

Analysis of Mobile and Internet Network Coverage: Propagation of Electromagnetic Waves and Concept of Digital Divide in Burundi

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Abstract

Mobile and Internet network coverage plays an important role in digital transformation and the exploitation of new services. The evolution of mobile networks from the first generation (1G) to the 5th generation is still a long process. 2G networks have developed the messaging service, which complements the already operational voice service. 2G technology has rapidly progressed to the third generation (3G), incorporating multimedia data transmission techniques. It then progressed to fourth generation (4G) and LTE (Long Term Evolution), increasing the transmission speed to improve 3G. Currently, developed countries have already moved to 5G. In developing countries, including Burundi, a member of the East African Community (ECA) where more than 80% are connected to 2G technologies, 40% are connected to the 3G network and 25% to the 4G network and are not yet connected to the 5G network and then still a process. The objective of this article is to analyze the coverage of 2G, 3G and 4G networks in Burundi. This analysis will make it possible to identify possible deficits in order to reduce the digital divide between connected urban areas and remote rural areas. Furthermore, this analysis will draw the attention of decision-makers to the need to deploy networks and coverage to allow the population to access mobile and Internet services and thus enable the digitalization of the population. Finally, this article shows the level of coverage, the digital divide and an overview of the deployment of base stations (BTS) throughout the country to promote the transformation and digital inclusion of services.

Keywords

Coverage of Mobile Networks and Internet, Digital Divide, Rural and Isolated Areas, Antenna, Connectivity and Digital Inclusion

1. Introduction

The issue of mobile and internet network coverage is becoming more and more important, influenced by many factors. Rural and isolated areas often face constraints in terms of connectivity and accessibility to mobile networks and the Internet. Therefore, the deployment of cost-effective and sustainable basic telecommunications infrastructure in rural and remote areas represents a crucial aspect to ensure coverage of the rural environment, especially in remote areas with low coverage. This in turn helps reduce gray areas.

In order to benefit from the benefits offered to the population, including those living in rural areas, it is essential to deploy mobile and Internet networks to ensure total geographic and demographic coverage. This will enable connectivity of these localities and thus reduce the digital divide between urban and rural areas. Indeed, the coverage of mobile networks and the Internet constitutes a basic foundation for offering accessibility and diversification of services from information and communication technologies (ICT). Therefore, the deployment of mobile networks and the Internet improves the signal reach in the most remote and isolated places.

The deployment of ICT services in rural areas facilitates the penetration of digital transformation and digitization.

According to the Global System Mobile Association, in “The Mobile Economy 2023” ([1], p. 4), 3.5 billion people are not covered by mobile networks and the Internet.

The Federal Communication Commission (FCC) website for the United States states that as of June 30, 2022 ([2], p. 2), 367 million individuals were mobile subscribers, while 125.8 million were connected to high-speed Internet as of December 31, 2021. ([3], p. 2)

In Asia, Malaysia, according to the Malaysian Communications and Multimedia Commission (MCMC), the 2023 report indicates that mobile network users numbered 50136.5 million, comprising both postpaid and prepaid subscriptions, which represents a penetration rate of 148.7%. ([4], p. 7).

Concerning internet subscriptions, the Internet Observatory 2022 indicated a clear increase in subscriptions, going from 88.7% in 2020 to 92.7% in 2022, an increase of 4% ([5], p. 15).

In sub-Saharan Africa, according to figures produced by Orange, the coverage of the 3G network is 75% and that of 4G is estimated at 49% ([6], p. 14). The operator Orange’s strategy is to deploy lightweight base stations in remote areas of central and eastern Africa in order to reduce energy consumption ([7], p. 15).

It is evident that energy deployment is a more important factor in promoting coverage, especially in sub-Saharan Africa, where 600 million people (according to Orange, 2023) do not have access to electricity.

The Orange Middle East and Africa Company offers solar kits and sustainable energy management solutions using smart meters to enable the deployment of equipment and reduce the digital divide linked to coverage and accessibility. These solutions are designed to facilitate the deployment of ICT networks and services.

In Burundi, despite the efforts of telecommunications operators, certain areas of the national territory still lack complete geographic coverage. As of December 31, 2022, the geographic coverage of the GSM mobile network was 92% in 2G, 41% in 3G and 16% in 4G.

The penetration rate of mobile services is 66.02%, while that of the overall Internet is 22.9% as of December 31, 2023 ([8], p. 4).

In order to achieve optimal coverage and identify areas of low signal strength, it is essential to analyze the signal transmission chain, with particular emphasis on signal propagation and transmission between a transmitter and a receiver. This analysis should also include an investigation of potential constraints associated with interference in the signal transmission system, including a review of frequency resources and the deployment of base stations for maximum coverage and quality of service.

This article will undertake a theoretical study of the evolution of mobile and Internet networks, with a view to identifying isolated areas not covered by the network and proposing strategies for their overall coverage. Finally, the article will examine the concept of digital divide between urban, semi-urban and isolated rural areas, and propose strategies to ensure coverage of rural and isolated areas, assess the impacts and contribution of ICT coverage on conditions of life of the populations.

2. Literature review

In an article published in 2020, titled “The Evolution of Mobile Networks towards 5G”, authors Azar Abid Salih, Subhi RM Zeebaree, Ahmed Sinali Abdul Raheem, Rizagr R. Zebari, Mohammed AMSadeeq and Omar M. Ahmed ([9], p. 3, 4) posit that the evolution of mobile wireless communications has been characterized by a series of significant changes over generations. The first generation (1G) was used exclusively for voice calls, while the second generation (2G) focused on digital telephone communication and text messaging services. The third generation (3G) appeared, supporting multimedia techniques and improving the process of information transmission. The fourth generation (4G) is significantly faster and more reliable than 3G, overcoming the limitations of 3G and improving quality of service and data transfer capacity.

As observed by François Bart (2019) ([10], p. 4), Africa is a continent characterized by great diversity and marked by strong upheavals. In this context, the advent of digital technology has played a central role in the development of the

continent, favoring the emergence of a new and innovative generation.

In their article published in September 2022, Lanseur Akila and Ait Sidhoum Houria argue that a customer's decision to change service operator is influenced by three main factors: the quality of GSM and Internet coverage, the cost and pricing policy of the service and the overall price of the service ([11], p. 9, 14).

The GBAME Hervé Daniel article indicates that research carried out in the countries of the West African Economic and Monetary Union (UEMOA) has demonstrated that investments in the telecommunications sector play an important role in improving the performance of this sector while reducing the risk of congestion on mobile networks. This article demonstrates that numerous studies have concluded that the liberalization of the telecommunications sector has considerably reduced costs and improved the quality of service and accessibility to telecommunications networks. ([12], p. 2, 8)

The objective of our study is to analyze the coverage of telecommunications networks, with a view to determining the level of mobile and Internet coverage and proposing improvements. This will involve analyzing the digital divide in order to propose strategies to promote universal service through access to digital services in our country.

In Burundi, despite the deployment of mobile networks and broadband Internet, there are still areas where the radio signal is insufficient to ensure connectivity, particularly in remote and isolated locations. This constitutes a challenge and shortcoming for the Burundian population residing in these areas, who are unable to take full advantage of the opportunities offered by the deployment of mobile and Internet networks in the country. The article highlights the causes that hinder the maximum coverage of the country and will propose strategies to reduce the uncovered areas.

3. Materials and Methods

3.1. Theoretical Approach

Before describing the methodology adopted to carry out our study, it is appropriate to summarize some theoretical notions of the propagation of electromagnetic waves, planning of the radio frequency spectrum, antennas, network coverage and reduction of the digital divide.

The thesis of Jasmina Wallace, 2020 ([13], p. 36], shows that photons can propagate in a vacuum in a straight line while carrying an elementary energy E , called "quantum". The energy flow carried by photons is proportional to the frequency of the wave and is defined by the formula: The energy carried by a photon is given by the equation $E = hf$, where h is Planck's constant (6.62×10^{-34} J·s).

The energy E , expressed in joules (J) or electronvolt (eV), is linked to the wavelength λ by the following formulas:

$$E = 1.98 \times 10^{-25} \lambda \text{ J} = 1.24 \times 10^{-6} \lambda \text{ eV} .$$

The main characteristics of electromagnetic waves are frequency, wavelength

and period.

Frequency and period are linked by the following equation:

$$T = 1/f .$$

The wavelength λ in a vacuum is the propagation distance over a determined period of time, expressed in meters per second (m/s), and is calculated by the expression:

$$\lambda = cT = c/f ,$$

with: C = the speed of light (approximately 3×10^8 m/s); F : frequency in Hertz (HZ); λ : wavelength of the signal in meters (m).

The following **Figure 1** graphically represents a variable electromagnetic wave signal.

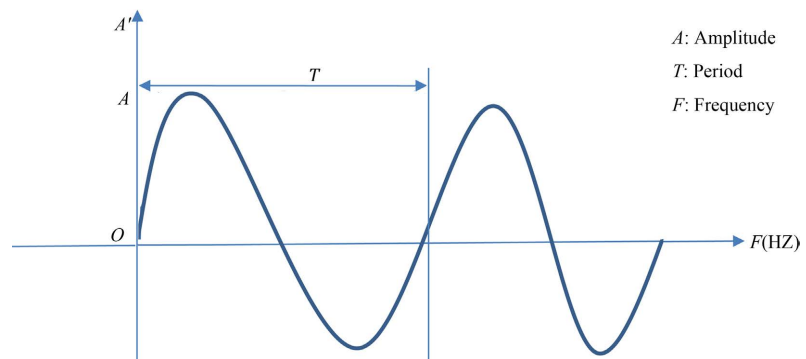


Figure 1. Sine wave of amplitude A and frequency F .

According to the Radio Regulations (RR) of the International Telecommunications Union (ITU), the whole world is subdivided into three regions and our country is located in Region 1. **Table 1** indicates the subdivision of the radio spectrum.

Table 1. Distribution of the radio band ([14], RR, 2012).

No.	Frequency band	Denomination
1	300 GHZ - 30 GHZ	EHF: Extra high frequency
2	30 GHZ - 3 GHZ	SHF: Higher High Frequency
3	3 GHZ - 300 MHZ	UHF: Ultra high frequency
4	300 MHZ - 30 MHZ	VHF: Very high frequency
5	30 MHZ - 3 MHZ	HF: High frequency
6	3 MHZ - 300 KHZ	MF: Average frequency
7	300 KHZ - 30 KHZ	LF: Low frequency
8	30 KHZ - 3 KHZ	VLF: Very low frequency

3.1.1. Channelling of 2 GHZ Frequencies in the GSM 900 MZ and 1800 MHZ Bands

In Burundi, as in other countries, frequency band planning is a central aspect of

the deployment of mobile networks and second generation GSM networks exploit the 900 MHz bands in rural areas and 1800 MHz in urban areas.

The following **Table 2** shows the mathematical calculation of the frequency channels respecting a channel spacing of 200KHZ in the up and down band. ([15], RR, 2019)

Table 2. Calculation of frequency channels in the 900 MHz and 1800 MHz GSM bands.

	GSM band 900 MHz	GSM band 1800 MHz
Formula for calculating frequency channels (n = number of channels and f = frequency)	$f_d = 935 + (0.2 \times n)$	$f_d = 1805 + (0.2 \times n - 512)$
Spacing between channels (Up Link and Down Link)	200 KHZ	200 KHZ

3.1.2. Frequency Band Planning

The distribution of frequency bands respects international planning and ITU radio regulations. After a period of 4 years, the ITU organizes a World Radio-communications Conference (WRC) to put in place an updated tool which is a regulation for the management of the radio spectrum and frequency bands. Each country, through its telecommunications regulatory authority, uses these tools in their frequency band planning.

Table 3 is a planning tool that allows operators in the telecommunications sector in Burundi to ensure broad coverage.

Table 3. Frequency planning in Burundi, according to ITU Radio Regulations (RR) ([15], RR-2019).

No.	Frequency bands	Applications
1	700 MHz band	LTE-IMT
2	800 MHz band	Even
3	900 MHz band	GSM
4	1800 MHz band	GSM
5	2100 MHz band	3G
6	2.5 GHz band	WIRELESS
7	2.6 GHz band	Wimax
8	3.5 GHz band	Wimax
9	5.8 GHz band	Wimax
11	7 GHZ, 8 GHZ, 13 GHZ, 18 GHZ, 24 GHZ, 28 GHZ, 32 GHZ	Radio transmission beam

3.1.3. Omnidirectional Antenna Coverage

Another effective method of ensuring wide coverage is to use omnidirectional antennas. The propagation of electromagnetic waves between a signal transmitter and receiver depends on several factors, including the types and polarization of the antennas used to achieve the uplink and downlink.

Research carried out by Sandra Gommez, Patrice Pajusco and Christian Peron ([16], p. 1, 2) indicates that the antenna type and polarization affect the calculated power value, resulting in differences of up to 30 dB.

The determination of the electric and magnetic field emitted is determined according to the LORENZ formula,

$$F = q \left[E^{\rightarrow}(M, t) + V^{\rightarrow}(M, t) \wedge B^{\rightarrow}(M, t) \right],$$

with E^{\rightarrow} : electric field, V^{\rightarrow} : velocity vector and B^{\rightarrow} = flux of the magnetic field.

Furthermore, Maxwell by its linear equations in E^{\rightarrow} , B^{\rightarrow} , ρ and j , indicates that for there to be the presence of the signal, there simply needs to be an electric current: $j = f(t)$, $E^{\rightarrow} = f(t)$ and $B^{\rightarrow} = f(t)$. ([17], p. 17)

$$\begin{cases} \operatorname{div} E^{\rightarrow} = \rho \varepsilon_0 \\ \operatorname{div} B^{\rightarrow} = 0 \\ \operatorname{rot} B^{\rightarrow} = \mu_0 \left(j + \varepsilon_0 \frac{\partial E^{\rightarrow}}{\partial t} \right) \end{cases}$$

The propagation of electromagnetic waves in free space is achieved through the use of isotropic omnidirectional antennas, which emit waves in all directions of space at a constant power $P(\theta, \varphi) = \frac{PA}{4\pi}$. ([17], p. 59, 63)

A radiation pattern of each antenna represents the variations in the power radiated by the antenna in different directions of space and indicates the directions of space (θ_0, φ_0) in which the radiated power is maximum. The conversion of incident electrical power into radiated electromagnetic power is characterized by the directivity, gain and efficiency of the antenna.

3.1.4. National Coverage

In Burundi, the obligation to cover the entire national territory is an obligation included in the concession contracts between the State and telecommunications operators. The deployment of 2/3/4G networks throughout the territory is carried out by three mobile telephone operators, namely ONATEL, ECONET LEO and VIETTEL, which have obtained operating licenses to ensure geographical and demographic coverage.

Internet coverage is provided by nine high-speed Internet service provider operators. Connections up to the last mile are provided by a metropolitan network (MAN) to connect households.

3.2. Methodological Approach

During our study of mobile and Internet network coverage, we identified li-

censed mobile operators and Internet service providers. We developed a questionnaire using Kobo Collection software on a sample of three mobile operators and 9 Internet provider operators to collect quantitative data.

The processing of data imported by Excel software made it possible to trace changes in the geographical coverage of the territory and that of the population by an electromagnetic signal. The comparative method made it possible to analyze the results obtained and draw conclusions.

4. Analysis of Results

4.1. Analysis of the Existing Situation and Impact of Mobile Network Coverage on the Digital Divide

The expansion of mobile network coverage across the country presents an opportunity for investors in the telecommunications sector. This has the effect of reducing the digital divide between urban and rural areas.

In Burundi, initiatives and projects are being implemented with the aim of exploiting the opportunities presented by the coverage of telecommunications networks in order to ensure the accessibility of telecommunications services. The following projects deserve particular attention:

The establishment of community television centers in remote and rural areas aims to provide the surrounding population with access to information and communication technology (ICT) services and reliable connectivity for television centers, which will be provided by optical fiber, a high-speed backbone deployed in all provinces of Burundi.

Another project involves creating ICT clubs in schools through the ministry in charge of ICT. This will provide students with the ability to log in and upload documents. Furthermore, the BERNET network facilitates interconnection between 14 universities, offering students the opportunity to engage in online browsing and distance learning (e-learning).

The GIGA project aims to facilitate the interconnection of educational establishments and academic establishments. The PAFEN project, for Support Project for the Digital Economy Foundation, aims to facilitate the digitalization of public services by financing connectivity and coverage projects. This objective must be achieved thanks to the World Bank budget.

4.2. Coverage Analysis

The coverage of mobile networks and the Internet is a very important issue to enable universal access, connectivity and digital inclusion of the population through ICT.

According to data analysis, the geographic coverage of second generation mobile telephony is estimated at 92% of the national territory and 96.83% of the population.

Table 4 indicates national coverage by technology, evaluated over a period from 2018 to 2022, taking into account the deployment of base stations (BTS).

Geographic coverage and demographics showed increasing variations, indi-

cating that mobile network coverage areas gradually increased during this period.

Table 4. Geographic and population coverage by technology, 2018-2022.¹

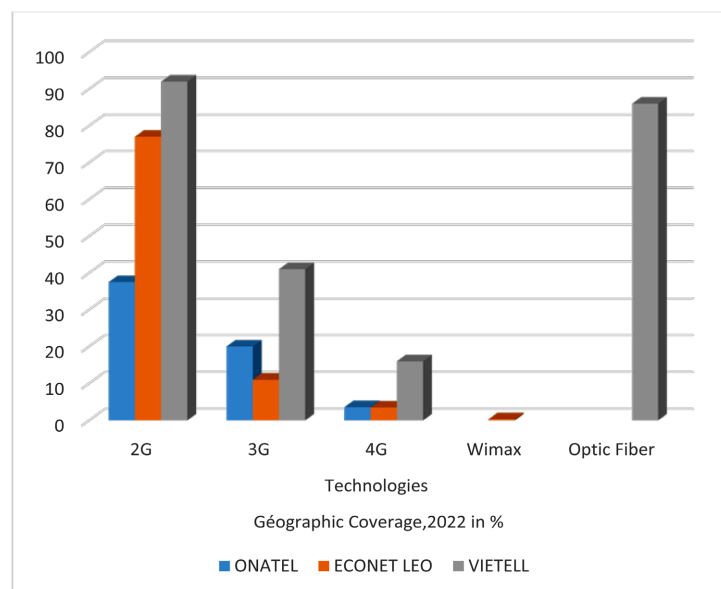
Period	Geographic coverage in %			Population coverage in %		
	Technologies			Technologies		
	2G	3G	4G	2G	3G	4G
2018	90	33	-	95.4	39.03	23
2019	92	34	11	97	48	25
2020	92.12	38.66	12	96.83	50.6	23
2021	92	39	16	97	51	32
2022	92	41	16	97	53	32

However, there remain areas of incomplete coverage, requiring a solution that would involve the redeployment of base stations throughout the country. The work in question is demanding and will require a lot of time and resources, especially since operators tend to concentrate their investments in regions with a high customer base.

4.2.1. Geographic Coverage of Telecommunications Networks

The graph below shows the level of geographic coverage provided by telecommunications operators in Burundi.

Figure 2 illustrates the geographic coverage of the 2G, 3G and 4G networks until December 31, 2020. We see that the 2G network has a coverage of 92%, the 3G network has a coverage of 39% and the 4G network has a coverage of 12%.



¹Coverage by technology.

²Population coverage by technology.

Figure 2. Geographic coverage in 2022.²

4.2.2. Coverage of the Population by Telecommunications Networks

The coverage of the population by the electromagnetic signal indicates that the available signal allows the population to access and connect to the mobile network and the Internet across the country. Uninhabited forest areas, lakes and hills are not included.

Figure 3 shows the population coverage achieved by mobile telephone operators and the Internet coverage using WiMax technology and fiber optics.

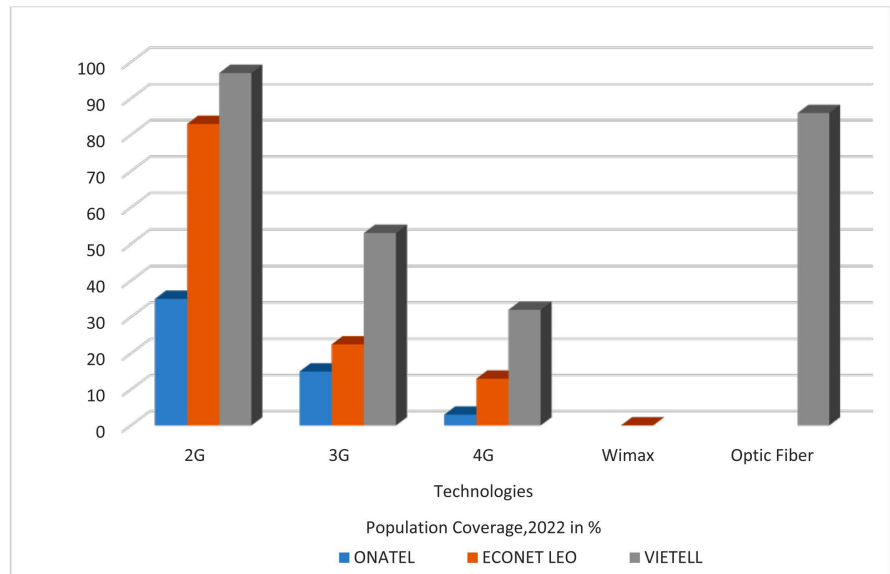


Figure 3. Coverage of the population by telecommunications networks in Burundi.³

4.3. Current State of Mobile and Internet Coverage

As of December 31, 2022, the geographic and demographic coverage of the most dominant mobile operator in Burundi was estimated for the different technologies as follows:

4.3.1. Mobile Coverage by Technology

Table 5 indicates the changes in the geographic coverage and population of the mobile network as of December 31, 2022. Thus, the graph of the changes is as follow:

Table 5. Mobile coverage by technology.

Service/Technology	Geographic (%)	Population (%)
2G	92%	97%
3G	41%	53%
4G	16%	32%
Fiber optical	86%	86%

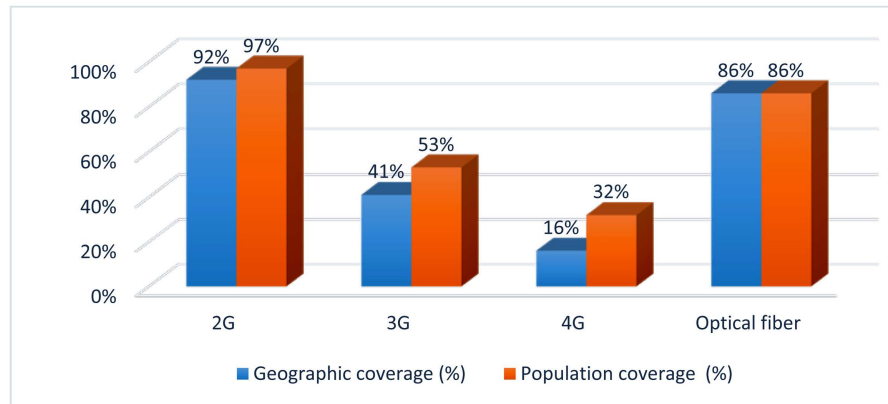


Figure 4. Mobile coverage by technology.⁴

Figure 4 shows the progression of coverage by mobile technology and fiber optics.

4.3.2. Coverage of Fiber Optic Networks in 2022

Table 6 shows the length of fiber optic deployment across the country. Coverage of all provinces is provided by a national fiber optic backbone.

Table 6. Fiber optic coverage.⁵

Optical fiber deployment	Length of fiber already installed	Number of provinces and municipalities connected
Total distance in km of installed fiber	3400	-
Number of km of aerial fiber already installed	3400	-
Fiber distance installed at Bujumbura Town Hall	1014	-
Total number of provinces covered by fiber	-	18 provinces out of 18
Total number of municipalities already covered by fiber	-	102 out of 118 municipalities

4.3.3. Subscribers Connected to Optical Fiber

Table 7 indicates the fiber optic connection by households, schools and hospitals and health centers from 2020 to 2023.

Table 7. Connection to optical fiber.

Indicators	2020	2021	2022	2023
Number of clients	93	112	144	145
Number of schools	137	137	137	137
Number of universities	3	3	4	5
Number of hospitals	38	38	38	38
Number of health centers	77	77	77	77

⁴Graph of changes in mobile coverage by technology.

⁵Table showing the deployment of the fiber optic network in the country.

Figure 5 shows the evolution of access to the fiber optic network by households, schools, hospitals and health centers from 2020 to 2023.

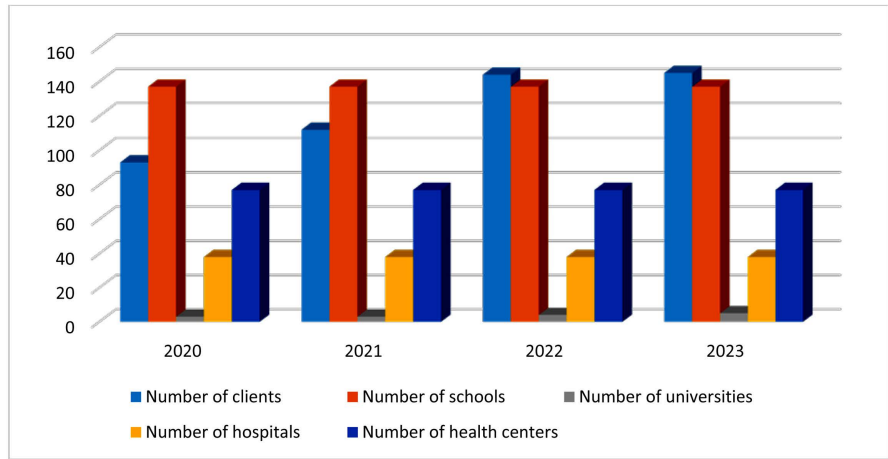


Figure 5. Optical fiber connectivity.⁶

4.4. Geographical Subdivision of Burundi

The data collected from the Geomatic Centralization Office (BCG) provides the coordinates of the communes of each provincial entity of Burundi. The country is divided into 18 provinces and 115 municipalities, as shown in the following Table 8.

Table 8. List of provinces and number of municipalities per province.⁷

No.	Province	Number of municipalities
1	BUBANZA	5
2	BUJUMBURA	9
3	BURURI	6
4	CANKUZO	5
5	CIBITOKÉ	6
6	GITEGA	11
7	KARUSI	7
8	KAYANZA	5
9	KIRUNDO	7
ten	BUJUMBURA TOWN HALL	3
11	MAKAMBA	6
12	MURAMVYA	5
13	MUYINGA	7

⁶Evolution of access to the fiber optic network from 2020 to 2023.

⁷Table of administrative subdivision of the country's municipalities and provinces.

Continued

14	MWARO	6
15	NGOZI	9
16	RUMONGÉ	5
17	RUTANA	6
18	RUIGI	7

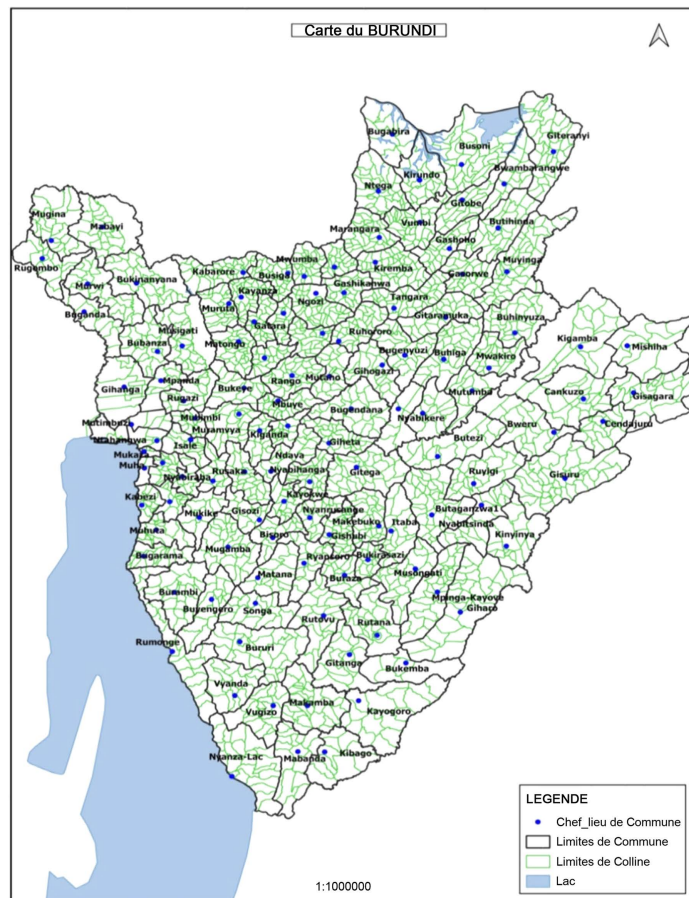
The table above shows that the current subdivision of the country includes 18 provinces and 118 municipalities.

The attached map represents the geographical distribution of Burundi.

Geographic coverage encompasses the entire extent of the territory, including habitable and non-habitable areas, such as high mountains, roads, forests, lakes and rivers.

Population coverage will be in habitable areas, including those populated by the country’s urban and rural communities, located in towns, villages and hills.

4.4.1. Map of the Provinces and Communes of Burundi⁸



Source: The Geomatic Centralization Office was consulted in June 2023.

⁸Administrative map of the country’s municipalities and provinces.

4.4.2. Base Station Deployment Results by Technology

Table 9 provides base stations (BTS) of mobile telephone networks in Burundi for 2G, 3G and 4G technologies. The number of mobile base stations is gradually changing according to the type of technology, the analysis indicates that the number of 2G network base stations remains predominant in the past five years.

Table 9. Deployment of base stations of telecommunications operators as of December 31, 2023.

	BTS 2G	BTS 3G	BTS 4G
ONATEL	150	110	40
ECONET LEO	380	105	32
VIETTEL	586	331	198

Figure 6 indicates the evolution of base station deployment and antennas to ensure coverage of the national territory.

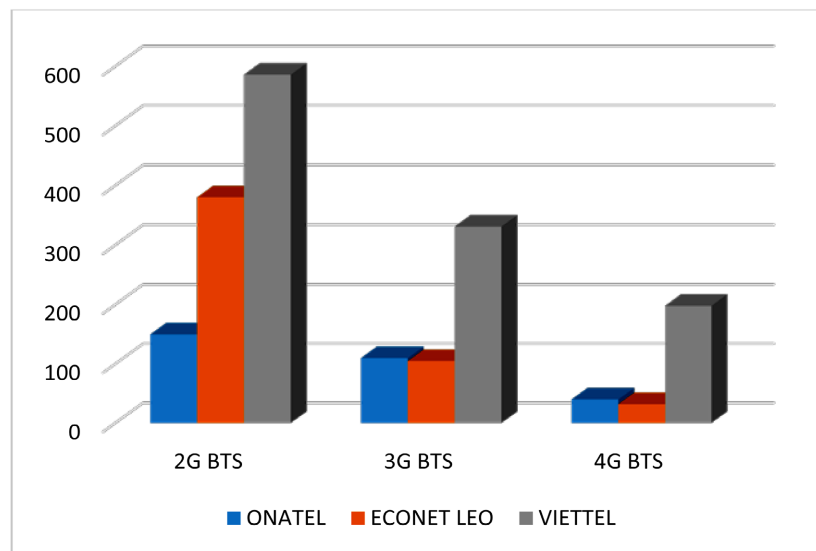


Figure 6. Base stations by technology and by mobile operator as of December 31, 2023.⁹

5. Discussion of the Results Obtained

Coverage of the country is ensured by the deployment of mobile telephone networks by telecommunications operators, while Internet coverage is ensured by Internet service providers (ISPs) who operate optical fiber, thanks to the National Optical Fiber Backbone. (Operators BBS and VIETTEL) and the Metropolitan network (MAN) operated by the National Telecommunications Office (ONATEL).

The use of alternative networks and technologies, such as satellites and radio links, is essential to guarantee complete coverage of the national territory, especially in the most remote and economically unviable regions.

⁹Evolution of base stations by technology.

5.1. Geographic Coverage

Our analysis focuses on comparing coverage between operators regarding the second generation 2G network, the country's geographic coverage increased from 90.12% in 2018 to 92% in 2022, an increase of 2.22%.

Regarding the 3G network, the country's geographic coverage increased from 33% in 2018 to reach 41% in 2022, an increase of 24.24%.

Regarding the 4G network, the country's geographic coverage increased from 10% in 2018 to 16% in 2022, an increase of 60%.

Figure 2 illustrates that the operator VIETTEL offers the greatest 2G geographic coverage, at 92.12%, followed by the company ECONET LEO with coverage of 77%.

In 2023, 4G coverage provided by VIETTEL is 41% followed by ONATEL at 20% and ECONET LEO at 11%.

5.2. Population Coverage

The proportion of the population covered by the network increased from 95.4% in 2018 to 97% in 2022, an increase of 16.77%.

The proportion of the population covered by the 3G network increased from 39.03% in 2018 to 53% in 2022, an increase of 35.79%.

For the 4G network, population coverage increased from 23% in 2018 to 32% in 2022, an increase of 39.13%.

Figure 3 illustrates that the operator VIETTEL ensures the greatest coverage of the 2G population with 96.28%, followed by the company ECONET LEO at 83% and ONATEL at 35%.

The coverage of the population by the 3G network of the operator VIETTEL is 53%, followed by ECONET LEO at 22.5%.

Regarding the 4G network, the territory is covered by VIETTEL with 32% followed by ECONET LEO with 15% and ONATEL with 3%.

These results indicate that mobile operators need to invest more to improve the deployment of base stations in areas where radio signals are not yet available.

The 5G network has not yet seen the light of day and we have not had data to conduct our analyses.

5.3. Base Station Deployment (BTS)

The deployment of base stations ensures wide coverage of the territory. **Figure 6** illustrates that for the 2G network, the company VIETTEL installed 586 basic transceiver stations (BTS), followed by Econet Leo with 380 BTS and 150 BTS for ONATEL.

These results indicate that VIETTEL ensures broad coverage of the 2G network.

In terms of 3G technology, VIETTEL deployed 331 BTS, followed by ONATEL with 110 BTS, and ECONET LEO with 105 BTS.

The results indicate that VIETTEL provides high coverage compared to other

operators.

Regarding 4G technology, VIETTEL deployed 198 BTS, followed by ONATEL and ECONET LEO with 40 and 32 BTS respectively.

5.4. Comments and Proposed Solutions

After analyzing the results, we observed that operators must deploy significant technical and financial resources to deploy 3G and 4G networks to the population. Considering the advantages offered by the 4G network, an average coverage of 32% of the 4G network is insufficient for a population of Burundi with a high population density.

The objective of this study was to identify the reasons for the slow deployment of 3G and 4G mobile technologies in Burundi and the absence of a 5th generation (5G) network which offers many advantages and innovations using the Internet of Things, Artificial Intelligence, etc.

This article aimed in particular to assess the challenges of mobile network and Internet coverage and to show the existing digital divide to allow operators to reduce these challenges.

After our analysis, we note that the following factors contribute to slowing down coverage in certain areas of the country in particular:

- The low profitability of these sites discourages operators from investing in them.
- The low purchasing power of the population to connect to networks via smartphones.
- The problem of electric power deployment and road accessibility prevents the deployment of BTS and consequently the supply of fuel to base stations.

To resolve this problem, it is necessary to implement a number of solutions. These include the acquisition of mobile terminals by users, the encouragement of new investors to subsidize the establishment of the access network in rural and isolated areas thanks to support from the universal service fund, or even the development of the use of renewable energies.

6. Conclusions

According to statistics provided by the National Institute of Statistics of Burundi (INSBU), it is evident that more than eighty percent (80%) of the Burundian population resides in rural areas, which requires the availability of network coverage and ICT services to facilitate their development.

Analyzing the country's coverage will enable decision-makers to develop network deployment strategies that will incentivize operators and new entrants to invest in uncovered areas with the aim of reducing the digital divide.

The objective of this research was to conduct a coverage analysis, which involved examining statistical data relating to the current state of mobile network deployment and Internet infrastructure.

This indicates that there are still areas of uncertainty, given that the country is

only covered by 92% of its territory and on average by 97% of its population.

However, further efforts are needed from telecom operators, while new investors could also help reduce areas lacking signal in order to facilitate connectivity and accessibility to ICT services for the population living in non-signal areas still covered.

Finally, it is important for operators to implement 5G networks. Very recently, new company STAR LINK has just obtained on May 30, 2024 a license to operate a Satellite Internet network. This network will make it possible to deploy and offer Internet services to the most remote and isolated areas of the country.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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