GenderInSITE

Gender in science, innovation, technology and engineering

Gender Dimension of Digital Technologies

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About GenderInSITE

Gender in science, innovation, technology and engineering (GenderInSITE) is an international initiative to promote the role of women in science, innovation, technology and engineering. Its mission is to inspire transformative actions and more effective development by understanding the impacts of SITE on women and men and how women and men can contribute to SITE.

GenderInSITE builds partnerships among its members to identify, understand, and develop strategies to apply the gender lens to SITE in six key areas: agriculture and food security; water and sanitation; energy; transportation; climate change and disaster & risk reduction; and science education & the workforce. Its aim is to demonstrate that this can provide deeper insights, more effective programmes and more sustainable outcomes in the context of development.

It engages with networks of researchers and policy-makers, organizing awareness-raising activities and using dissemination tools and resources. Currently GenderInSITE has two regional focal points: in Africa, and in Latin America & the Caribbean.

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1. Introduction

The concept of the digital divide, coined in the early 1980s by the Maitland Commission, was one of the first used worldwide to reflect the social impact of information and communication technologies (ICTs), and rose to peak popularity in the 1990s. According to Camacho (2005), assumptions associated with the digital divide have changed over time. Initially, the link between ICTs and development was conceived of in a linear and deterministic way, as if access to technology itself produced social development (Camacho, 2005). Subsequently, after extensive debate, the concept of the digital divide increased in complexity and incorporated new factors. According to Camacho (2005) and Warschauer (2003), social and historical contexts are important and the digital divide relates not only to hardware and software access, but also to information, knowledge and the necessary skills to make meaningful use of technological devices. The economic aspect of the digital divide refers to access to equipment and connectivity, conceptualized as a first-order digital divide. However, there is also a cultural aspect of the digital divide, the second-order divide, defined as the absence of cultural and educational tools which affect the capacity for ICT appropriation. Lastly, considering "how" and "why" different users utilize technologies, there exists a third-order digital divide, which, according to Camacho (2005), consists of "the possibility or difficulties confronting social groups in taking advantage of information and communication technologies collectively, transforming the reality in which they live, and improving participants' living conditions." In this respect, we consider access and digital skills as necessary but insufficient conditions for assessing ICT appropriation.

The concept of the digital gender gap or divide is usually defined as gender biases that are coded into technology products and that are widespread in the technology sector and in digital skills education (UNESCO & EQUALS, 2019). The digital gender gap refers to gender not simply in terms of the difference between male and female, but as a socially constructed relationship (a power relationship of dominance and resistance) between them that changes according to historical contexts, social classes, age, ethnic identities, and other sociological variables. Sorensen (2002) identifies three main topics in the studies of gender and technology:

1. problems created by new technologies for women at work;
2. male dominance in the professions that design these technologies; and
3. the fluid nature of both technology and gender.

For Sorensen (2002), the understanding of ICT inclusion as a process of diffusion (as time goes by, more people are included) is mechanistic and ignores motivation. So, exclusion and inclusion should not be thought of independently (we might know why women are excluded but we don't know how to include them). According to Sorensen (2002), there is a relationship of mutual shaping and co-construction between gender and ICT. The gender and technology problem was initially an issue of social exclusion (women being excluded by transformation in the working world, which was more demanding in terms of computer skills). Sorensen (2002) argues that masculine information technology keeps women away from a source of power. Moreover, there is not just one male and one female relationship towards computers. Neither gender nor technology should be considered constants in the much-needed broader strategy of getting women included in the information society (Sorensen, 2002). Consequently, as existing power relations determine who benefits from ICTs, we note that these technologies are not gender neutral.

This report is organized as follows. In the first section, the available information on the gender digital divide in Latin America and Africa is reviewed, taking into account three dimensions: access to devices and the Internet; digital skills; and the use and appropriation of digital technologies. For this purpose, gender-disaggregated data are collected and reconstructed from official international and national statistics and research papers. The second section analyzes the main barriers that hinder women's participation in the digital economy and prevent an equitable distribution of its benefits. To this end, special attention is given to firstly, the access and permanence of women in science, technology, engineering and mathematics (STEM) careers, in general, and in computer science, in particular; and secondly, the access of women to the labour market and the participation of women in the gig economy. In the third section, successful experiences aimed at closing the gender digital gap in Latin America and Africa are reviewed. The fourth and final section reflects on the way in which women's appropriation of digital technologies contributes to the achievement of the Sustainable Development Goals (SDGs) and to a reduction in gender inequalities. Finally, a set of gender-related recommendations and suggestions for decision-makers on both continents is provided.

2. Digital Gender Gap

2.1 Digital access gender gap

Globally, 200 million fewer women than men - some 14% across the world - own mobile phones (GSMA, 2015). Similarly, Internet penetration is unequal; according to the United Nations, in 2017 women's access to the Internet was 12% less than men's (ITU, 2019). In developed countries, the gender gap in terms of access to ICTs is narrowing, thus equalizing the levels of access to digital devices and the Internet between men and women (OECD, 2018; UNESCO & EQUALS, 2019; Sainz *et al*., 2020). However, in developing countries, there are still marked biases in favour of men. The gap is wider in lesser developed countries, where the rate of connectivity among women reaches only half the rate for men (ITU, 2019).

> "In Africa, Latin America and Asia, women have less access to technology than men, even to mobile services widely used by the poor (After Access, 2018). Women in low- and middle-income countries are, on average, 10% less likely to own a mobile phone than men; with 184 million fewer women owning a mobile phone (…) Urban users far exceed rural users in all three regions. Even with mobile broadband coverage, people are not necessarily getting online" (Mariscal *et al*., 2019: 3-4).

In Latin America, even though access to mobile telephony reaches 86% of women, the gender digital gap in terms of access to ICT equipment favours men (GSMA, 2018). However, there is some diversity within the countries of the region as reflected in the After Access survey administered in six countries (Argentina, Colombia, Ecuador, Guatemala, Peru and Paraguay). For instance, in Guatemala and Ecuador there are gaps in smartphone use in favour of men, of 15 and 6 percentage points respectively. The same occurs in Colombia, regarding the use of computers and tablets, where men far outnumber women. On the other hand, in some countries where mobile Internet access is relatively even, when analyzing Internet use, the gender gaps tend to appear.

> "Peru and Guatemala exhibit the largest gaps. In both countries the gap accounts for more than 22% in favour of men (relative to women). In contrast, this gap reaches only 5% for Argentina, Colombia and Paraguay. On average the region has a relative gap of 10%" (Agüero *et al*., 2019: 5).

In Africa, gender disparities in terms of access are even greater and far from being bridged. Internet access and use is 25% lower among women than men (ITU, 2017). Studies conducted in 17 African countries indicate that in 11 countries, women have less access to ICTs than men (Deen-Swarray *et al*., 2012; Gillwald *et al*., 2010). In general, the gender access gap is strongly associated with income levels. Thus, in the poorest countries, cell phone penetration is markedly unequal in favour of men because women have lower incomes, lower levels of education and more poorly paid jobs. Countries such as Tanzania, Rwanda and Mozambique have the lowest levels of cell phone penetration and Internet access and use, and, at the same time, the highest gender gaps in the region. The gender gap in Internet use is approximately 35% in Ghana, Kenya and Tanzania; 46% in Nigeria and over 60% in Rwanda and Mozambique. In contrast, South Africa has high levels of access and gender parity (After Access, 2018: 13-15). The case of Rwanda is surprising as it is a relatively gender equal society, occupying 6th place in the most gender-equal country ranking (World Economic Forum, 2018), but the 153th position in the ITU ICT Development Index (IDI) (see Appendix). Future research is needed to investigate if Rwanda represents another case of the ICT gender equality paradox that other studies have pointed out for European countries where there is "a surprising lack of a direct relationship between gender equality levels and the proportion of female students pursuing advanced-level digital skills" (UNESCO & EQUALS, 2019: 76).

2.2 Digital skills gender gap

Current data suggest that, rather than narrowing, the digital skills gender gap is in fact widening. Moreover, it is quickly surpassing the digital access gap: "globally, digital skills gender gaps are growing – despite at least a decade of national and international efforts to close them" (UNESCO & EQUALS, 2019: 10).

The literature shows that the relationship with technologies is conditioned by gender identifications (Tomte, 2008). Various studies have found that boys and girls have similar attitudes towards the computer and Internet at an early age, but from the beginning of secondary school, gender differentiations start to appear (Mey, 2007; Volman *et al*., 2005). Female adolescents tend to be less interested in ICTs and less confident of their capacity to learn how to use them (Tomte, 2008). Over and above the more intensive use that male

adolescents make of the computer, there exist different uses. Males tend to play and program, whereas females' focus is on virtual social networks and they use technology more creatively (Colley and Comber, 2003; Howe and Mercer, 2007).

The above findings support the idea that the greater the complexity and level of advancement of skills, the greater the gender gap. While for communication and entertainment activities there is little difference between men and women regarding routine tasks, the distances become noticeable for programming and web design activities. This is worrying since computer skills and programming have the greatest impact in terms of access to work.

The gender gap also varies across and within regional boundaries. "It is more severe for women who are older, less educated, poor, or living in rural areas and developing countries. Thus, the digital skills gap intersects with, and is compounded by, issues of poverty and educational access." (UNESCO & EQUALS, 2019: 15).

Studies that document and analyze data on gender-differentiated digital skills for developing countries are scarce, making it very difficult to measure the extent of these inequalities, and to establish comparisons and tendencies among these countries. Hakfin and Huyer (2008) explain that this data scarcity is due to many governments not collecting ICT statistics consistently and regularly, while rarely disaggregating the data by sex.

The International Telecommunication Union (ITU) has collected and consolidated global data on digital skills, classified as "basic", "standard" and "advanced" (ITU, 2018)[1]. Its latest report shows a significant gap between the levels achieved by developed and developing countries for the set of these skills, as well as between male and female populations. In the remainder of this subsection, we analyze digital skills gaps by country based on recently published data bases (ITU, 2021; Helsper, 2021). We will focus mainly on six countries (four Latin American and two African), as we have information that is sufficiently robust only for these cases.

Figure 1 displays the extent of digital skills gender gaps in the mentioned countries. It averages the differences recorded for each country's male and female populations in basic and standard digital skills levels. A positive difference indicates a larger proportion of men having such skills and a negative difference, a larger proportion of women with those skills. As Figure 1 shows, among the countries considered, Brazil has the largest gender gap. However, as we shall see below, these differences may vary, depending on whether basic or standard skills (and, within these, particular skills) are considered.

The distribution of digital skills varies widely across Latin America as shown in Figure 2. The disparities are likely due to the strong overlap between digital skills and contextual variables such as economic, educational, and cultural factors.

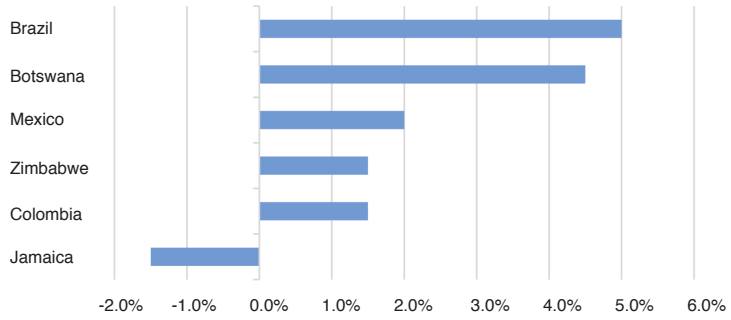

Figure 1: Differences in proportion of men and women with digital skills per country, 2017

Source: Compiled by author based on data from ITU (2021) World Telecommunication/Indicators Database. Original analysis for this Report

For the countries considered (see Fig. 2), the proportions of females and males that have recorded digital skills defined as "basic" are relatively similar but, even so, the latter have reached higher percentages[2]. This tendency is replicated for "standard" skills (see Fig. 3), although it is also noted that in all cases, for both males and females, markedly lower levels were recorded.

Further insights into the inequalities are gained by examining the gender differences across the three digital skills levels, as is done for Brazil (Table 1).

1 The ITU skills indicator is based on nationally representative household surveys. The specific digital skills considered in this scale are displayed in Table 1.
2 Jamaica could be regarded as an exception, although the skills levels registered are the lowest among the countries examined.

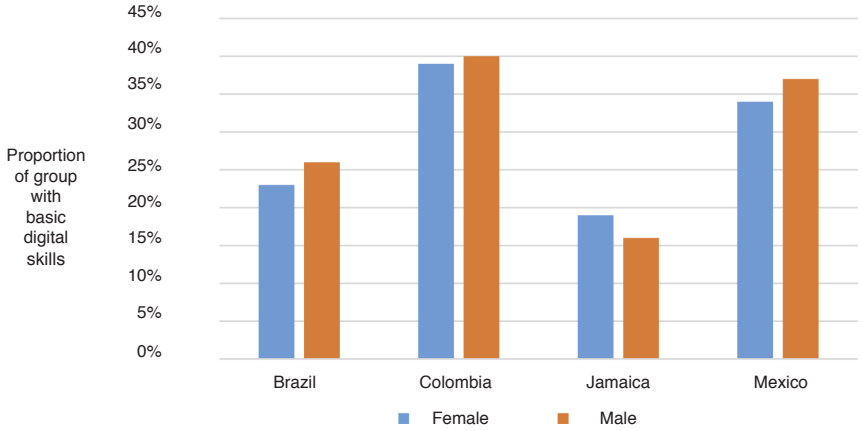

Figure 2: Gender differences in basic digital skills for four countries of Latin America and the Caribbean, 2017

Source: Compiled by author based on data from ITU (2021) World Telecommunication/Indicators Database. Original analysis for this Report

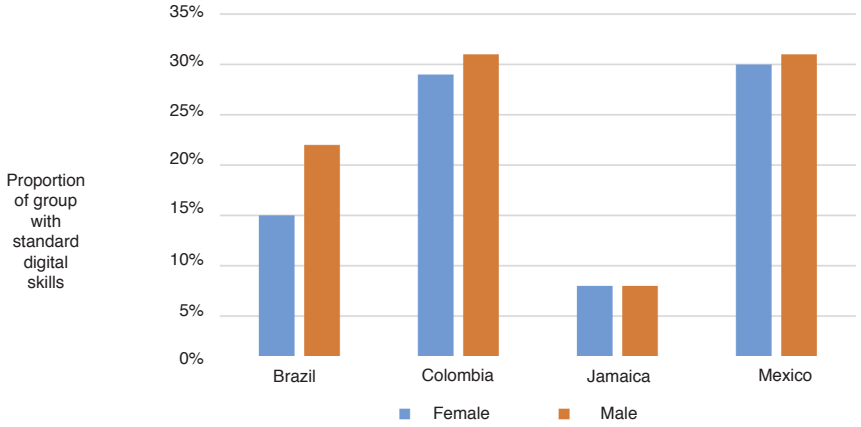

Figure 3: Gender differences in "standard" digital skills for four countries of Latin America and the Caribbean, 2017

Source: Compiled by author based on data from ITU (2021) World Telecommunication/Indicators Database. Original analysis for this Report

Table 1: Gender differences in digital skills, 2017

	Digital skills	Female proportion	Male proportion
Basic	Copying or moving a file or folder	23%	26%
	Sending e-mails with attached files	21%	23%
	Transferring files between a computer and other devices	17%	22%
	Using copy and paste tools to duplicate or	20%	22%
Standard	Connecting and installing new devices	9%	14%
	Finding, downloading, installing and configuring software	15%	22%
	Creating electronic presentations with presentation software	11%	12%
	Using basic arithmetic formulas in a spreadsheet	11%	16%
Advanced	Writing a computer program using a specialized programming language	3%	4%

Source: Compiled by author based on data from ITU (2021)

World Telecommunication/Indicators Database. Original analysis for this Report

It is evident that the proportions recorded for each type of digital skill are inversely proportional to the degree of complexity involved. While all the skills show a higher proportion for the male population, it is noteworthy that, overall, the gender gap is larger for most of the "standard" skills than for the "basic" skills.

Additional data from another source reveal a similar pattern as highlighted for Uruguay in Table 2. The Survey of ICTs use in urban households (EUTIC) reveals that the proportions of men are higher than those of

women across all the skills considered. The greatest differences were observed in relation to technical and security issues, while they were lower in relation to the management of office programs.

Table 2 : Gender differences in digital skills. Uruguay, 2019

	Gender	
	Female	Male
Office automation	66	70
Informational	69	73
Technical: devices & applications	51	62
Security & applications	63	70
Total Skills	57	63

Source: EUTIC (INE, 2019a)

For African countries, the 2017 ICT Development Index country ranking provided by the ITU positions them among the lowest-ranked (see Appendix 1). Indeed, of the 176 countries listed, nine of the ten lowest-ranked countries are African. This implies that important segments of African society are excluded from access and usage of digital technologies, with women being one of them. It can be stated that "in the typical patriarchal African societal context, the lack of access to digital devices and Internet connectivity which hinders societal digital development is felt more intensely among women and girls" (Okunoye, 2020: 95).

Specific data from two African countries, Botswana and Zimbabwe, support these findings (Table 3). In both countries gender gaps in digital skills were registered. On the one hand, while Botswana recorded higher levels for the set of the skills, the gender gaps were also wider. On the other hand, Zimbabwe showed significantly lower levels for both men and women, although it is notable that in all cases the female proportion with digital skills was under 5%.

Table 3: Gender differences in digital skills. Botswana and Zimbabwe, 2017

		Botswana		Zimbabwe	
	Digital skills	Female proportion	Male proportion	Female proportion	Male proportion
Basic	Copying or moving a file or folder	32%	37%	4%	6%
	Sending e-mails with attached files	18%	23%	3%	5%
	Transferring files between a computer and other devices	20%	28%	2%	4%
	Using copy and paste tools to duplicate or move information within a document	29%	34%	3%	4%
Standard	Connecting and installing new devices	16%	23%	1%	2%
	Finding, downloading, installing and configuring software	-	-	1%	2%
	Creating electronic presentations with presentation software	9%	15%	1%	2%
	Using basic arithmetic formulas in a spreadsheet	19%	21%	1%	2%
Advanced	Writing a computer program using a specialized programming language	4%	6%	0%	1%

Source: Compiled by author based on data from ITU (2021)

World Telecommunication/Indicators Database. Original analysis for this Report

In summary, in much of the developing world, women and girls suffer neglect and disadvantage in leveraging digital technology (Okunoye, 2020). Either by considering the Latin American and African regions as a whole, or by analyzing by country, there is a consistent unequal distribution of digital skills; females lag in every digital skill measured, and this becomes more pronounced as the complexity of the skill increases. As captured by UNESCO & EQUALS (2019: 15), "further along the skills spectrum, the divides grow wider".

2.3 Appropriation gender gap

The concept of *appropriation* is crucial to understanding the perspective of subjects in their use of technologies because it considers their ability to make this process meaningful with regards to their objectives (Thompson, 1998: 62). Moreover, appropriation is a socially, historically and biographically constructed experience that varies according to social class, gender, generation and personal history. Benefits from this technology are "unequally distributed" (Bonder, 2002: 9). Beyond differences in access and ICT skills, "the question is to what extent they reproduce in their interactions the mark of the gender patterns that circulate in the offline world. Another option is to suppose that, on the contrary, this new technology and/or the historical frame in which it is recorded, has the potential to revert or question, at least, gender patterns mainly in the communication field" (Bonder, 2002: 14 – translated).

Then, we must take account of the benefits and uses that women and men manage to obtain. "For example, although 97% of women in nine cities around the world were using social media, only 48% of them were expanding their networks, and only 21% of Internet-connected women had searched online for information related to health, legal rights or transport. In some cities, less than one quarter of connected women had used the internet to look for a job" (UNESCO & EQUALS, 2019: 18-19). Other studies in developed countries reveal marked gender differences in Internet uses: while women prevail in the use of social media such as Facebook, Twitter and YouTube (5% more than men), calls through WhatsApp (3% more than men) and the search for health information (12% more than men), men show a greater tendency to read news, newspapers and magazines (4.7% more than women), use Internet storage space (4.5%) and sell goods or services (4.4%) (INE, 2019b, quoted in Sainz *et al*., 2020: 36 - translated). In other words, men connect to the Internet for recreational and economic uses (banking and online commerce) more than women, while women tend to use the Internet more for social welfare, communication, education and health. Moreover, when gender is intersected with the socio-educational level, it is observed that women with lower educational levels are the least likely to look for work, participate in political and government issues, and consult current news (Sainz *et al*., 2020).

In Africa, there are also marked differences in favour of males in the diversity and frequency of cell phone, computer and Internet use. This is especially true in the use of social media; the gaps are significant in most countries (Nigeria 37% vs. 20%; Ghana 35% vs. 23%; Kenya 31% vs. 22%; Mozambique 13% vs. 6%). Again, the only exception seems to be South Africa where the gap is not significant (46% to 43%) (After Access, 2018: 17).

In Latin America, studies show differences in both the diversity and frequency of cell phone, computer, and Internet use in favour of men. While communication uses are similar, the search for information, online procedures, home-banking, and mobile money, as well as business management and commercial issues are greater among men (Agüero *et al*., 2019). Similarly, the use of ICT for labour issues is more prevalent among men (31% to 20%). In contrast, educational uses are slightly higher among women (39% to 37%) (Agüero *et al*., 2020). In terms of cell phone use, while there are no significant differences in terms of making calls, chatting and texting, taking pictures and videos, men are more likely to use their phone to listen to or download music and watch or download videos, play games and check or send emails (43% men vs. 36% women). Thus, in summary, men tend to make more intensive and varied use of the cell phone than women (Agüero *et al*., 2020: 13). Similar trends exist with computer use; while 38% of men indicate daily or several times a week usage, only 24% of women do so. The most frequent uses of the Internet through the computer are e-mail, social media, watching videos, chatting and listening to music, and in all of them the percentage of men doing so is higher than that of women (Agüero *et al*., 2020: 16-17). "These results seem to support the statement that men make more varied use of digital devices". Agüero *et al*., 2020: 17 - translated). Men are making more use of the Internet for activities that are work-related and for administrative and government purposes (11% and 7% respectively). Moreover, there are statistically significant gaps in favour of men, in using social media to contact customers, and conduct sales online. However, it is interesting to note that there are no gender gaps in the use of the Internet for educational activities (Agüero *et al*., 2020: 17).

Qualitative studies show that many females do not use netbooks with frequency and intensity at home due to the lack of time and the lack of relevance as they have to perform household chores and care work. Especially among lower classes, there is a gendered digital divide related to the unequal distribution of these household chores (see for example Benítez Larghi *et al*. (2015) in Argentina; Bossio & León (2015) in Perú; Philippi & Peña (2015) in Chile).

Consequently, the gender digital gap tends to replicate existing gender inequalities in relation to the division of productive and reproductive work. In this sense, ICT appropriation seems to obey traditional and hegemonic gender roles; while commercial, labour and income management activities have traditionally been assumed by men, the tasks of caring and domestic work have fallen on women.

3. Barriers to the full participation of women in the digital economy

The main barriers to women's access to and use of ICTs are: device and connectivity costs; lower levels of literacy and education, traditional cultural beliefs and practices, economic inequality, male-dominated ICT design, household responsibilities, less financial resources, geographical localization (UNESCO & EQUALS, 2019; Agüero *et al*., 2020; After Access, 2018; Sainz *et al*., 2020). These barriers are part of larger social inequalities, which can be classified according to their connection with economic factors, knowledge and digital skills development and socio-cultural patterns.

Firstly, economic factors are identified as the main barrier for those without access to devices and the Internet. In this regard, women tend to be more affected than men. This is the case especially for Africa, "where the cost of devices is the primary barrier for those who are not connected, while for those who are connected the reason for low usage is the price of data services (…) however, particularly in predominately rural areas populations, access to electricity is a greater challenge than not having mobile coverage" (After Access, 2018: 21). The situation is exacerbated for women from low-income sectors and rural areas.

A second type of barrier to women's participation in the digital economy is related to knowledge and digital skills. In Latin America, this type of barrier has become even more important than the access barrier. Thus, the lack of knowledge about what it is and how to use the Internet appears in greater proportion among women than among men (40% versus 33%) (After Access, 2018: 21). In Brazil, for example, "women are also far more likely to report that they do not see a reason to access and use ICT. Interest and perception of need are closely related to skills, as people who have little experience with or understanding of ICTs tend to underestimate their benefits and utility" (UNESCO & EQUALS, 2019: 28-29).

A similar pattern occurs in Africa, where knowledge of the Internet is lowest among women in rural areas (less than 35%). In Kenya, for instance, the number of women who indicate not knowing what the Internet is, is more than double that of men (After Access, 2018: 22-23). However, the fact that Internet use is higher among urban women than rural men indicates that "the gender gap is not necessarily because of the sex of an individual, but could be due to many other factors, such as location. Where women are at the intersection of multiple factors of inequality, they are the worse off" (After Access, 2018: 23).

These asymmetries in knowledge and skills lead us to a third type of barrier, framed within the social structures and cultural patterns that tend to segregate women. For instance, women's ICT appropriation is constrained by their exclusion from education in technology, time constraints, financial limitations and social norms that favour men (Gillwald *et al*., 2010). Furthermore, literature points out that a major problem for women's empowerment is the non-recognition and undervaluing of their knowledge. Thus, "women tend to have less confidence in their ICT abilities than men and this has consequences in actual outcomes" (Agüero *et al*., 2019: 3). While girls and boys have the same types of digital skills, the former are less confident of their abilities:

> "The stereotype of technology as a male domain is pervasive in many contexts and appears to affect girls' confidence in their digital skills since a young age (…) The most compelling evidence of the impact of gender stereotypes around technology is the 'self-efficacy' gender gap, or the difference between girls' and boys' confidence and belief in their abilities (…) Yet despite demonstrating promising early performance, girls had lower levels of self-efficacy even when they outperformed or performed similarly to boys on measures of digital skills (…) Thus the disparities in confidence and belief in self-efficacy that surface in late primary and early secondary school become prophetic as education advances: When girls lose faith in the strength of their digital skills, they abandon or steer clear of technology-oriented studies, and this, in turn, likely results in an amplification of self-doubt among the girls who remain. Girls' confidence drops slowly at first and then precipitously, so that by the time female students complete higher education, only a tiny fraction graduate with ICT degrees" (UNESCO & EQUALS, 2019: 20-23).

The above-mentioned barriers have two direct consequences that deepen gender inequalities. Firstly, they constrain women's entry into STEM careers; and secondly, and linked to the above, they sustain a lower participation of women in the digital economy. In the following subsections we illustrate both processes in the cases of Latin America and Africa.

3.1 ICT and the gender gap in STEM

The link between women's access to STEM and gender inequality is expressed in a number of metaphors that explain the invisible limitations that hinder women's professional careers: "glass ceiling", "glass walls" and "sticky floor". These various unexpressed barriers, both vertical and horizontal, block women's development in science and technology fields.

Although several studies support evidence on stereotyping, Huyer (2003, 2005) includes in her analysis clear barriers, which determine less access to scientific and technical education: cultural and attitudinal barriers based on perceptions and traditional gender roles, situational barriers where context (natural or cultural) limit and restrict their actions and qualification barriers. These barriers have not yet been analyzed in Latin America and Africa.

The misleading belief that science learning occurs only in-school is surprisingly widespread, although it has been challenged by several researchers who have proven the importance and influence of out-of-school science activities. The fact that there are systemic barriers that prevent greater participation of women in STEM, leads to a complex situation in which we understand that efforts should be made on two different and parallel paths. On the one hand, it is essential to provide robust evidence on the systemic barriers that are prompting unequal access of women to STEM careers in developing countries; and on the other, it is critical to work on the design of protocols and interventions that contribute to the creation of fair and equal access to scientific culture.

According to the UNESCO (2017), girls' and women's participation in STEM careers reaches only 35%, with most in the health and care fields. The same study shows that that there are multiple factors that deter girls from STEM subjects at high school. A report from OEI (2018) explains that even in those countries where access to university is equal in terms of gender, vertical exclusion of women in the science and technology system is still strong.

In Latin America, 60% of university graduates are women, yet they represent only 30% of STEM graduates and 28% of ICT graduates (Agüero *et al.*, 2020: 12). Chile has the largest gender gap in ICT, with only 13% of ICT graduates being women (OEI, 2018: 9). In contrast, Argentina seems to perform well in terms of women's participation in STEM fields, reaching almost 60%. However, a closer look at the data reflects several issues; senior positions and budgets are two of the indicators that show significant inequities. In addition, the low demand for science and technology degrees by women is also worrying. Enrollment in computer sciences barely reaches 7%, engineering (across all types) reaches 22% and physical sciences, 33% (http://estadisticasuniversitarias.me.gov.ar/). The factors that keep women away from computer sciences are largely stabilized in adolescence; among girls, computer science is in the second to last place and it is chosen by only 2.3% of those interviewed. In the case of boys, IT appears as the most favoured career, with a 19.4% preference.

In Africa, the levels of women's representation in STEM careers are even lower than in Latin America. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), the percentage of women researchers reaches only 30% in sub-Saharan Africa. Although the situation varies greatly from one country to another, as can be seen from the percentage of women researchers in some African countries: South Africa (43.7%); Egypt (42.8%); Morocco (30.2%); Senegal (24.9%); Nigeria (23.3%); Rwanda (21.8%); Cameroon (21.8%); Ethiopia (31.3%) (AAS, 2020: 12). According to UNESCO (2015), the lowest ratios of women to men graduates at the tertiary level tend to be found in low income countries. Examples are Ethiopia (31%), Eritrea (33%), Guinea (30%) and Niger (28%). In Central African Republic and Chad, male tertiary students are 2.5 times more common than female ones (AAS, 2020: 13). In this context, less than 25% of African higher education students are in STEM fields, with the majority of students studying social sciences and humanities. Unfortunately, most African schools do not specialize in STEM subjects[3]. Low proportions of female students enrolled in engineering are found in sub-Saharan Africa, while the attrition rate from higher education STEM careers is particularly high among women, and girl´s achievement in sciences at school is lower than that of boys (UNESCO, 2017: 21-24).

3.2 ICT and the gender gap in the digital economy

Low levels of women´s self-efficacy operate as a barrier to access the labour market linked to the digital economy. The gender gap for technology workers is over 28%, while the average gap for all workers is

3 African Development Bank quoted in https://thestempedia.com/blog/stem-education-in-africa-the-past-present-and-future/

around 6% (EQUALS, 2018; UNESCO & EQUALS, 2019). “A smaller number of women studying ICT in secondary school and college translates into a gender gap in the labour market. Globally, women hold only 24% of all digital sector jobs, and in developing countries, men are 2.7 times more likely than women to work in the digital sector (…) As the digital sector grows and jobs become more digitally-intensive, this trend has the potential to further exacerbate the pay gap between men and women” (UNESCO & EQUALS, 2019: 24-25). Again, cultural barriers, that is, stereotypes that associate ICT careers and jobs with a male domain and activities, produce gender asymmetries and inequalities.

In Latin America, the gig economy, based on the use of digital platforms, could expand women’s employment opportunities by offering greater time flexibility and reducing entry barriers in an industry that, as seen above, is heavily male-dominated (Agúero *et al*., 2020; Bustelo *et al*., 2019). However, this type of employment lacks sufficient labour protection and social security, while the employment relationship between workers and companies becomes opaque (Bosch *et al*., 2018; Bustelo *et al*., 2019). Statistics show that participation of men and women in the gig economy is very low in the region. Studies in Colombia, Argentina, Paraguay, Peru, Ecuador and Guatemala indicate that less than 10% of the people (7% for men and 5% for women) who use the Internet have earned money, during the last year, by doing some work within the gig economy (Agüero *et al*., 2020: 20). The greater participation of men in this economy in relation to women replicates traditional labour market patterns: women tend to concentrate on jobs related to the purchase and delivery of household goods and cleaning services, while men do so in those related to taxi services (Agüero *et al*., 2020: 21).

Galperín and Arcidiacono (2020) provide evidence confirming a complementary hypothesis: unequal access to employment explains the differences in access, skills development and beneficial use of the Internet between men and women in favour of the former. In other words, due to differences in employment patterns, being employed affects Internet use differently for men and women. They argue that this adds a new determinant to the gender digital divide that deserves to be addressed by public policy. For example, in the cases studied in Peru, Mexico and Ecuador, “lower female labour participation and higher incidence of part-time work among women are associated with fewer opportunities to access the Internet at work or develop ICT skills through job training and intensive use of the Internet” (Galperín and Arcidiacono, 2020: 52 – translated). In addition, they detect how the unequal distribution of unpaid domestic work results in less intensive use and lower acquisition of digital skills by women (Galperín and Arcidiancono, 2020: 54).

> “Even when using the lower limit estimates for each country, the results suggest that differences in employment are responsible for about a quarter of the gap in Internet use between men and women. The only other variable with a similar-sized contribution is educational attainment, which in Mexico and Peru is responsible for approximately one-quarter of the gender digital divide. In the case of Ecuador, gender differences in income seem to contribute more than differences in educational level. However, the contribution is significantly less than that of employment. In general, the results of the decomposition validate the hypothesis that gender gaps in labour force participation, unemployment rates, and part-time employment lead to different opportunities for Internet access and digital training between men and women in the region” (Galperín and Arcidiancono, 2020: 66 – translated).

A similar pattern is noted in the few available studies for African countries. Using data from six sub-Saharan African countries, Alozie and Akpan-Obong (2017) find that employment positively affects Internet adoption among men, but not among women. In this regard, we see how far-reaching social and cultural patterns affect the appropriation of digital technologies and the Internet, forming a vicious cycle whereby women then have fewer opportunities for access to the labour market and to highly qualified and highly-paid jobs in the digital economy. Even though the sub-Saharan Africa region is characterized by high female labour force participation (World Economic Forum, 2018), women´s participation in the tech industry is low. For example, by 2015, less than a 15% of women in Africa were working in technology (Jamme, 2015). This is tending to change with the gig economy. By the end of 2018, there were 277 unique digital platforms in Africa alone, serving close to 5 million gig workers (54% male and 46% female) (Research ICT Africa, 2018). A study in Kenya indicates increasing participation of women in the digital gig economy but it was observed that women were more involved in traditionally female-oriented jobs, such as hair-dressing, beauty, and housekeeping (Kiarie *et al*., 2020). “Gig work appears to affect the strategies that (mostly) women use in combining paid work with unpaid care. Although many workers viewed gig work as more flexible and conducive to a manageable work–life balance than other paid work available to them, they were nonetheless still forced to make difficult trade-offs between their time-use, income-generation and caring roles” (Hunt *et al*., 2019:10). Moreover, the income generated through the platform is essential for meeting basic needs for 68% of women gig workers compared with 45% of men gig workers. Women also tend to be more flexible in pricing and hence are more susceptible to being underpaid on gig platforms (Kiarie *et al*., 2020).

In summary, regardless of which variable is dependent and which is independent, technological appropriation (with all that it implies: access, digital skills and Internet use) and employment patterns are always correlated, contributing to the widening of the gender digital gap in favour of men and to the detriment of women.

4. Closing the digital gender gap

In the last few decades, the digital gender gap and women's empowerment through ICT have become an important issue in academic investigations and public policy. "A better understanding of all aspects and manifestations of the gender digital divide is essential in order to be able to prevent the adverse impact of the current trends of access and use on women worldwide, as well as to enhance the potential of ICTs to become an effective tool for women's empowerment (…). Empowerment, therefore, necessarily embodies challenging patriarchy at all its levels of expression: social structures and relationships, moral and cultural values and norms, and institutions and power structures" (Huyer and Sikoska, 2003: 2-4). Considering that technologies are not gender neutral, projects and policies should develop a gender perspective in ICT that focuses on women's needs, with meaningful and useful content that enables the appropriation of ICTs and the empowerment of women. "ICTs have the potential to alleviate some of the barriers that women face, including illiteracy, poverty, time scarcity, hindrances of mobility and cultural and religious taboos. ICTs also have the potential to provide tools that may break constraints on voice, particularly public voice, and social control including surveillance of women's physical and social mobility" (SIDA, 2015: 1). In summary, closing the gender digital gap is not only about providing ICT access to women, but is also about developing specific strategies and projects according to women´s needs, interests, technological trajectories, cultural and social context, ensuring a gender perspective.

In the following sections we provide examples of interventions aimed at closing the gender digital gap in Latin America and Africa and we analyze how gender can be integrated into public policies for digital inclusion and development.

4.1 *Chicas en tecnología* (Girls in Tech)

"*Chicas en tecnología*" (CET)[4] is an Argentinian non-profit organization created in 2015, whose main goal is to reduce the digital gender gap in the region by promoting the development of digital skills, technology-related training spaces and encouraging the approach of young women to STEM careers. By doing so, they support seven of the UN's SDGs[5]. CET comprises an interdisciplinary team of mostly female professionals.

Their initiatives, programs and campaigns have reached over 5 000 girls and young women and, by 2019, 84 cities over the country. Specifically, they have developed five main programs, in which participation is open and completely free of charge, involving a wide range of activities such as workshops, mentorships, a virtual campus, webinars, and internships, among others. For example, over 220 adolescents have participated in the "Programming a Better World" program (PUMM), a set of intensive meetings where girls from different schools can join to develop applications which offer solutions for problems in their own environments. Through these activities, CET has strengthened partnerships with more than 30 companies, organizations and institutions.

Most of CET's initiatives target female adolescents of secondary school age, encouraging their interests regarding technologies and bringing them closer to working and formative opportunities in ICT fields. As a result, CET expects to empower female adolescents and promote their self-efficacy, reinforcing their self-perceptions as leaders in technologies.

Through the online program 'Protagonists of the Future', CET has extended its scope of action to the regional level, as it intends to provide free workshops and talks to young women from another five Latin-American countries. Additionally, they conduct and participate in research projects that collect, analyse and communicate data aiming to provide guidance for promoting access to Science, Technology, Engineering, Arts and Mathematics (STEAM) areas.

CET has received several prizes and awards, including the Google Rise Award in 2016. Through its initiatives, CET aims to promote gender-inclusive practices that contribute to cultural and systemic change.

4 https://chicasentecnologia.org/

5 hese are: Quality Education; Gender Equality; Decent work and Economic Growth; Industry, Innovation and Infrastructure; Reduced Inequalities; Peace, Justice and Strong Institutions; and Partnerships.

4.2 Women of Uganda Network (WOUGNET)

The Women of Uganda Network (WOUGNET)[6] is a non-governmental organization initiated in May 2000 by several women's organizations in Uganda to develop the use of ICTs as tools to share information and address issues collectively among women. WOUGNET's vision is a society in which women are empowered through the use of ICTs for sustainable development.

WOUGNET's mission is to promote and support the use of ICTs by women and women's organizations in Uganda, in order to enable them to take advantage of the opportunities offered by ICTs to effectively address national and local sustainable development challenges. ICTs such as email and the Internet facilitate communication among local organizations and with the international community. Access to information about best practices, appropriate technologies, and the ideas and problems of other groups dealing with similar concerns have been identified as critical information and communication needs for women's organizations in Africa. WOUGNET activities are conducted under three program areas: Information Sharing and Networking, Technical Support, and Gender and ICT Policy Advocacy. This last project aims to strengthen the skills of other gender activists and highlights their main issues during meetings with policy-makers, stressing the need to integrate gender into ICT policies. These include research, studies and analysis of issues in the areas of e-governance, Internet access, women rights online and ending gender-based violence.

4.3 *Paremos el Acoso Callejero* (Stop the street harassment)

Paremos el Acoso Callejero is a Peruvian feminist organization, considered the main source of information on street harassment and recognized for its commitment to building cities based on respect, where women and men can move around with equal freedom and without fear of being harassed because of their gender or sexual orientation.

The organization carries out different anti-harassment tactics and strategies based on research, collective training, and ICT appropriation. One example is the development of the Virtual Street Sexual Harassment Map. In a very simple way, victims of sexual harassment can make complaints, indicating the exact place where the incident occurred. This virtual tool serves to make the problem visible and to put pressure on the respective State agencies to take action.

4.4 Women´s Net

Women's Net[7] is a feminist organization that works to improve gender equality and justice in South Africa, through the use of ICTs. They provide training and facilitate content dissemination and creation that supports women, girls, and women's and gender organizations and networks to take control of their own content and ICT use.

One of its main projects is GirlsNet, which provides girls a virtual space for learning, sharing, and networking. This platform gives the girls the opportunity to feed content onto the website with the citizen journalism skills they have acquired. It is an ideal opportunity for them to document the issues that concern them about their community and to teach others how to do the same.

The Social Media Training project equips young females with the necessary tools and skills to harness the power of social media via various ICTs. Workshops provide women with knowledge about safety online, using social media for campaigns and causes, tips on web-based article writing and how to spread positive change online through social media platforms. The project is designed to help women's organizations to meet each other, find people, discuss issues, share resources and sharpen their tools for social activism.

4.5 #NiUnaMenos

In Latin America, there are numerous experiences of appropriation of ICTs to denounce violence against women. By using the Internet and social networks, women's movements are able to generate repertoires of collective action by articulating the online and offline worlds in favour of women, their demands and claims. This continuum favours the reduction of inequalities due to the digital gap since, according to these

6 https://www.wougnet.org/home
7 https://womensnet.org.za/

organizations, “the activities and meetings help older people or minorities with difficulties in accessing the Internet to participate and feel included” (Navarro et al., 2018: 296 – translated).

#NiUnaMenos movement has had a strong presence in the region with an epicentre in Argentina. On 3 June 2015, some 420 000 people demonstrated against male violence and femicide in more than 240 locations throughout the country. According to Laudano (2017), this massive demonstration was generated over several days through social networks such as Facebook and Twitter. Through selfies and other altered or modified images, the campaign in favour of the call became a Trending Topic on Twitter with the hashtag #NiUnaMenos. For the first time in the country, a feminist theme was ranked number 1 on the social media. According to Accossatto and Sendra (2018), the experience can be typified as feminist political cyberactivism: “Ni Una Menos deployed a strategic use of ICTs that allowed it to position itself as a mass movement, while at the same time energizing internal organizational mechanisms” (Accossatto and Sendra, 2018: 118 – translated). The use of social media not only facilitated the diffusion and visibility of women’s demands and claims but also contributed to the movement’s internal communication and decision-making.

The case of #NiUnaMenos is interesting because it allows us to reflect on the forms of articulation between offline organization, online communication and street demonstrations. What is certain is that women with previous activism experience and other women who joined after the massification in the social media converged there. In this way, the experience of #NiUnaMenos shows how women, through the appropriation of ICTs, can strengthen gender identity, form a collective actor capable of expressing their voice, and generate forms of democratic participation in public life.

The above are some examples of successful experiences in overcoming the digital gender gap in Latin America and Africa. Based on an analysis of their attributes, a set of good practices emerges to develop the digital skills of girls and women, to develop self-confidence in girls’ own abilities from childhood and to encourage an interest in ICT-related careers. These examples of good practices share the following characteristics:

1. They are based on a concrete need of the social actors within a given context;
2. They involve the development of digital skills in a contextualized way from a non-techno-centric perspective;
3. They manage to promote trust by working on the deconstruction of hegemonic gender stereotypes;
4. They are built as collective initiatives that are the fruit of the action of girls and women as protagonists and not as passive beneficiaries.

5. Contribution of digital technologies to the achievement of the Sustainable Development Goals (SDGs) and key recommendations

The correlation between digital gaps and previous social inequalities is a matter of debate. There are those who, from a more pessimistic viewpoint, argue that the emergence of ICTs (through their access or lack thereof) would be another manifestation of existing social inequalities, that they would be reproducing, reinforcing and deepening. Others, from an optimistic standpoint, affirm that access to and use of the opportunities created by ICTs make it possible to reduce existing inequalities, both among countries and among social groups, by making available resources that have hitherto been confined to an economic and cultural elite.

In the current context, gender equality in relation to the appropriation of digital technologies transcends the mere demand for women’s inclusion in these areas and involves questioning the patriarchal values that regulate them. Consequently, not only reducing the gender gaps but also transforming gender power relations is critical to achieving the SDGs contained in the UN´s 2030 Agenda for Sustainable Development (UN, 2015).

In general terms, equal access and appropriation of digital technologies will contribute to a reduction in poverty (objective 1), access to good health services (objective 3), quality education (objective 4), gender equity (objective 5), improved employment conditions and economic growth (objective 8), development of innovation, industry, and infrastructure (objective 9), reduction in inequality (objective 10), and improved transparency and institutional stability through participation in public life and open government (objective 16).

The equitable appropriation of digital technologies by women will make it possible to contribute to the achievement of the following specific goals:

1.4 Ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.

4.4 Increase the number of youth and adults who have relevant skills;

4.5 Eliminate gender disparities in education and ensure equal access to all levels of education and vocational training;

5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation;

5.5 Ensure women's full and effective participation and equal opportunities for leadership;

5.B Enhance the use of enabling technology, in particular, ICT, to promote the empowerment of women;

9.C Increase access to ICT and strive to provide universal and affordable access to the Internet in least developed countries;

10.2 Empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status;

Even though ICT access is becoming universal among men and women, different kinds of inequalities persist. The question, now that ICT access is increasing, is how these inequalities are evolving and what "new inequalities" are developing. Although the access divide has significantly decreased over the past few years and women are now "less unequal" (in material and symbolic terms) than before, unequal ICT appropriation is ongoing and will result in long-term inequalities. Considering this, new research is needed to address the ways in which these effects emerge and are experienced by girls and women and how they can be changed through specific public policies.

Based on the analysis displayed in the previous sections, we propose the following key recommendations for public policy-makers:

1. Ensure Internet access in all regions and geographical areas of each country, giving special consideration to economic restrictions for poor women in rural areas.
2. Meet training demands through contextualized programs, which transmit and build skills based on local interests and needs (and not through standardized training packages or focusing on hardware and software).
3. Understand that potential benefits of the Internet must first become significant according to the perceptions and representations of the populations involved.
4. Propose concrete interventions that aim to dismantle stereotypes around ICT.
5. Build sensitive analytical tools to interpret how gender identities are co-constructed simultaneously with technological practices.
6. Given the gender inequalities among young people, implement educational strategies that encourage female adolescents to develop new and meaningful ICT skills that enable them to continue their studies and/or get well paid and satisfying jobs.
7. Regulate the gig economy to guarantee equal working conditions and pay for women.
8. Capitalize on the potential of ICTs for the defence of women's rights; the expression of the demands of feminist movements and the construction of new forms of masculinities.

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Appendix 1

The ITU ICT Development Index (IDI) is a composite index that combines eleven indicators on ICT access, use and skills into one benchmark measure of the level of ICT development in countries across the world. By doing so, it makes it possible to monitor and compare ICT development between countries and over time.

IDI 2017 covers 176 economies worldwide. We have extracted the positions held by Latin American and Caribbean (LAC) and African countries, in order to provide an overview of the level of ICT development of these economies.

Position	Region	Country
34	LAC	Barbados
37	LAC	St. Kitts and Nevis
42	LAC	Uruguay
51	LAC	Argentina
56	LAC	Chile
57	LAC	Bahamas
60	LAC	Costa Rica
66	LAC	Brazil
68	LAC	Trinidad & Tobago
72	Africa	Mauritius
73	LAC	Grenada
76	LAC	Antigua & Barbuda
77	LAC	Dominica
82	LAC	St. Vincent and the Grenadines
84	LAC	Colombia
86	LAC	Venezuela
87	LAC	Mexico
88	LAC	Suriname
90	Africa	Seychelles
92	Africa	South Africa
93	Africa	Cape Verde
94	LAC	Panama
96	LAC	Peru
97	LAC	Ecuador
98	LAC	Jamaica
104	LAC	St. Lucia
105	Africa	Botswana
106	LAC	Dominican Rep.
112	LAC	Bolivia
113	LAC	Paraguay
114	Africa	Gabon
116	Africa	Ghana
118	Africa	Namibia
119	LAC	El Salvador
120	LAC	Belize
124	LAC	Guyana
125	LAC	Guatemala

Position	Region	Country
129	LAC	Honduras
130	LAC	Nicaragua
131	Africa	Côte d'Ivoire
132	Africa	S. Tomé & Principe
133	Africa	Lesotho
136	Africa	Zimbabwe
137	LAC	Cuba
138	Africa	Kenya
142	Africa	Senegal
143	Africa	Nigeria
144	Africa	Gambia
146	Africa	Zambia
149	Africa	Cameroon
150	Africa	Mozambique
152	Africa	Uganda
153	Africa	Rwanda
155	Africa	Mali
156	Africa	Togo
160	Africa	Angola
161	Africa	Benin
162	Africa	Burkina Faso
163	Africa	Equatorial Guinea
165	Africa	Tanzania
166	Africa	Guinea
167	Africa	Malawi
168	LAC	Haiti
169	Africa	Madagascar
170	Africa	Ethiopia
171	Africa	Congo (Dem. Rep.)
172	Africa	Burundi
173	Africa	Guinea-Bissau
174	Africa	Chad
175	Africa	Central African Rep.
176	Africa	Eritrea

Source: ITU (https://www.itu.int/net4/ITU-D/idi/2017/index.html)

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