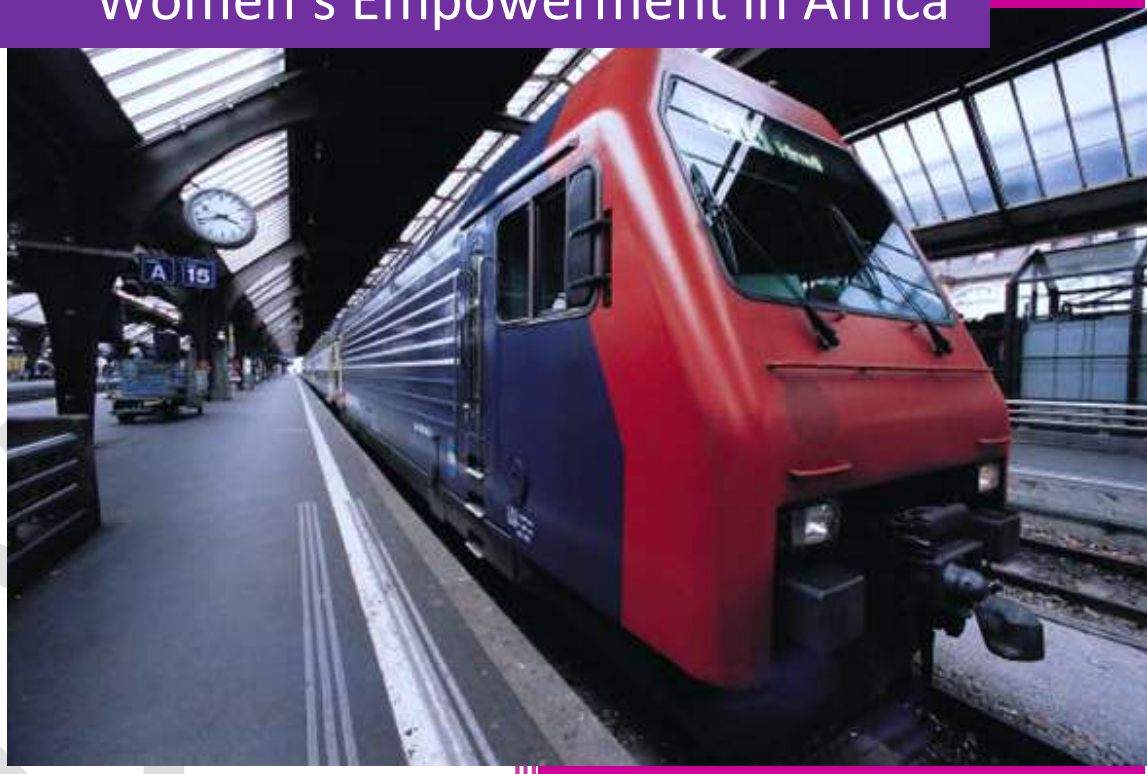
[DRAFT]

2022

Leveraging Digitalisation for Gender Equality and Women's Empowerment in Africa



Suggested capacity development programmes to digitally upskill women and girls in selected ECA member States

Africa

12/1/2022

Acknowledgements

The report was prepared under the dedicated support, leadership and guidance of Ms. Keiso Matashane-Marite, Officer-in-chargeof the Gender Equality and Women's Empowerment Section (GEWES), of the Gender, Poverty and Social Policy Division (GPSPD), United Nations Economic Commission for Africa (ECA).

The lead authors of the report are Mr. Syed T. Ahmed, Associate Economic Affairs Officer, GEWES, GPSPD and Ms. Kelly Hayden, Consultant, GEWES. Ms. Makopoi Nkopane Consultant, GEWES and Ms. Yosra Kalleli, Consultant, GEWES, provided significant contributions in drafting and research.

The report incorporates the considerations, outcomes and recommendations of an expert group, comprising of country representatives, United Nations agencies, the African Union Commission, civil society organizations, academia, private sector, as well as other development partners, whom held the Africa preparatory Virtual Consultation of the 67th Session of the Commission on the Status of Women, in November 2022. The theme of which is on "" . ECA provided a background document to inform meeting participants which comprised initial research, excerpt findings and recommendations from an earlier draft of this report.

The report was reviewed by Mr. Gonzague Rosalie, Economic Affairs Officer, GEWES, GPSPD and by the staff of the Economic Commission for Africa (ECA), namely, Mr. Mactar Seck and….

The following ECA staff provided editing as well as useful administrative and programme assistance to finalize the publication: Snober Abassi, Deborah Abebe, Angelique Kayetsiri and Hannan Mohamed.

The report team acknowledges with thanks the support of the Publications Section at ECA.

Contents

List of tables

List of figures

1.0 Introduction

Technological inequality is widening globally with those who are digitally connected reaping benefits while many remain excluded. The fourth industrial revolution is being forged by a number of emerging technologies that are playing a greater role in business and industry as well as life and society. These include artificial intelligence (AI), the Internet of things (IoT), big data and analytics, 5G, 3D printing, robotics, blockchain, and nanotechnology, just to name a few. While innovations in their own right, all these technologies rely on the principal foundation of computer data exchange between electronic components, which is essentially the internet at a macro-level. Understanding common internet exchange, the ubiquitous modern devices connected to this global network, and the primary activities that take place on this omnipotent medium, is essential in conquering technology fears and harnessing the potential of the digital revolution.

Africa is the region with the lowest proportion of internet users, at 33 per cent in 2021, compared with a global average of 63 per cent. Such disparities exacerbate inequalities in wealth, income, opportunity, education and health. While internet use is moving closer to gender parity across the world, internet use among the female and male population in Africa stood at 24 per cent and 35 per cent respectively. According to the International Telecommunication Union (ITU), the digital gender divide is slowly decreasing in Africa, with the internet user gender parity score moved up from 0.58 in 2018 to 0.67 in 2020. However, this score is still the lowest among all regions, with women less likely than men to own or use mobile phones every day, or to have phones with access to the Internet.

The COVID-19 pandemic has increased reliance on ICTs, digitalization and the use of online platforms to conduct business transactions, learning and development activities as well as everyday interactions. Many countries have taken this opportunity to explore digital solutions for women and girls and integrate them into these digital spheres. This imposed embracing of digital solutions, due to the pandemic, has altered structural inequalities causing a paradigm shift in favour of gender equality. It has created spaces for women and girls to participate in society and public life, accelerated their integration into the digital revolution and is helping to address gender digital divides.

However, women and girls can face many hurdles when trying to harness ICT to improve their lives, from cultural attitudes to poorly designed software or programmes. Particularly in rural areas, women are often left with heavy domestic responsibilities such as fetching water, cooking, caring for children and the elderly, and undertaking agricultural work. On average, girls often attend less school than boys, often due to helping with laborious household tasks leading to lower rates of literacy. Young people, especially adolescent girls, face risks and threats that limit learning opportunities and challenge education systems. These include exploitative labour, the lack of employment, conflict and violence, drug abuse, school-age pregnancy, and HIV/AIDS.

Women can face higher hurdles than men in starting or owning an entrepreneurial endeavour, often struggling to combine family duties, and generating additional household income[1]. Having the time to learn about ICTs and how to use them effectively to support their work can be a serious challenge.

[1] OECD. 2018. Bridging the Digital Gender Divide: Include, Upskill, Innovate.

From a cultural perspective, women may feel uncomfortable visiting cybercafes or telecentres if attitudes lean towards these places being frequented mostly by men or are in areas that may be considered uncomfortable for women to travel. When first obtaining technologies in the household, such as a mobile phone, the man may claim this for his purposes even though it may make the many chores for a woman easier. Attitudes that women may be harassed or exposed to a perceived risk of unsolicited calls from men are another reason why access to phones may be limited. Other perceptions about women, such as their traditional roles at home, may also limit their ability to access ICT technologies or training[2].

The cost of owning and using a mobile phone is one of the most important barriers[3]. Women are often likely to earn less than men so are less likely to buy ICT hardware of pay for training, if available. If there is only one mobile phone in the household, women may only have access to it during certain times of the day or week. The lack of identification documents to register for a phone may be a challenge for some women, with one estimate in Nigeria indicating that eight million fewer women than men have a national ID[4].

Challenges can also develop when initiatives are developed for improving access to ICTs for specific purposes. Such initiatives often consider the beneficiaries of the sector, for example agriculture, as a homogeneous group and don't take the differences between men and women into account. Furthermore, initiatives that exclusively target women can be just as damaging. Designing initiatives to support access to ICT requires careful consultation between men and women to ensure it provides the service needed in an inclusive manner. For example, content that is not in local languages has been implicated as a greater barrier for women and girls than for men[5].

It is vital to give women equal rights land and property, sexual and reproductive health, and to technology and the internet. Today there are more women in public office than ever before but encouraging more women leaders will help achieve greater gender equality. Globally, women do not earn high positions in the public or private sectors in the numbers that could be expected despite their improved and advanced education and work experience. Gender legislation in some of the African countries still does not allow women to obtain equal pay or access decision-making and leadership positions in significant numbers. The number of women receiving higher education is more relevant to their ability to enter higher positions at work. In all regions, it is the registration of women at this level increased the most. The number of women enrolled in Africa varies from region to region and from one educational sector to another. This representation is due to the limitations and constraints, which have marked certain fields as male domains more than for women, such as the Science, Technology, Engineering and Mathematics (STEM) education sector.

Capacitating women and girls in the use of digital technologies will provide a range of skills to integrate them into the high-tech digital revolution. This digital upskilling would increase the critical mass of women and girls in STEM, shape the future job skill requirements for women and girls, and empower women to address sustainable development challenges.

---

[2] FAO. 2018. *Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development*, by Sophie Treinen and Alice Van der Elstraeten. Rome, Italy.
[3] GSMA. 2022. The Mobile Gender Gap Report 2022.
[4] Jarrahi. J. (2021). Massive gender disparities in digital ID systems persist.
[5] UNICEF. (n.d). What we know about the gender digital divide for girls.

In this regard, the aim of this report is to provide an overview of the progress of five African member States that are more advanced with respect to digitalization - Mauritius, Nigeria, Seychelles, Tunisia and South Africa. The report will present examples of how ICT can drive development and create opportunities, particularly for women. It will also provide a general overview of the status of each country with respect to digitalization and how ready the population is to embrace it.

The first section of this document will provide an overview of key socio-economic factors relevant to being able to access digital tools and services, along with the challenges faced, particularly for women. The digital capability and capacity for each country will be reviewed, considering education and the populations' capacity to use ICT, followed by the infrastructure and services available. Government policies and institutions are important for creating an environment that enables access to digital services, but also protects users from exploitation and cybercrimes. Therefore, an overview of government policies and institutions in each country will be reviewed.

The potential benefits to people's livelihoods the countries in general will then be illustrated using several specific examples, from the emergence of mobile applications and software, digital platforms and content, the use of space applications and drones, and the rise of digital finance options. These examples will particularly focus on how women and girls can benefit from these tools and information wherever possible.

2.0 The status of digitalisation and an enabling environment: digital capacities and capabilities

2.1 Social and economic conditions

Though access and use of ICTs is improving, various basic conditions can be challenging. The location of a person in proximity to a service provider, the cost of the service, the capacity of a person to use devices, including the literacy rate of the population, are just a few factors that could be barriers. Some of these factors will be reviewed in this section for the five target countries.

Generally, ICT services have been available in cities, but have been taking longer to extend to rural areas. The population of each country over time is presented in table 1, with the percentage of people living in rural areas over time in table 2. Though population size differs dramatically for each country, it has been steadily growing for the past 20 years, with Nigeria's population growth being the most significant, and Mauritius being much steadier. When viewing the per cent of rural versus urban population though, with the exception of Mauritius, the rural population of most countries has been steadily decreasing as urban areas expand and people migrate to cities seeking better employment or services.

Table 1: Total population, 2001 - 2021

	Population, total		
	2001	**2011**	**2021**
Mauritius	1,196,287	1,252,404	1,266,060
Nigeria	125,394,046	162,805,080	211,400,704
Seychelles	81,202	87,441	99,202
Tunisia	9,793,915	10,741,872	11,935,764

South Africa	45,571,272	52,003,759	60,041,996

Source: World Bank

Table 2: Per cent of population in rural areas, 2001 - 2021

Rural population (% of total population)			
	2001	**2011**	**2021**
Mauritius	57.4	58.6	59.2
Nigeria	64.3	55.6	47.3
Seychelles	49.4	46.3	42.0
Tunisia	36.2	33.1	30.1
South Africa	42.6	37.3	32.2

Source: World Bank

The cost of owning and using a mobile phone is one of the most important barriers for women in particular[6]. Women are often likely to earn less than men, so are less likely to buy ICT hardware or pay for training, if available. Poverty is therefore a factor that will exacerbate the digital divide.

Table 3 provides an overview of poverty for the five countries reviewed in this report. It shows that extreme poverty is minimal in Mauritius, the Seychelles and Tunisia, while Nigeria and South Africa do still have a relatively larger proportion of their population below the $3.65 a day poverty line.

Table 3: Poverty gap at $2.15 and $3.65 a day for five African countries

	Poverty gap at $2.15 a day (2017 PPP) (%)	Poverty gap at $3.65 a day (2017 PPP) (%)	Year
Mauritius	0	0.3	2017
Nigeria	9	25.1	2018
Seychelles	0.1	0.4	2018
Tunisia	0	0.4	2015
South Africa	6.9	16.6	2014

Source: World Bank

One study on the welfare impacts of mobile broadband in Nigeria indicated that mobile broadband coverage had large and positive effects on household consumption of food and non-food items over time. With one year of broadband coverage, consumption increased by 5.8 per cent – 6.2 per cent for food and 6.3 per cent for non-food consumption. After two years, consumption increased 7.8 per cent for food and 6.1 per cent for non-food. For households in extreme poverty, one year of mobile broadband coverage improves their circumstances by 4.3 per cent on average, with this climbing to 6.9 per cent by the second year. The study speculates that these improvements are mainly due to an increase participation in labour force and employment, particularly for women[7] as poverty often correlates with informal income or vulnerable employment.

[6] GSMA. 2022. The Mobile Gender Gap Report 2022.

[7] Bahia. Kalvin and Others. 2020. *The Welfare Effects of Mobile Broadband Internet: Evidence from Nigeria*. Policy Research Working Paper 9230. World Bank.

Vulnerable employment is defined by ILO as "contributing family workers and own-account workers as a percentage of total employment[8]". This portion of the population is less likely to have formal work arrangements, may have inadequate earnings, difficult working conditions, and a general lack of social security[9].

According to the International Labour Organization, the percentage of people in vulnerable employment for most of the countries in 2019 is less than 20 per cent, though this is still a significant number of people. In table 4 it can be seen that almost 80 per cent of the population in Nigeria is employed in vulnerable occupations.

Table 4: Vulnerable employment, 2019

	Per cent of total employment	Per cent of female employment	Per cent of male employment
Mauritius	16.11	12.1	18.58
Nigeria	79.57	85.21	74.87
Senegal	62.8	69.8	58.1
Seychelles	NA	NA	NA
Tunisia	18.93	11.47	21.29
South Africa	10.67	10.59	10.73

Source: Modelled ILO estimate

The proportion of the vulnerable population is often self-employed in agriculture, which covered almost 35 per cent of the employed population of Nigeria in 2019 (refer to table 5). Table 6 shows that agriculture still contributes around 22 per cent of the GDP of the country in 2019, which rose to 23 per cent in 2021. Tunisia had the next highest number of people employed in agriculture at a little under 14 per cent in 2019, where its contribution to the country's GDP was slightly less than 10 per cent, dropping in 2021. For Mauritius and South Africa, employment in agriculture is much lower, at around five to six per cent of the population. No data was available for the Seychelles but given the small contribution of agriculture to the country's GDP, it's likely that employment in agriculture is low. Though the percentage of women employed in agriculture is less than men in each country, women still make up a significant portion of the workforce, particularly in Nigeria (refer to table 5).

Table 5: Employment in agriculture, 2019

	Per cent of total employment	Per cent of female employment	Per cent of male employment
Mauritius	5.97	3.93	7.23
Nigeria	34.97	23.57	44.48
Seychelles	NA	NA	NA
Tunisia	13.8	8.96	15.32
South Africa	5.28	3.79	6.46

Source: Modeled ILO estimates

[8] Find reference from ILO. This one came from World Bank based on ILO data.
[9] ILO

Table 6: Contribution of agriculture, forestry, and fishing to the GDP (value added % of GDP)

	1999	2001	2009	2011	2019	2021
Mauritius	5.00	6.15	3.88	3.70	2.90	3.76
Nigeria	26.03	24.48	26.75	22.23	21.91	23.36
Seychelles	3.10	2.83	2.26	2.22	2.65	2.24
South Africa	2.85	2.81	2.40	2.04	1.96	2.43
Tunisia	10.61	9.42	8.46	7.58	9.64	9.15

Source: Reference

2.2 Education and skills

To answer the challenges of the 21st century, education in science, technology, engineering and math (STEM) is reinforced to be one of the motors of the society and countries' development. The 2030 Agenda for Sustainable Development, adopted by the United Nations General Assembly in 2015, underscores the crucial role that science and technology play in finding innovative solutions for making progress toward a more sustainable, prosperous, and equitable planet. In particular, Sustainable Development Goal 4, "Ensure inclusive and quality education for all and promote lifelong learning", and its targets, emphasizes the relevance of STEM to forge sustainable development and sustainable lifestyles. STEM in education has the aim of preparing students to be competitive and ready to work according to their preferred fields.

Women have always had a strong presence in education, whether as students or teachers, but an analysis of their participation in this sector shows that they occupy an inferior position that both reflects and helps perpetuate women's inequality in society. The African Gender Index relating to STEM education was only 37.9 per cent for the 20 countries where it was measured, indicating a significant imbalance in favour of men undertaking education in this field, and consequently in STEM careers. While girls are just as capable as boys of excelling in STEM, cultural expectations in households, schools, colleges and workplaces, along with environmental circumstances and levels of support, discourage girls from studying these subjects[10]. In 107 out of 114 countries, women are under-represented among STEM graduates, with less than 4 women of 10 men[11]. Worldwide, women represent only 35 per cent of students pursuing STEM fields in higher education[12]. It is in poor countries where such talent is most needed and yet where women are most underrepresented. Worldwide, less than 30 per cent represents the number of women of scientific researchers[13]. This is also the case in high-tech domains such as artificial intelligence (AI), women represent 29 per cent of the workforce in the AI sector in the African continent, and only 10 per cent of executive positions are taken by women[14].

However, according to the latest report compiled by Times Higher Education (THE) and the United Nations Scientific, Cultural and Educational Organization (UNESCO), 47 per cent of African universities' science, technology, engineering and mathematics graduates, undergraduates and postgraduate levels are women. This means Africa now has highest proportion of female STEM graduates, though women are still

[10] African Development Group and United Nations Economic Commission for Africa, Africa Gender Index Report 2019, March 2020.
[11] World Bank Blog
[12] Gender Responsive STEM Education, UNESCO Education sector, Education 2030, ED/ESC/IGE/2019/01 Rev, on.unesco.org/STEMinitiatives.
[13] Op.cite.
[14] Study of the Strathmore University

underrepresented in the ICT sector. The gender gap in STEM is also a missed opportunity for economies and an inefficient allocation of labour and talent.

The percentage of females graduating from tertiary education engineering fields was below 30 per cent for many Sub-Saharan African Countries, among them South Africa. Consequently, scientific work and technological innovation are missing women's perspectives and critical contributions. This also means that most women will remain in jobs that are likely to be replaced by technology on lower pay grades or less economically impactful in an increasingly technology-driven world. Female participation in the labour market in STEM fields also trails behind that of men: only seven per cent of all engineers in South Africa today are women[15].

However, education in STEM begins from an early age, and a basic education and level of literacy is the first step. For the countries covered by this report, good progress has been made. Mauritius has a compulsory primary and secondary education system which enables enrolment for both male and female students, resulting in high literacy rates which can be seen in tables 7 and 8. Women tend to occupy more tertiary education spaces though, possibly marking progress in empowering women. The island is also constantly evolving in the digital world. The Government of Mauritius has a Digital Mauritius 2030 Strategic Plan and therefore places importance on building the digital capacity of young people. Basic ICT training is becoming part of the curriculum and educational tools and facilities are being upgraded to support this digital shift[16]. The government is also working on expanding the culture of e-education with training at all levels (including management) and coverage of ICT in Sciences.

Table 7: Literacy rate, youth (% of ages 15-24)

	Total	Female	Male	Year
Mauritius	98.1	98.6	97.7	2011
Nigeria	75.0	68.3	81.6	2018
Senegal	69.5	63.5	75.6	2017
Seychelles	99.1	99.6	98.6	2018
Tunisia	96.2	95.8	96.6	2014
South Africa	98.4	98.8	98.0	2019

Source: World Bank

Table 8: Literacy rate, adult (% ages 15 and above)

	Total	Female	Male	Year
Mauritius	93.2	91.0	95.4	2016
Nigeria	62.0	52.7	71.3	2018
Senegal	51.9	39.8	64.8	2017
Seychelles	95.9	96.4	95.4	2018
Tunisia	79.0	72.2	86.1	2014
South Africa	95.0	94.5	95.5	2019

Source: World Bank

[15] UNESCO South Africa
[16] FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/cb7943en47

In South Africa, the literacy rate is quite high for both adults and the youth (see tables 7 and 8). The per cent of graduates from tertiary STEM programmes in 2020 was 17.4 per cent, though in 2022, only 13 per cent of STEM graduates were women in South Africa. 50.3 per cent of girls compared to 58.6 per cent of boys achieved 30 per cent or higher in Mathematics in the National Senior Certificate Examination (UNESCO).

Despite the low numbers of women in tertiary STEM education in South Africa, efforts are being made to change the disparity. For example, the Taungana or 'coming together' programme creates opportunities in STEM for selected secondary girls. The girls receive mentoring and make contacts with different organisations by attending Taungana's annual STEM expo event. They also promote STEM in their own communities and countries[17]. Tables 9 and 10 show the gender parity index related to tertiary school life expectancy and gross enrolment ratio for some of the countries of focus in this report. The gender parity index indicates the ratio of male to female enrolment or education, with an indicator of one describing balance between male and females. A figure less than one generally indicates inequity in favour of men, while above one indicates disparity in favour of women. In South Africa there is general parity in the gross enrolment ratio, slightly in favour of women, while school life expectancy for women seems to be more favourable.

Table 9: School life expectancy, tertiary, gender parity index (GPI)

	2018	2019	2020	2021
Mauritius	..	..	1.46	..
Nigeria	..	..	..	..
Seychelles	2.13	2.32	2.48	3.74
South Africa	1.45	1.47	1.54	..
Tunisia	1.81	1.85	1.85	..

Source:

Table 10: Gross enrolment ratio, primary to tertiary, gender parity index (GPI)

	2018	2019	2020	2021
Mauritius	..	..	..	..
Nigeria	..	..	..	..
Seychelles	1.17	1.19	1.16	1.23
South Africa	1.05	1.05	1.05	..
Tunisia	..	..	..	..

Source: http://data.uis.unesco.org/Index.aspx#

For the economy, it is estimated that 90 per cent of South African businesses are undergoing digital transformation requiring a large pool of skilled ICT experts[18]. To realize the Government's goal of initiating a fourth industrial revolution to produce a digital society, the most needed skills indicated by the Department of Higher Education and Training in South Africa in 2020 were data scientists, web developers, electrical engineers, crop produce analysts and agricultural scientists. Furthermore, they consider

[17] UN women, (2016), Gender Forum-Pushing to Parity in Science, Technology, Engineering and Mathematics (STEM) at Kenya National Theatre

[18] FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/cb7943en47

artificial intelligence, big data, cybersecurity, digital modelling, internet of things (IoT), machine learning, and robotics as areas of significant growth. One study estimates that digitization could produce more than one million jobs by 2030[19].

From tables 7 and 8 it can be seen that literacy levels in Nigeria are quite low, with 62 per cent of literate adults in 2018, with only 52.7 per cent of women literate compared to 71.3 of adult men[20]. Youth between the ages of 15 and 25 have a higher literacy rate of 75 per cent, with 68.3 per cent of women that age being literate still lower than the 81.6 per cent of young men. Even though school attendance is free and compulsory by law in Nigeria, around 10.5 million children do not attend[21]. In the southern areas of Nigeria, 9 out of 10 women are literate, though for the northern areas only 4 out of 10 are literate, with some states having only 3 out of 10[22]. Several social, economic and security issues have resulted in limited public funds to support adequate education, with only 1.4 per cent of the GDP spent on education over the last three years, well below four to six per cent recommended under the UNESCO's Education 2030 Framework for Action[23]. Even though education is free, low public funding has meant that parents have had to support their children's education, which is challenging for poorer communities. Other reasons for a low attendance are distance to school and a lack of interest in school[24].

A number of initiatives have been initiated by NGOs, international organizations and the Government to support better education, even for ICT. For example, a government supported programme called Knowledge for Development without Borders has been providing ICT training to underprivileged youths with the support of the private sector[25]. However, without improved attendance at school for basic education, improving digital literacy for a skilled workforce for the future will be a challenge.

The question of STEM education teaching has been a major concern of considerable reflection in Senegal for two decades including external contributions, particularly in the context of inter-African exchanges. In a developing country like Senegal, there is probably nothing left to demonstrate and no one to convince about the importance of the role of science and technology in the socio-economic development process of a nation. On the other hand, we must emphasize the gap that generally exists between the recognition of this role through rhetoric, declarations, and political discourse and what is practically implemented in the educational system.

However, in recent years, Senegal has recorded an increase in the availability of STEM courses in higher education as part of its emphasis on tertiary education, the Plan Senegal emergent (PSE) has set a target for 50 percent of students to follow STI disciplines[26]. Nonetheless, the inclusion of STEM in the education system in Senegal was a challenge due to several reasons. The shortage of teachers and laboratory

[19] Nomfanelo Magwentshu, Agesan Rajagopaul, Michael Chui, and Alok Singh. 2019. *The future of work in South Africa: Digitisation, productivity and job creation*. McKinsey and Company.
[20] World Bank Indicators available from https://data.worldbank.org/ (accessed 16 September 2022)
[21] IIEP-UNESCO (2021). *Nigeria Education Sector Analysis 2021*. Available from https://dakar.iiep.unesco.org/en/news/nigeria-improving-free-quality-basic-education-tight-budget (accessed December 2022).
[22] UNICEF (2017). UNICEF Nigeria Equity Reports. Fact sheet on *Education: Literacy among young women*.
[23] IIEP-UNESCO (2021). *Nigeria Education Sector Analysis 2021*. Available from https://dakar.iiep.unesco.org/en/news/nigeria-improving-free-quality-basic-education-tight-budget (accessed December 2022).
[24] IIEP-UNESCO (2021). *Nigeria Education Sector Analysis 2021*. Available from https://dakar.iiep.unesco.org/en/news/nigeria-improving-free-quality-basic-education-tight-budget (accessed December 2022).
[25] FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/cb7943en47
[26] FINAL TECHNICAL REPORT / RAPPORT TECHNIQUE FINAL SENEGAL PE2 CASE STUDY - MAY 2020

technicians is a major concern in teaching a new major. Teachers receive insufficient training during their initial training on the methodology and scientific awareness. In most disciplines, not all teachers have received the same training, both theoretical and pedagogical. The lack of material resources is also a challenge and many institutions do not have adequate infrastructure including equipment and other resources. For the few that do, the impact of these resources on the quality of teaching is not encouraging. The Senegalese education system has established a number of gender considerations in STEM education-taking into consideration the necessity to raise the awareness of girls and women prior to university from an early age and through secondary school about career opportunities for women in the STEM field in Senegal. While these efforts ought to mainly remove the obstacles facing young girls and parents towards the STI and STEM fields[27], much more needs to be done to address the multiple obstacles existing.

Seychelles has a high literacy rate at 95.9 per cent of adults and 99.1 per cent of youth literate in 2018. For women and girls, the rate is 96.4 per cent for adults and 99.6 per cent for young women, which is slightly better than young men[28]. From secondary school some basic digital skills are taught, and improvements have been made in connecting schools to the internet. However, teachers specialized in digital skills are lacking[29]. To further illustrate the underrepresentation of women and girls graduating in STEM programmes in Seychelles only 8 per cent were women at tertiary level compared to 38 per cent men in 2020[30]. However, from table 9 it can be seen that the gender parity index for tertiary school life expectancy is quite high, and therefore favourable for women. The Seychelles National ITC Policy contains a section on building the human capacity in ICT[31] and in 2019, several schools introduced STEM programmes[32].

Tunisia records a high literacy rate of 89.62 per cent of male adults while lower for female adults at 74.24 per cent. For the youth however, literacy rates are 98.35 and 97.76 per cent for males and females respectively. The overall youth literacy rate was 98.06 per cent in 2016.

Tunisia ranks second in the world in terms of the percentage of women graduates in higher education in STEM[33] with women occupying more tertiary education spaces at 43 per cent in 2021, compared with men at 23.2 per cent[34]. Tunisian women have played a vital role in building the next generation of equitable Artificial Intelligence systems and STEM education programs. However, fewer women still go into scientific studies. Women recorded 65 per cent of all graduates in 2020-2021 (152,320 from a total of 232,614), with 86 per cent in science, 61 per cent in mathematics, and 43 per cent in engineering[35].

The Ministry of Higher Education and Scientific Research in Tunisia has developed and implemented a reform in the education system since 2007 called ''The school of Tomorrow'' and was championed by the guiding principles for schools and institutions to include gender equality in the different education programmes. The aftermath of the revolution saw some improvements to the educational system, with

[27] Op.cited, National Case study report of Senegal, International Development Research Center, May 2022.
[28] World Bank Indicators available from https://data.worldbank.org/ (accessed 16 September 2022)
[29] Republic of Seychelles, 2019 (reference not found) FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/cb7943en47
[30] DataReportal, (2021), Digital 2021: The Seychelles, https://datareportal.com/reports/digital-2021-seychelles
[31] Seychelles, (undated) *National ICT Policy*. Available from https://www.ict.gov.sc/homecnt/policies.aspx (accessed November 2022).
[32] https://www.nation.sc/articles/980/two-more-schools-embrace-stem-programme
[33] World Bank, 2015 to 2017
[34] UNESCO institute for statistics
[35] Statistics Report, Ministry of higher Education and Scientific Research of Tunisia, 2020-2021.

an increased annual budget and the formulation of different political initiatives, aiming at reforming the education system, improving teachers' training, upgrading curricula, including of gender equity, and providing better infrastructure. The government has also been working collaboratively with civil societies organizations to promote STEM education. For example, the First Skills Club is a Tunisian non-profit association that provides a high-quality teaching programme allowing kids to learn and communicate in English via STEM education[36].

Despite all these efforts to improve education, particularly in STEM, there are still large gaps in ICT literacy. Though no data was available for Nigeria or Seychelles, table 11 provides an estimate of ICT skills in terms of basic, standard and advanced. Figure 1 provides a general description of what actions fall under each category.

Though almost a third of people in Mauritius was estimated to have basic ICT skills, only three per cent had advanced skills. For Tunisia, roughly a fifth of the population had basic skills around 16 per cent of people have advanced skills, possibly their efforts in STEM education. ICT skills in South Africa are quite low, with only 15 per cent estimated to have basic skills.

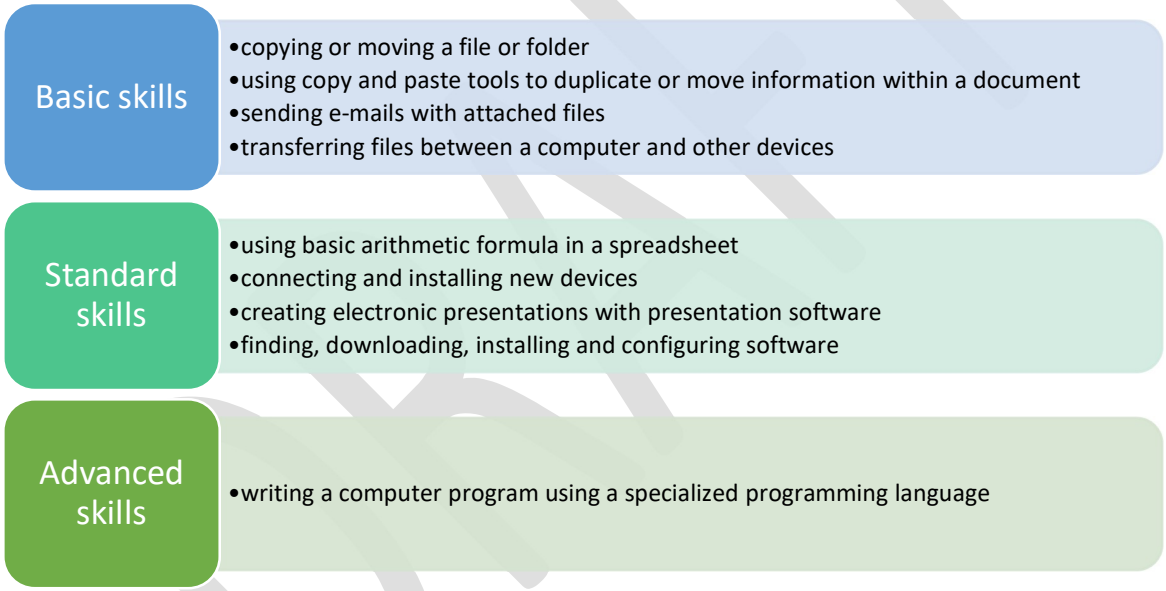


Figure 1: ICT Skill types and skills, as defined by ITU

Table 11: Level of ICT skill in selected countries

	Individuals with advanced ICT skills (%)	Year of data	Individuals with standard ICT skills (%)	Year of data	Individuals with basic ICT skills (%)	Year of data
Mauritius	3.0	2020	21.3	2020	32.5	2020
Nigeria	NA		NA		NA	
Seychelles	NA		NA		NA	
South Africa	5.0	2019	9.5	2019	15.0	2019
Tunisia	16.1	2019	17.1	2019	21.4	2019

[36] Reference

Source: ITU

ICT skills will be important for countries wanting to embrace the digital revolution, but without access to these services people won't be able to learn. Table 11 however only relates to computer skills and does not include one of the major sources of internet access in Africa – mobile phones. The next section will discuss ICT infrastructure and services, along with some key factors that affect their accessibility.

Table 12: Percentage of graduates from STEM education

Indicator	Percentage of graduates from Science, Technology, Engineering and Mathematics programmes in tertiary education, both sexes (%)						
Time	2016	2017	2018	2019	2020	2021	2022
Country							
Mauritius	..	23.3	..	..	21.6	..	..
Nigeria	..	..	..	..	..	..	..
Seychelles	16.2	15.7	17.2	19.9	28.8	19.8	..
South Africa	18.5	18.6	18.3	18.3	17.4	..	..
Tunisia	44.4	..	43.3	..	38.3	..	..

Source: World Bank

UNESCO Statistics Database available from http://data.uis.unesco.org/# (accessed 9 November 2022)

2.3 Infrastructure and services

Many countries in Africa have made significant advances in digital infrastructure development over the past decade. According to the International Telecommunications Union (ITU), 100 per cent of the population of South Africa was covered by a mobile cellular network in 2021, with Mauritius, Seychelles and Tunisia close behind at 99 per cent of the population covered. From table 13 it can be seen that Nigeria had achieved 93 per cent coverage by a mobile network in 2021[37], while both Mauritius and the Seychelles had 99 per cent of the population were covered by 4G. South Africa had 98 per cent of the population covered by a 4G network, while Tunisia and Nigeria had 96 and 62 per cent respectively covered. In Nigeria, 85 per cent of the population was covered by a 3G network at least[38].

Though the mobile network may cover the majority of these countries, the number of people actually owning a mobile phone to be able to access it varies, with close to 80 per cent of the population owning a mobile phone in Mauritius, South Africa and Tunisia in 2019 and 2020, and around 41 per cent of people in Nigeria (refer to table X). Mobile phone access in the Seychelles is thought to be quite high with an estimated 94 per cent of households having access to a phone, and the number of mobile connections equivalent to 176.9 per cent of total population, with many people having more than one mobile connection[39],[40].

When breaking this down further to the percentage of women and men owning a phone, data becomes less available. In Mauritius and Tunisia, slightly more of the male population owns a phone compared

[37] ITU, World Telecommunication/ICT Indicators Database available from https://www.itu.int/itu-d/sites/statistics/ (accessed October 2022).
[38] ITU, World Telecommunication/ICT Indicators Database available from https://www.itu.int/itu-d/sites/statistics/ (accessed October 2022).
[39] DataReportal, (2021), Digital 2021: The Seychelles, https://datareportal.com/reports/digital-2021-seychelles
[40] https://www.ict.gov.sc/ReportsStatistics/Reports.aspx

with the female population, though in South Africa the percentage of women owning a phone compared to men is slightly higher. No data on the per cent of women owning a phone is available for Nigeria, though for men, 49 per cent owned a phone[41]. Furthermore, according to the State of ICT in Nigeria 2018 report, men are more likely to own a smartphone than women, who are more likely to own a feature or basic phone[42].

Table 13: Population covered by mobile network

	Population covered by a mobile-cellular network in 2021 (%)	Population covered by at least a 3G mobile network in 2021 (%)	Population covered by at least a 4G mobile network in 2021 (%)
Mauritius	99	99	99
Nigeria	92.9	84.63	61.94
Senegal	99	99	83
Seychelles	99	99	98.5
South Africa	99.97	99.88	97.94
Tunisia	99	99	96

Source: ITU, World Telecommunication/ICT Indicators Database available from https://www.itu.int/itu-d/sites/statistics/ (accessed October 2022).

Table 14: Mobile phone ownership

	Individuals owning a mobile phone (%)	Year of data	Female mobile phone ownership as a % of total female population	Year of data	Male mobile phone ownership as a % of total male population	Year of data
Mauritius	79.4	2020	77.5	2020	81.3	2020
Nigeria	40.7	2017	NA		49.0	2017
Senegal	NA		NA		NA	
Seychelles	94 (households)*	2018	NA		NA	
South Africa	78.1	2019	79.7	2019	76.5	2019
Tunisia	80.0	2019	76.7	2019	83.4	2019

* Data is for households having a mobile phone, not individuals. Source: ITU, 2018

Source: ITU, World Telecommunication/ICT Indicators Database available from https://www.itu.int/itu-d/sites/statistics/ (accessed October 2022).

In comparison, household access to the internet varies significantly and tends to be much less than cellular coverage. Table X shows that in Mauritius, 73 per cent of households had access to the internet in 2020, while in South Africa and Tunisia, 63 per cent and 51 per cent of households had access in 2019

[41] ITU, World Telecommunication/ICT Indicators Database available from https://www.itu.int/itu-d/sites/statistics/ (accessed October 2022).

[42] Gillwald, A., Odufuwa, F., & Mothobi, O. (2018). *The State of ICT in Nigeria* (Policy Paper No. 3; Series 5: After Access – Assessing Digital Inequality in Africa). Research ICT Africa. https://researchictafrica.net/2018/12/19/the-state-of-ict-in-nigeria-2018/

respectively. Access to the internet at home in the Seychelles and Nigeria has been estimated at almost 58 per cent in the Seychelles in 2017, and 18 per cent for Nigeria[43]. Though a breakdown of data between rural and urban households with internet access is limited, for Nigeria and South Africa, where information is available, urban households are significantly higher than rural households (refer to table 15).

Table 15: Households with a computer and Internet access

	House-holds with a computer at home (%)	Year of data	House-holds with Internet access at home (%)	Year of data	House-holds with Internet access at home, rural (%)	Year of data	House-holds with Internet access at home, urban (%)	Year of data
Mauritius	48.7	2020	72.6	2020	NA		NA	
Nigeria	6.4	2018	17.8*	2017	2.4	2017	18.0	2017
Senegal	16	2018	7	2018	NA		NA	
Seychelles	58.7*	2017	57.9*	2017	NA		NA	
South Africa	22.7	2019	63.3	2019	42.7	2017	70.1	2017
Tunisia	52.1	2019	51.5	2019	NA		NA	

*ITU estimates from Measuring the Information Society Report 2018
Source: Reference

Though not everyone has the internet at home, many people are still able to access it with more than 60 per cent of individuals in Mauritius, Seychelles, South Africa and Tunisia using the internet in 2020, shown in table 16. Nigeria lags at around 35 per cent, possibly because it lacks a national backbone network for high-speed internet covering the entire country. As a result, the majority of internet access is through mobile networks (99 per cent in 2017) [44]. Limited data is available for the countries of focus under this study with respect to the gender breakdown, however the female and male population using the internet seems to be even in Mauritius, though in Tunisia women used it slightly less than men in 2019.

Table 16: Population using the internet

	Individuals using the Internet, total (%)	Year of data	Female Internet users as a % of total female population	Year of data	Male Internet users as a % of total male population	Year of data
Mauritius	64.9	2020	63.9	2020	65.9	2020
Nigeria	35.5	2020	NA		NA	
Senegal	43	2020	NA		NA	
Seychelles	79	2020	NA		NA	
South Africa	70	2020	NA		NA	
Tunisia	71.9	2020	61.1	2019	72.5	2019

Source: Needs reference

[43] ITU, World Telecommunication/ICT Indicators Database available from https://www.itu.int/itu-d/sites/statistics/ (accessed October 2022).
[44] Agboje et al., 2017 In GSMA, 2019 from Status of Digital Infrastructure in 47

The cost of internet and mobile services is one major factor that can cause inequity, particularly as women often earn less than men in many countries. Table 17 provides an overview of the cost of mobile and broadband data in each country based on purchasing power parity. Mobile data in Nigeria is much less expensive that fixed broadband, reflecting the limit of the broadband network discussed earlier. In the Seychelles, this is reversed with broadband being generally less expensive despite the high ownership of mobile phones in the country. Tunisia seems to have relatively less expensive ICT services which is likely to contribute to its higher mobile phone and internet penetration.

Table 17: Cost of internet and mobile services in 2021 (PPP)

	Mauritius	Nigeria	Senegal	Seychelles	South Africa	Tunisia
Data-only mobile-broadband basket (2GB)	15.11	8.94	8.44	43.67	22.82	10.29
Fixed-broadband basket (5GB)	27.52	96.12	54.46	22.02	47.22	27.28
Mobile data and voice high-consumption basket (140 min + 70 SMS + 2 GB)	26.69	17.58	16.89	77.42	53.16	15.86
Mobile data and voice low-consumption basket (70 min + 20 SMS + 500 MB)	20.4	14.9	9.29	38.02	23.95	5.89
Mobile-cellular low-usage basket (70 min + 20 SMS)	8.32	7.45	9.29	18.96	14.05	4.06

Source: ITU data

Overall, infrastructure development and basic education are the responsibility of the government, and the policy and vision of a government will have dramatic long-term implications on how people and countries will be able to harness the digital revolution. The next section discusses government institutions and policies relevant to ICT in the target countries, and how they plan to empower their people and countries to become digital societies.

2.4 Government institutions and policy

Several governments in Africa have developed policies and plans for a digital revolution and as these policies develop into regulation and initiatives, it will be important to ensure that they empower women and lead to gender equality, not exacerbate the situation.

In the Seychelles, the Department of Information Communications and Technology is tasked with the development of legislation, regulations and policies relating to telecommunication and related services. They are also responsible for the development of software for Government services, Government ICT infrastructure, collaboration with other agencies to support their ICT needs, radio communication management and planning, and the identification of the role of ICT in various ministries[45]. The National ICT Policy covers five broad areas: ICT infrastructure, the legal and regulatory framework, human resource

[45] Seychelles, Office of the President, Department of Information Communications and Technology. Available from https://ict.gov.sc/ (accessed September 2022).

development, industry and Government. It aims to promote the following vision: "A Seychelles that will be globally competitive, with a modern ICT enabled economy and a knowledge-based Information Society where strong, efficient and sustainable improvements in social, economic, cultural, good governance and regional integration are achieved through the deployment and effective application of ICT."[46]

In Nigeria, the Federal Ministry of Communications and Digital Economy[47] was created in 2011 (called the Ministry of Communication Technology at the time) to "facilitate ICT as a key tool in the transformation agenda for Nigeria in the areas of job creation, economic growth and transparency of governance." The Ministry's main mandates were to "facilitate universal, ubiquitous and cost effective access to communications infrastructure throughout the country"; to "(p)romote the utilization of ICT in all spheres of life to optimize the communications infrastructure – digital content creation, domestic software applications and the delivery of private and public services over the internet"; to "(p)romote and facilitate the development of the ICT industry and increase the contribution of the ICT industry to GDP"; and to "(u)tilize ICT to drive transparency in governance and improve the quality and cost effectiveness of public service delivery in Nigeria." In addition to the Ministry of Communications and Digital Economy, the Nigerian Communications Commission (NCC) is an independent authority for the telecommunications industry which is responsible for the regulation of the ICT sector[48].

The Ministry has developed the National Digital Economy Policy and Strategy of Nigeria (2020-2030) to reposition the Nigeria economy and utilize the growth of the digital technology sector as a catalyst to rapidly develop the economy[49]. Eight pillars of this development policy have been identified: developmental regulation, digital literacy and skills, solid infrastructure, service infrastructure, digital services development and promotion, soft infrastructure, digital society and emerging technologies, and indigenous content development and adoption. Furthermore, under the 2020-2025 National Broadband Plan, women are required to be educated on the use of ICT and all women in national social investment programmes are provided access to ICT[50].

In Senegal, the digital economy represents a significant opportunity to catalyse gains in productivity and level the playing field in terms of access to opportunities[51]. To support the development of the digital sector, Senegal has introduced incentive-based policies in the fields of legislation, technical infrastructure and training. The national development plan, Plan Senegal Emergent (PSE) - 2019–2023 made Information and Communications Technology (ICT) a prominent priority across the different sectors of the economy[52]. Subsequently, the country developed the National Strategy Digital Senegal 2016-2025 (DS2025), derived from the PSE as a national development policy. The strategy is based on three key prerequisites (legal and institutional framework, human capital, and digital asset) and the four priority areas[53]. The priority areas are affordable and easy access to digital networks and services; an administration serving citizens and

[46] Seychelles, Office of the President, Department of Information Communications Technology. *National ICT Policy*. Available from https://www.ict.gov.sc/homecnt/policies.aspx (accessed November 2022).
[47] Nigeria, Federal Ministry of Communications and Digital Economy. Available from https://www.commtech.gov.ng/ (accessed September 2022).
[48] Nigeria, Nigerian Communications Commission. Available from https://www.ncc.gov.ng/the-ncc/who-we-are (accessed September 2022).
[49] https://www.itu.int › pub › D-INNO-GOOD_PRACT
[50] https://www.ncc.gov.ng/documents/880-nigerian-national-broadband-plan-2020-2025/file
[51] Cenfri, 2021, Unlocking the digital economy in Senegal
[52] Ministry of Finance, 2018. Phase II - PSE - Prority Actions Plan - 2019-2023.
[53] The digital Senegal 2016-2025 strategy (DS2025)

enterprises through digital services; the support to an innovative digital industry producing value addition and promoting digital technologies in priority economic sectors.

The Senegalese digital strategy contributes to building productive and human capacities. A strong emphasis is given to capacity development in the DS2025, pointing out that digitalization is a critical tool for building individual and economic capacities for a country. One of the major objectives of the strategy is to enhance feminine digital entrepreneurship to contribute to women's empowerment and social inclusion by giving access by 2025 to e-commerce and electronic public services to 33 percent of rural women in the country[54]. These regulations and policies are meant to reduce or remove barriers to digitalisation while creating an enabling environment and facilitating innovation and digital solutions to existing real-economic problems. The DS2025 strategy embodies the Senegalese ambition to maintain its role as a leading country in the digital sector at the continental level in Africa and, more particularly, in West Africa[55].

There are several government ministries and institutional champions for digitalisation in Senegal. However, according to the World Bank (2019), there is a lack of policy consistency, strategic leadership and no integration protocols that recognise the interrelation between the different enablers of the economy's digitalisation despite the general mandate of PSE and DS2025. These include the National Digital Council (Conseil National du Numérique – CNN), Regulatory Authority for Telecommunications and Post (Autorité de Régulation des Télécommunications et des Postes – ARTP), Delegation for Rapid Entrepreneurship (Délégation Générale à l'Entreprenariat Rapide pour les Femmes et les Jeunes – DER), Promotion of Investments and Major Works (APIX), and the Ministry of Communications, Telecommunications, Post and Digital Economy (Ministère de la Communication, des Télécommunications, des Postes et de l'Economie Numérique – MCTPEN)[56]. Recommendations have been made that the ARTP, as core ICT regulator, be equipped to take the leadership role with other national ministries and regulators regional actors (Begazo, et al., 2017)[57].

In Mauritius, the Ministry of Information Technology, Communication and Innovation[58] has the mission to "provide high speed communication infrastructure, develop a digital economy and strengthen innovation in industry by improving delivery of service as well as the dissemination of information through the optimal use of emerging technologies." Under this overarching mandate, the Ministry has been working on formulating policies and the legal framework for the development of ICT in Mauritius, facilitating the provision of an E-Government programme, and promoting the development of the ICT sector so that ICT "permeates all levels of society to bridge the digital divide" [59]. The Ministry is also responsible for capacity building in ICT, the development of ICT enabled services such as e-business and encourages the adoption of new technologies and practices.

[54] The digital Senegal 2016-2025 strategy (DS2025)
[55] Issue Brief, 2020. The Digital Senegal 2016-2025 Strategy, as an Appropriate Instrument to Implement the Sustainable Development Goals. The Digital Senegal 2016-2025 Strategy
[56] Cenfri, 2021, Unlocking the digital economy in Senegal
[57] Begazo, T., Mugyenyi, P. & Coelho, G., 2017. Guide for Policy-Makers Pro-competition markets solutions to address key bottlenecks in senegal's telecommunication services, Washington D.C.: World Bank Group.
[58] Mauritius, Ministry of Information Technology, Communication and Innovation. Available from https://mitci.govmu.org/SitePages/Index.aspx (accessed September 2022).
[59] Mauritius, Ministry of Information Technology, Communication and Innovation. Available from https://mitci.govmu.org/SitePages/Index.aspx (accessed September 2022).

Mauritius is aiming to build an "intelligent and smart" economy with its Mauritius Vision 2030. The Digital Mauritius 2030 Strategic Plan under this Vision covers five areas: digital government, ICT infrastructure, innovation, talent and cybersecurity. Other policies aim to create smart cities and technology parks, improved and high-speed telecommunication infrastructure, a competitive workforce for technology and communication, a National Innovation Programme, and enable the country to become a regional hub for Africa[60]. Mauritius is also working towards a safer ICT environment by enacting the Data Protection Action, the Electronic Transaction Act and establishing a Center of Excellence on Cybersecurity and Cybercrime. Further strategies, such as the Artificial Intelligence Strategy 2018, the Digital Government Transformation Strategy 2018–2020, and the Open-Source Software Strategy, focus on further propelling their digital transformation[61]. CERT, which is a division of the National Computer board, aims to educate citizens about internet issues and undertakes research to keep abreast of developments. Mauritius also has a cyber security portal for users that provides advice to parents to protect children from online risks[62], and an online reporting system for cybercrime[63].

The Department of Communications and Digital Technologies[64] of South Africa aims to "encourage digital inclusion and economic growth", including facilitating "South Africa's digital transformation by creating an enabling policy and regulatory environment". The Digital Society South Africa strategy maps out how the country intends to leverage the digital economy between 2017–2030[65]. The strategy aims to position South Africa as a significant player in the development of ICT and to accelerate the uptake and usage of ICT in other social and economic sectors through a cohesive National e-Strategy in combination with national policies to establish an ecosystem as the basis of the digital society[66]. There are challenges that have been noted for the effective roll out the strategy though, including fiscal constraints and insufficient coherence across a number of other national and sectoral policies and strategies.

The advent of the Fourth Industrial Revolution (4IR) necessitated that South Africa should develop new policies, strategies and innovation plans to enable an inclusive whole of society approach with Government playing a leadership responsibility. In 2019 Presidential Commission on the Fourth Industrial Revolution (PC4IR) was established to steer South Africa forward by recommending how the country can position itself in the global 4IR economy. The Commission has developed a framework to harness the opportunity and the framework consists of eight pillars of 4IR strategy[67].

Several agencies are involved in the ICT sector of Tunisia, though the main regulatory and policy making body is the Ministry of Communication Technologies and Digital Transformation[68]. The ministry worked on updating its national digital strategy 2021-2025, which aims at putting digitalization at the heart of the economic and social development of the country. The ministry has initiated a review of the legal

[60] FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/cb7943en47
[61] FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/cb7943en47
[62] ADF. (2021). Island Nation Tackles Cyber Security.
[63] https://maucors.govmu.org/maucors/
[64] https://www.gov.za/about-sa/communications
[65] South African Government, 2017
[66] https://www.dtps.gov.za/images/phocagallery/Popular_Topic_Pictures/National-e-strategy.pdf
[67] Report-of-the-Presidential-Commission-on-the-4th-Industrial-Revolution-PC4IR-.pdf
[68] https://tahseen.ae/tech-policy/tunisia/; https://www.mtc.gov.tn

framework and digital governance in Tunisia to ensure social inclusion (digital and financial) in order to reduce the social divide, guarantee citizen equity and preserve access to digital tools.

Another key stakeholder is the Tunisian Internet Agency, which is responsible for promoting internet usage, developing the internet network and providing training on the internet. Several related agencies include the Technical Communications Agency which is responsible for "technical support to judicial investigations into ICT-related crimes", the National Agency for Computer Security, which protects against cyber-attacks and is responsible for network security, the National Authority for the Protection of Personal Data which administers data privacy policies, the Telecommunications Study and Research Centre which reviews and reports on advances in the ICT sector, and the National Instance of Telecommunications, which aims to provide a conducive investment environment for the telecommunications sector[69].

All target countries of this report are positioning themselves to empower citizens to propel their development into a digital economy for development. Massive opportunities already exist despite all challenges faced, and people are already learning how ICT can change their lives. The next section takes a snapshot of some of the initiatives and potential of ICT, and why governments and people are excited about the digital revolution. Government guidance and support is needed though, not only through policy and programmes, but to ensure the safety of people on the Internet.

The next section begins by touching on the importance of cybersecurity and online safety, but then moves onto reviewing the potential of mobile application development, digital platforms, digital content, space applications and geospatial information, and digital financing.

2.5 Culture and perception

To be included.

[69] https://tahseen.ae/tech-policy/tunisia/

3.0 Analysis of gender and emerging digital technologies for sustainable development and enterprise in Africa: opportunities and potential for digital transformation

3.1 Cybersecurity, online safety and virtual etiquette to better prepare women and girls in navigating digital spaces

Women and girls often face online violence and harassment in the form of explicit or pornographic messages and cyber-stalking. Online harassment can also have offline consequences - the potential for harassment and privacy violations were cited as some of the main barriers to women's access to digital services. The pressure can have devastating effects on women's mental health, with online violence linked to depression and even self-harm. When women and girls are excluded from the benefits of digital technology access and use, they are further marginalized, and equitable development is impossible to achieve.

Data and information on breaches of online safety and cybersecurity are needed in order to gauge the dangers that lurk for many in using digital technologies. For example, data shows that in some countries 62 per cent of adult internet users and over 80 per cent of children (aged 12-15) have had potentially harmful experiences online, and in the UK in 2020, there were nearly 22 million reports of child sexual exploitation made online, including over 65 million images, videos and other files. There internet and the use of online tools and services are not free of risks.

Through consultation with countries, significant emphasis was placed on ensuring the safety of women and girls online, especially where there are increases of online abuse, harassment and exploitation, and the internet could present an extension of gender-based violence opportunities moving beyond the real-world to online platforms. Cyber-bullying has become a new concern for parents online as well as teenagers and adults spending time on social media. In addition, the security threats posed by increased online exposure also needs to be addressed through education and knowledge of using encrypted means of communication and more secure authentication procedures and tools for logging into online accounts.

Some countries have made progress, such as South Africa where the Films and Publications Bill was amended in early 2022 to prohibit sharing a person's intimate phones or videos without their consent. It also prohibits the publication of digital content that incites violence[70].

3.2 Mobile application development

With the increase in people using smart phones in Africa, mobile phone application development has grown immensely and adapted to the local needs of people. One report from 2019 indicates around 53 mobile applications in the local languages of Nigeria already exist[71]. The mobile industry is estimated to generate US$154 billion in technologies and services by 2025 in sub-Sahara Africa alone[72]. Much of this

[70] The Films and Publications Amendment. Act 11 of 2019.
[71] GSMA, 2019 in FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/cb7943en47
[72] GSMA, https://www.gsma.com/mobileeconomy/sub-saharan-africa/

has the potential to help the most vulnerable, opening up opportunities that range from better information to support existing income generation, to new business entrepreneurship.

With the number of women employed in agriculture, either formally or informally, this additional data could be of great benefit to entrepreneurial and innovative thinkers. Already, advisory services and simple applications provide massive opportunities for farmers to obtain key information to help with growing their crops and can make ordering resources such as fertilizer or seeds, and selling their products online, much easier.

A good example of this is the tool M-Farm. Developed by three enterprising young women from rural Kenya, they sought a way to cut out the middleman when selling their crops by developing software and an agribusiness company which provides simple text messages to farmers' mobile phones on the price of their products as well as farm supplies, such as fertilizer and tools. This transparent tool provided farmers' with more favourable and easily accessible information, allowing them to better negotiate prices for products and supplies, as well as saving valuable time at the market[73].

Farmline, a start-up organization based in Ghana, develops web platforms and mobile applications for farmers in isolated areas. One mobile learning tool designed for women sends voice messages in the local language to a farmers' mobile phones with information valuable to agriculture, such as weather forecasts, market prices, and good farming practices. This tool helps to provide much needed information in a format that is accessible to those without high data capacity mobile devices or smart phones and is tailored to the local needs, both in terms of language and accessibility for people with low literacy skills.

Another example of ICT advisory services is the ESOKO service that delivers market information to farmers and allows specific questions to be asked by SMS. The service tried to tackle possible barriers to women in particular, such as a lack phone access or illiteracy, by setting up a call centre, allowing people to simply call in with questions from any phone. The call centre was staffed by both men and women, allowing women who were more comfortable discussing farming issues with other women to better access the service. Those who subscribe to the service obtain timely information on good farming practices tailored to the farmer's need and translated into the local language[74].

Some other applications aim to help women with education or supply health information. Tigo Biashara is a mobile educational service in Tanzania, which provides business skills training aimed at low-income women through voice and SMS messages. Grace health is a low data use application that provides health information to women, and has helped 3.7 million people in Kenya, Ghana and Nigeria[75]. SafeNes, being developed in Tunisia, aims to increase awareness of sexual harassment in public and connects victims with NGOs specialized to provide support[76].

In South Africa a suite of mobile applications have been developed to provide an integrated information management platform to improve governance and management of small-scale fisheries in a time of climate change. The ABALOBI programme provides an open-source platform to strengthen market

[73] FAO. 2018. *Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development*, by Sophie Treinen and Alice Van der Elstraeten. Rome, Italy.
[74] FAO. 2018. *Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development*, by Sophie Treinen and Alice Van der Elstraeten. Rome, Italy.
[75] https://www.grace.health/about-us
[76] UN Women. (2018). From where I stand: "It would be a better world if women felt safe in public spaces".

participation of local fishers, to record catch data and promote fisheries related data monitoring, resulting in transparent and traceable data relevant to the sector. With an emphasis on usability among low-literate and low-skilled fishers, ABALOBI has served as a catalyst for cross-sector livelihood development among underserved communities in rural South Africa[77]. The mobile application user-base grew across South Africa so much that it has now been endorsed by the Minister of Fisheries to become the official catch management system for the small-scale fisheries sector. The ABALOBI platform has also evolved into a revenue-generating mechanism with the goal of supporting annual operations and management of both the fisher cooperatives who begin to use the platform and the non-profit organization (NPO) behind the platform[78].

3.3 Digital platforms

Digital technology has opened up more opportunities for income for informal or low-skilled workers, particularly during covid-19 when people were restricted in going to markets to sell their products in many countries. These platforms mean that people can reach beyond a specific location to a much broader market. At the most basic level, people with access to a smart phone are increasingly using existing free social media platforms, such as Instagram to market and sell their products, while managing orders through platforms such as WhatsApp or other messaging applications. The entrepreneurs can sell a variety of goods and services via these platforms if they are not large enough to be active on more formal e-commerce sites such as Jumia or Amazon. These microentrepreneurs using social media are a much smaller subset of a larger e-commerce group but they have the potential to grow considerably.

A wider e-market is already in effect in Africa, with online sales through various platforms. For example, the formalized e-commerce sites include around half the informal economy, or almost 170 million workers out of the total sub-Saharan labour force of 417 million[79]. Platforms such as Wosoko allow informal retailers to efficiently connect with local or international suppliers with same day delivery. Customers make their orders via text message or through the online application[80]. Jumia covers 13 African countries and allows local and international vendors to sell their products online. As of December 2022, Jumia had a value of $0.47 billion[81].

Digital platforms can also support women's empowerment and education. One good example is the Songtaaba Women's Association's telecentre in Burkina Faso. The organization manufactures shea butter skincare products and by developing a website, it enabled women members to improve their marketing and sales skills, as well improving their skills in ICT. The initiative allowed much greater market access with an increase in sales by 70 per cent after two years. Their telecentre is also a safe place for women to meet and obtain information to help their businesses, as well as attend training courses[82].

Another example aimed at supporting the health sector in Tunisia is the Digital Health (e-health) Development Initiative launched by the Ministry of Health in 2017. The initiative aimed to provide health facilities in Tunisia with ICT tools, particularly through setting up a digital platform leveraging information

[77] https://unesdoc.unesco.org › Abalobi: case study by UNESCO-Pearson Initiative for Literacy

[78] ABALOBI. ND. About ABALOBI. abalobi.info/about/ (Accessed 23 October 2022.)

[79] International Labor Organization. 2018. *Women and Men in the Informal Economy: A Statistical Picture*. Geneva: International Labor Organization.

[80] https://wasoko.com/our_story/

[81] https://companiesmarketcap.com/jumia/marketcap/

[82] FAO and ITU. 2022. *Status of digital agriculture in 47 sub-Saharan African countries*. Rome. https://doi.org/10.4060/

systems and telemedicine functionality. The first functionality will be used to facilitate the management of the patient flow and to improve their care by facilitating reception and transfers while ensuring traceability. The second feature was to consolidate sponsorship efforts between university hospitals and regional hospitals in inland areas.

Another growing opportunity is crowdsourcing workers through digital platforms. Examples include Amazon Mechanical Turk, Upwork, Freelancer and 99designs, whereby clients can outsource small, often low skilled routine tasks to a potential global pool of workers online. Some, like Upwork and Freelancer, match demand and supply of a large range of professional services, which can range from anything such as translation services to coding and business consulting. Some of the activity may become localized, but some tasks, such as digital content moderation or data validation, may not be subject to geography.

Smart Tunisia is a programme for offshoring sector companies, with the ambitious goal of creating 50,000 jobs over the next five years in the areas of offshoring, the nearshoring and collocation. Designed as part of a public-private partnership, "Smart Tunisia" responds to offshoring sector revitalization will, through the provision of incentive mechanisms for the implementation of supply and convergence demand for employment in the sector. The Tunisian government has allocated a budget equivalent to €500 million for 5 years in the form of incentives, to support international and local operators in their growth and development strategies of their activities[83].

Other platforms focus on transport, such as the Kobo360 app in Nigeria, which connects truck drivers to cargo owners, allowing logistical transportation to be streamlined and more efficient, cutting transport times cross-country from seven days to three[84].

These platforms provide opportunities for workers, particularly informal workers and women, by decoupling work from geographical constraints and providing flexible working options for additional income[85]. The downside is the potential to erode labour protection and possibly exacerbate existing labour divides[86]. There is a need to ensure that online platforms actually provide real opportunities rather than becoming a digital substitution to the traditional "sweat shop"[87].

Tunisia established an ambitious program for the development of 10 technological parks. This program currently comprises three parks specializing in ICT: Digital Technology in Sfax/ Nano and microelectronics in Sousse / Communication technologies in Tunis, in addition to an ICT component in all the other parks (bioinformatics). This environment has fostered synergies between industry, research and educational universities. The technological parks have also promoted the emergence and development of innovative foreign and Tunisian companies. The first technological park dedicated to ICT in Tunisia and North Africa, was Elgazala Technopole, which began its activities at the end of the 1990s. It accommodates over 90 companies employing 1650 people including 98 per cent who are graduates.

[83] Add reference….
[84] https://www.ifc.org/wps/wcm/connect/NEWS_EXT_CONTENT/IFC_External_Corporate_Site/News+and+Events/News/CM-Stories/nigeria-digital-growth-drives-economy-forward
[85] Graham et al. 2017a in Digital Commerce and Youth Employment in Africa, 2019
[86] Belle & Mudavanhu 2018 in Digital Commerce and Youth Employment in Africa, 2019
[87] OECD, 2017b in Bridging the Digital Gender Divide

3.4 Digital content

The growth of the internet has revolutionized research, allowing greater access to information than ever before. According to one source, "at the beginning of 2020, the number of bytes in the digital universe was 40 times bigger than the number of stars in the observable universe[88]." From obtaining up to date information on the weather to help with crop production, to opening new forms of art and markets, the internet has changed the world dramatically.

For Africa, this can provide women with greater access to education and information without needing to travel, enabling new opportunities to support their livelihoods, direct their own lives or innovate solutions to problems[89]. Some examples include KamiLimu from Kenya, which is a mentoring programme that aims to complement classroom learning with modern skills for tertiary-level tech students[90]. The Barefoot Law NGO in Uganda has helped over 800,000 people, 40 per cent women, with free legal information using digital technology[91]. Si Jeunesse Savait from Central Africa, trains online security and advocacy for women and survivors of violence, including how to create online content and access online services[92].

Tunisia has shown a significant interest in the development of ICT with concrete support to the development of the private sector, the environment, infrastructure, and the legislative framework. A set of incentives was set up and promoted Tunisia as a favourable site for the development of ICT. The Tunisian government has created a service portal for the benefit of citizens and businesses in various sectors, including health, finance, agriculture, education, transportation and energy.

Beyond information, the digital world is often used for entertainment. It has been estimated that about 80 per cent of all Internet traffic relates to videos, social networking and gaming. Monthly global data traffic is expected to surge from 230 exabytes in 2020 to 780 exabytes by 2026[93].

The rise of Nollywood, Africa's self-sustaining popular film industry, uses affordable technologies such as digital cameras and desktop editing for filmmaking and has grown from Ghana and Nigeria to the entire continent[94]. Nollywood is estimated to generate $590 million annually[95] and will continue to grow.

The rise of social media has opened up new avenues for revenue for people without the need for extensive technical skills. "Social media influencer" is now a full-time job for some people, with nano-influencers (generally less than 1000 followers) on Instagram earning around $10-$100 per post while mega-influencers (more than a million followers) earning more than $10,000 per post, as an example[96]. YouTube, Twitter, Facebook and Snapchat are other examples of typical social media platforms where

[88] https://seedscientific.com/how-much-data-is-created-every-day/#:~:text=How%20Much%20Data%20Is%20on,to%20reach%20463%20exabytes%20globally.

[89] FAO. 2018. *Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development*, by Sophie Treinen and Alice Van der Elstraeten. Rome, Italy.

[90] www.kamilimu.org

[91] https://barefootlaw.org/

[92] APC. (2016). Exploring technology-related violence against women in the Democratic Republic of Congo and Kenya.

[93] United Nations Conference on Trade and Development (UNCTAD). 2021. Digital economy report 2021. Geneva: United Nations.

[94] The future is digital: an introduction to African digital arts

[95] Moudio, Rebecca. 2013. *Africa Renewal.* Nigeria's film industry: a potential gold mine? United Nations. Accessed from https://www.un.org/africarenewal/magazine/may-2013/nigeria%E2%80%99s-film-industry-potential-gold-mine.

[96] https://influencermarketinghub.com/influencer-rates/#toc-1

advertisers will pay for digital content. The basic premise of the business is that the more followers, the more access advertisers can get to a potential market. The social media influencer market globally has grown from $1.7 billion in 2016 to a projected $16.4 billion for 2022[97]. As the influencer market has grown, so has the influencer marketing companies, with an estimated 26 per cent growth in 2021 to 18,900 worldwide businesses[98].

More than 30 million South Africans are active on social media[99], which is almost half the population of the country, with an estimated 64.6 per cent of the content locally relevant in 2022[100]. An estimated 42 per cent of Nigerians use Facebook, with 23.3 per cent Twitter, 6.7 per cent Pinterest, and 0.7 per cent LinkedIn, though 19 per cent of people use Instagram [101]. Likewise, in Tunisia in 2021, over 90 per cent of the population used Facebook, with 3.8 per cent using Twitter, 3 per cent YouTube and 0.7 per cent using Instagram[102]. More than 85 per cent of the population of Mauritius was on Facebook in 2022, though only 4.8 and 4.2 per cent on Pinterest and Instagram, respectively. [103]

Another social media tool which has grown immensely is TikTok, a video-streaming app that enables users to create and share videos in up to 60-second feeds. Though initially used as a site for teenagers, it has become one of the easiest and least expensive ways to promote brands and businesses with minimal digital skills required. For many small businesses, TikTok is quickly becoming the best way to grow an audience and reach new customers[104]. The latest social media report it is estimated that around 6 million South Africans use TikTok daily[105].

There are several inspiring TikTok success stories in the African region. Melissa for example, also known as pilot_onthegram, is a commercial pilot, an Aircraft Manager and content creator. She has amassed over 11 million followers on TikTok and became the first local pilot to be verified on the app[106]. The Joburg-based pilot makes fun and educational videos about her industry to teach others about aviation and encourage those who have aspirations of working in the industry to keep going for their goals. Melissa also helps other young people in pilot training, or who have aspirations to come onboard, by offering a mentorship program and classes in the field[107].

This growing access to and use of the internet and social media provides massive opportunities for people to earn money, as advertisers seek new markets in Africa. It is estimated that in 2022, digital advertising

[97] https://influencermarketinghub.com/influencer-marketing-statistics/
[98] https://influencermarketinghub.com/influencer-marketing-statistics/
[99] https://dezignit.co.za/social-media-stats-in-south-africa/#:~:text=How%20many%20people%20in%20South,25%20million%20users)%20in%202020.
[100] GSMA. 2021. GSMA Mobile Connectivity Index. Available from https://www.mobileconnectivityindex.com/#year=2021&zoneIsocode=ZAF&analysisView=ZAF (accessed 18 November 2022).
[101] Statcounter GlobalStats. 2022. Social Media Stats in Nigeria - October 2022. Available from https://gs.statcounter.com/social-media-stats/all/nigeria (accessed 18 November 2022).
[102] Statcounter GlobalStats. 2022. Social Media Stats in Tunisia - October 2022. Available from https://gs.statcounter.com/social-media-stats/all/tunisia (accessed 18 November 2022).
[103] Statcounter GlobalStats. 2022. Social Media Stats in Mauritius - October 2022. Available from https://gs.statcounter.com/social-media-stats/all/mauritius (accessed 18 November 2022).
[104] https://www.businessinsider.co.za/tiktok-content-in-south-africa-inspiring-global-brands-2022-10
[105] Social media landscape report 2022
[106] https://www.tiktok.com/@pilot_onthegram
[107] https://www.tiktok.com/@pilot_onthegram

spending reached 60 per cent of total media advertising spending.[108] Capacitating women and girls to utilise such platforms and begin producing their own online digital content and leveraging the advertising and revenue streams of such platforms, provides a promising avenue for artistic expression through digitalisation.

3.5 Digital finance

Digital finance is a rapidly growing area which provides massive opportunities for Africa, particularly for women. Both banks and ordinary citizens are trying to find more efficient ways to trade and pay for goods and services in a manner that reduces the challenges faced by domestic and cross-border payments. An estimate by McKinsey suggests that "Africa's domestic e-payments market is expected to see revenues grow by approximately 20 percent per year, reaching around $40 billion by 2025"[109].

E-payments have been growing in Africa since 2000, though have taken a leap forward during the Covid-19 pandemic. One estimate from Nigeria indicated that mobile money transactions doubled to around 800 million in 2020. During the 2020 to 2021 lockdowns in South Africa, online commerce grew by around 40 per cent[110].

Digital finance is particularly useful for women. In many parts of Africa, women are restricted in their access to finance, with some countries not allowing women to open a bank account at all, or only with the permission of their husband[111]. According to World Bank data seen in figure X, only 35 per cent of women in Nigeria had a bank account or access to finance with a mobile money service provider, compared to 55 per cent of men. For Mauritius, these figures were much more even with 92 per cent of men and 89 per cent of women owning a bank account or having access to finance. Similarly, South Africa was quite balanced with 85 per cent of men and 86 per cent of women, though in Tunisia the gender divide was much more pronounced with 45 per cent of men owning an account but only 29 per cent of women. In the Seychelles, 94 per cent of the population have a bank account, though gender disaggregated data was not available[112].

[108] UNCTAD (2021) Cross-border data flows and development: for whom the data flow, New York : USA
[109] The Future of Payments in Africa
[110] "The online retail industry in South Africa 2021," Who Owns Whom, November 6, 2021. Cited in The Future of Payments in Africa
[111] FAO. 2018. *Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development*, by Sophie Treinen and Alice Van der Elstraeten. Rome, Italy.
[112] IMF

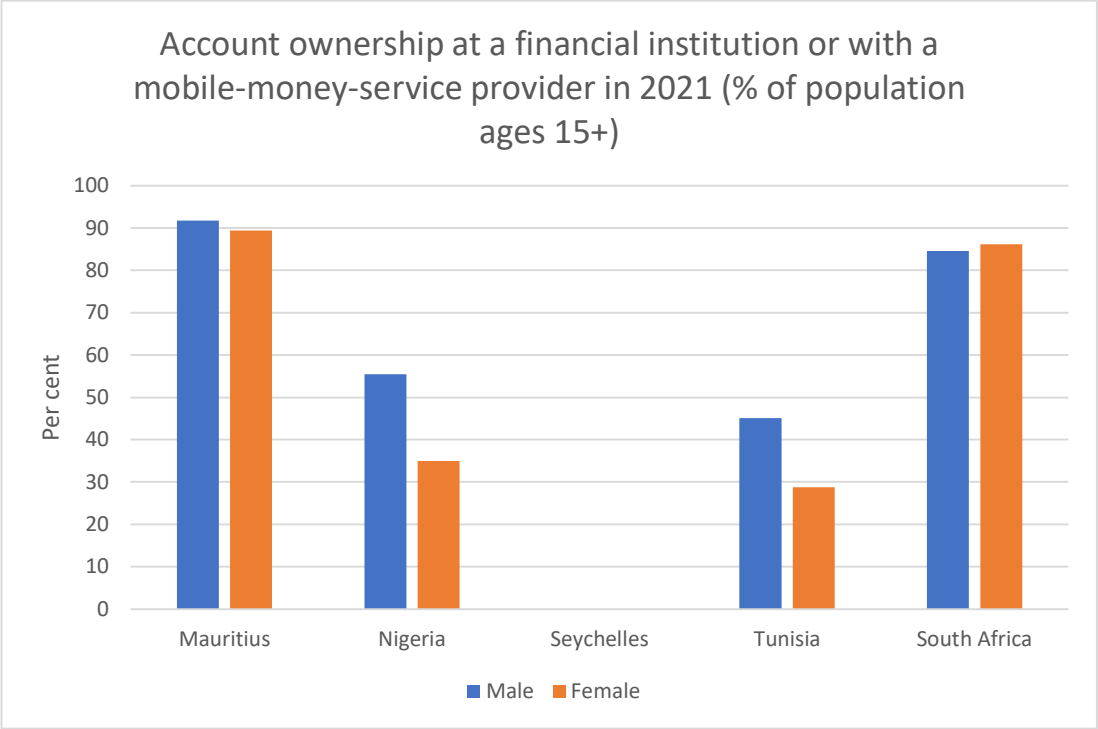


Figure 2: Account ownership among men and women

Source: *World Bank databank, accessed November 2021*

Mobile phones can now be used for financial transactions not subject to national legal restrictions presenting a range of opportunities for women to access finance. These services can even include loans or insurance and can save precious time as women would not need to visit a bank in person. M-Pesa, provided by Safaricom Ltd in Kenya, is one successful example of mobile finance services. Used by around 70 per cent of the population in Kenya, a study of one fishing community near Lake Victoria indicates that the service has brought significant benefits to women, who can now save their money in a safe place where their husbands can't access it. It allows them to save for costly purchases, including helping their families such as sending their children to school. It also saves considerable time as they do not need to travel to a bank, allowing them to focus more on their business or other tasks[113]. It should be noted though that this service does make money by charging higher transaction fees, which could cause problems in the future if the competition with other providers isn't strong.

Other tools developed to reduce the complexity of financial transactions include QR codes. Ghana's Quick Response service (GHQR) allows access and transfers from bank accounts, cards and mobile money. Nigeria has launched a similar tool. M-KOPA has a programme where customers can obtain a smartphone on a pay-as-you-go modality which helps unbanked people access credit[114]. Mobile wallets, which allows credit card or other information to be stored on a mobile device, are also commonly used. Though some technical challenges existed between different mobile wallets, the interoperability of these have now

[113] FAO. 2018. *Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development*, by Sophie Treinen and Alice Van der Elstraeten. Rome, Italy.
[114] GSMA. (2022). M-KOPA: Applying the pay-as-you-go model to smartphones in Africa.

improved substantially and provide additional financial services. Examples of these are SANEF in Nigeria and Mukuru in Southern Africa[115].

Financial empowerment for women is an incredibly important factor in reducing gender inequality. The era of traditional banking services is changing, and women are likely to benefit from this. Governments should embrace these changes, but care needs to be taken these services don't perpetuate existing problems or exploit women in their services.

3.6 Space science

The rapid evolution of geospatial technologies and availability of free data over the past few decades has caused a shift in the use of these data and tools from traditional military and national security purposes to civil and commercial purposes. One of the initial civil uses for satellite data and technologies was for disaster response, where these tools are valuable for the identifying areas most affected by a disaster, which is vital information for the rapid deployment of emergency services. The use of this data has expanded considerably over the past two to three decades, with much information becoming freely available to anyone with the know of how to access and utilize it. Areas beyond disaster risk management that space applications and data are used include environmental and agricultural monitoring, water resources management, climate change and monitoring or advising urbanization, among many other uses.

Satellite information and remote sensing data has long been used for agriculture. Though using the raw remote sensing data requires advanced technical skills to process and manipulate it, tools or portals have been developed which provides final digital satellite products, making this information much more readily available to users with no background in geospatial science. Portals like FAO's WaPOR (water productivity through open access of remotely sensed derived data)[116] provides a range of water, land cover and climatic data covering the whole of the African continent. Some understanding of the indicators is needed for interpretation though, possibly benefitting government planning more than small agricultural households.

Other tools include Digital Earth Africa[117], a datacube of analysis-ready satellite data and information covering agriculture, coastlines, water resources, land cover, meteorology, vegetation, elevation and topography. According to a report by the World Economic Forum, "Digital Earth Africa (DE Africa) is an example of how Fourth Industrial Revolution technologies can enable widespread socioeconomic development……Even under conservative assumptions, the impact of DE Africa for the African industry could be higher than $2 billion a year." [118] These kinds of tools provide valuable information for long term strategic planning and analysis of the interactions between people and their environment. It is also possible for farmers to easily view and utilize data to improve crop monitoring to help identify factors that may be causing lower yields, such as sowing during the wrong time of the season or better managing irrigation to ensure the most efficient and effective use of water. "Satellite data is particularly useful in regions where ground-based measures of sow date are lacking, such as Africa. Optimizing sowing dates,

[115] The Future of Payments in Africa
[116] https://wapor.apps.fao.org/home/WAPOR_2/1?theme=L1_QUAL_NDVI_D&dim=DEKAD:%255B2022-10-21%252C2022-11-01
[117] https://maps.digitalearth.africa/
[118] https://www3.weforum.org/docs/WEF_Digital_Earth_Africa_Unlocking_the_potential_of_Earth_Observation_to_address_Africa_2021.pdf

DE Africa can raise yearly wheat production (10% effect) by 136,000 tonnes, bringing a benefit of at least $35 million to the African economy." [119]

Beyond satellite information, the drone, or Unmanned Aerial Vehicle (UAV), industry in Africa is taking off and it is evolving into a massive enterprise. In many African countries, drones are being used to solve socio-economic or environmental problems and are proving to be an efficient way of providing logistical services for the delivery of supplies in rural areas. Research has shown that drones are also becoming important for the modernization of African agriculture, as they bring more efficiency, precision, and reliability at a much lower cost. Drones, data and artificial intelligence are leapfrog technologies that can potentially accelerate economic growth in the African region. However, there is a lack of qualified and skilled personnel to seize the opportunities offered by drone and data technology[120].

Zenvus in Nigeria uses electronic sensors and drones to collect soil data regarding its humidity, its nutrients, its temperature, and its pH[121]. This data is sent via mobile phone to a Cloud server and then analyzed to adapt irrigation or fertilization to the conditions of the soil. The startup uses drones to monitor the health status of the field and detect drought and pests. Hence, farmers are more connected and informed on their field, which allows for an increase in their agricultural production.

To respond to the skills deficit, UNICEF established in Malawi the first African Drone and Data Academy (ADDA) in January 2020[122]. The ADDA aims to be a centre of excellence that will dually equip young people in Malawi and the African region with necessary 21st-century skills while strengthening the drone ecosystem for more effective humanitarian and development response. Priority is given to young women to address the global gender gap among students and professionals in the areas of science, technology, engineering and mathematics.

Based on the promising results of the first cohort, with 90 per cent employed in the drone industry and another 21 per cent reportedly bringing drone competency to their current jobs, there is potential to further strengthen the programme and scaling it to other countries so that more young people acquire cutting-edge knowledge and digital skills that allow them to participate in the global workforce and prepare them to be successful social entrepreneurs[123].

119 https://www3.weforum.org/docs/WEF_Digital_Earth_Africa_Unlocking_the_potential_of_Earth_Observation_to_address_Africa_2021.pdf

120 https://www.do4africa.org/en/the-drone-industry-in-africa/

121 https://borgenproject.org/zenvus-nigerian-startup-for-farmers/

122 https://www.unicef.org/malawi/african-drone-and-data-academy-malawi

123 https://www.unicef.org/malawi/african-drone-and-data-academy-malawi

4.0 Reorienting the digital environment in favour of gender equality and women's empowerment: policy recommendations to strengthen agency

The world affected by a digital revolution that can have a profound impact on many people in Africa, particularly women and girls. From new opportunities to sell products virtually, to accessing new types of digital finance, empowering women and girls to develop their digital skills will help propel an economy into a new era of development and growth.

The fourth digital and industrial revolution is affecting the governance systems, industries, and the labour market. Cyber systems are multiplying and evolving. Artificial Intelligence (AI), robotics, nanotechnologies, three-dimensional (3D) printing, genomics, biotechnology, and cognitive sciences are increasingly intertwined and becoming inspiring to everyone.

To flourish during this era, governments, industry and people need to be prepared for opportunities that will come yet also protect against the risks of a digital revolution can bring, particularly to women and girls.

4.1 Extending infrastructure to the last mile

Enabling access of affordable digital services to the most disadvantaged and vulnerable people will be key to harnessing the digital revolution. Most of the countries of focus in this report have managed to extend the mobile and/or broadband services to much of their population, though some gaps remain.

4.2 Develop programmes to help the most vulnerable access affordable digital services

The gender digital divide persists, in part because of social and gender norms and deep-rooted gender stereotypes. As a result, many women-particularly those in developing countries-continue to face challenges in accessing and using digital technologies.

4.3 Regulation that supports entrepreneurial innovation, not suffocates it

Governments are already pressing forward with regulation and policies that support innovation in the digital space and aims to propel their citizens and their country forward with this new revolution. However, excessive regulation and bureaucracy can stifle innovation. A balance is needed between policies and regulation that enable the delivery of ICT services, supports citizens access to effectively utilize these services, and protects them from online risks, without undermining innovative start-ups and new ideas. Opportunity exists to further support these emerging industries with incentives, such as subsidies or tax breaks.

Furthermore, in developing and reviewing these policies and legislation, people should not be seen as a homogenised group. Regulation may benefit some parts of society more than others and can exacerbate gender discrimination. Regulation development should be viewed with a gender lens to ensure it benefits and protects everyone.

4.4 Cybersecurity and protection against online threats for women

There is a need for a safe, affordable, and inclusive Internet that does not fuel harmful gender stereotypes, silence women's voices, or jeopardize women's safety and rights. Similarly, we need digital tools to stimulate women's participation and authority in the digital space. It is not enough for women and girls to simply have access to technology and digital skills; they must also become active agents of change to create a safer and more equitable digital future for all.

Some policies and legislation have already been passed in some countries to help protect and raise awareness of online threats. A deeper understanding of the effectiveness of these policies and legislation, along with the sharing of experience among governments, will help strengthen existing policies and provide ideas for Governments that do not yet have such regulation.

4.5 Leverage the momentum of the private sector

As the digital service industry is increasing becoming privatized, potential exists for governments to partner with the private sector in extending services to the last mile. Furthermore, governments are recognizing that businesses all over Africa are upgrading their digital services and will need a skilled ICT workforce in the future.

4.6 Building digital capacity from an early age

Building a skilled workforce starts with basic education. Ensuring children have access to education equitably so that they can read and write is a basic right. Building STEM programmes into the school curriculum and particularly encouraging building skills in ICT from an early age, will set children with the skills and knowledge to enable them to harness and benefit from the digital revolution. Many governments are already working towards this as they recognize that the growing digital world will require many new people who are capable of building it.

Youth-friendly programs must be made available to provide the information, skills, counselling, and services needed to protect them from these risks. All young people should be given the opportunity for ongoing education. For those who drop out of school or complete school without acquiring the literacy, numeracy, and life skills they need, there must be a range of options for continuing their learning. Such opportunities should be both meaningful and relevant to their environment and needs, help them become active agents in shaping their future, and develop useful work-related skills.

4.7 Content should be relevant and local, particularly for women and girls

Though considerable progress has been seen in some of the countries reviewed in this report, it is clear that not everyone has a smartphone or an internet connection at home. Literacy rates in some areas are lower than others, and when a phone is available, it may only be a low data capacity handset, limiting the information it can access on the internet. Many people in some countries also don't speak English, and therefore it is important for information services to be in the local language or address other challenges that people may face in finding information, such as the distance from a computer or phone or the need to speak with someone directly. Designing digital content, platforms or applications need to be tailored to the target audience and consider vulnerabilities and barriers, particularly for women. Engaging women in the design process can produce new insight and ways of communicating, along with new market ideas.

4.8 Harness the power of social media, online platforms, and applications

Social media, digital platforms and applications provide new opportunities for people to generate income without requiring extensive ICT training. This growing access to and use of the internet and social media provides massive opportunities for people to earn money, as advertisers seek new markets in Africa.

Online platforms have also been providing new ways for people to generate income, from selling their wares online to providing services through online applications. The ease of access of these digital platforms has created new and easier ways of doing business, where people no longer have to go to a market or a service centre. With the growth of this industry, and the localization of these tools to enable more informal or vulnerable people to access them, new sources of income can become available.

4.9 Encourage more mentoring and innovation events and programmes

Several successful programmes have been mentioned that encourage women and girls, and young people in general, to develop their critical thinking skills. The integration of STEM into education promotes creativity and divergent thinking alongside core disciplines. It motivates and inspires young people to generate new technologies and ideas. Science gives learners a deep understanding of the world around them. This helps them become better at research and critical thinking. Technology prepares young people and children to work in an environment full of high-tech innovations. Engineering allows students to improve their problem-solving skills and apply their knowledge to new projects. Mathematics allows people to analyze information, eliminate errors, and make informed decisions when designing solutions. STEM education connects these disciplines in a coherent system. Thus, it prepares professionals capable of transforming society with sustainable innovations and solutions.

Mentoring programmes, scholarships, competitions and various capacity building initiatives can provide opportunities for innovation, inspiring and empowering young people, particularly girls, to consider careers or business opportunities that would not have traditionally been encouraged.

4.10 Protect workers from digital exploitation and eroded labour rights

New opportunities for work using digital platforms and applications have provided new income sources for many people in vulnerable populations. However, there is risk that social protection and labour standards are far behind the growth of these platforms for offering work. Many workers cannot access workplace protection and entitlements that may exist in other formalized employment agreements. Workers are also not capable of engaging in collective bargaining for pay or rights because they are geographically dispersed[124]. This could increase existing gaps in gender, as the more vulnerable in the population are left with limited alternative opportunities for work.

4.11 Explore innovative ways for enabling access to digital and microfinance, particularly for women

Digital finance can provide options to reduce the administrative burden of having a traditional bank account. In some countries, many women do not have an account or cannot access credit or can only do so with approval from their husband. Access to financial services contribute to women's economic

[124] ILO (2021), "World Employment and Social Outlook 2021." In UNDESA (September 2021) Policy Brief no. 113. Digitally enabled new forms of work and policy implications for labour regulation frameworks and social protection systems.

empowerment, allowing opportunities to save and borrow more. Care should be taken that these facilities don't exacerbate inequality. For example, if costs are much higher for using the facilities but one has no other option but to use it.

In general, however, women's access to financial services may need to be reviewed if they pose a barrier to economic empowerment. Digital finance should not be the only solution for long term development of financial literacy skills and economic empowerment for women. Programmes can be developed that promote additional income streams and savings. Policy can create enabling environments through fiscal and monetary policies, welfare systems, education opportunities, childcare, health care and labour laws, among other channels.

4.12 Better utilize geospatial information, tools and technologies

Remote sensing and GIS have been available for many years, though has required more advanced skills to utilize in the past. Data and technologies have been becoming rapidly available and accessible to anyone over the past couple of decades, and new advancements means that tools and online platforms have, or are, being developed to make space applications and geospatial information more accessible and understandable than ever. This can support many people but particularly those living in rural areas and relying on agriculture. Coupled further with applications targeted for specific users and emerging markets in drone technology, immense benefits can be seen from using the digital revolution to improve traditional farming techniques. With many women and girls still involved in agriculture in many countries, this will provide better information to improve decision making, with the long-term aim of improving crop productivity.