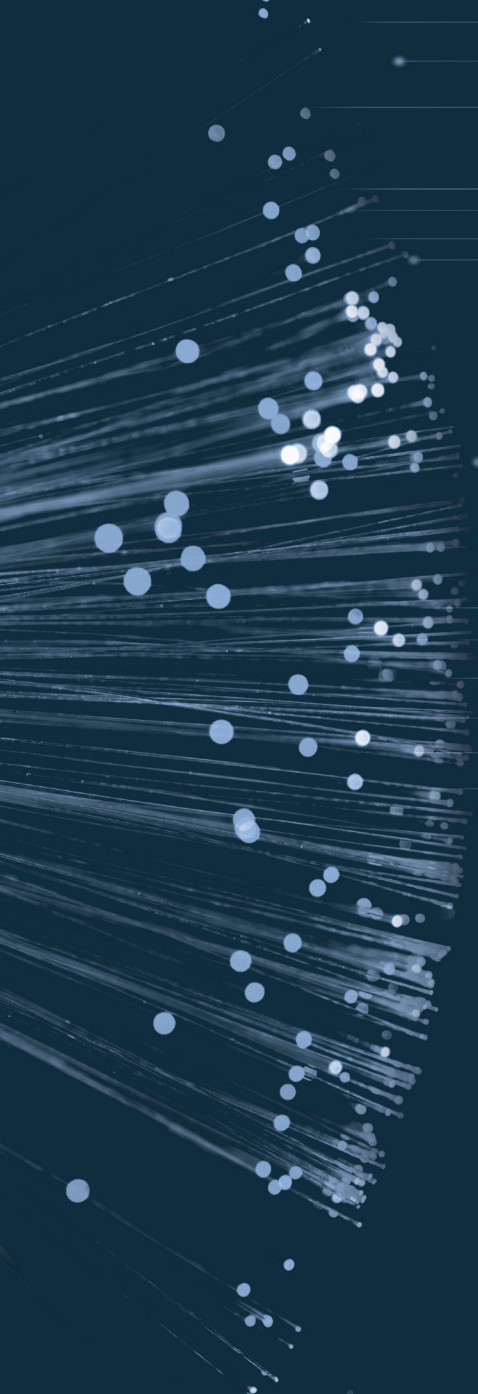

Frontiers of digital inclusion:

Social dynamics and public policies of Internet access in small Brazilian municipalities

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Frontiers of digital inclusion:

Social dynamics and public policies of Internet access in small Brazilian municipalities

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Brazilian Internet Steering Committee (CGI.br)
National Telecommunications Agency (Anatel)
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Charts

Tables

Presentation by NIC.br

Internet access in Brazil has shown remarkable growth in recent years. Around 152 million users had already accessed the network in 2020[1], as shown by the data published by the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br). The advancement of the Internet was the result of continuous improvement in its infrastructure, including the expansion of fiber optics in access networks throughout the Brazilian territory, especially in the last decade. The indicators released by Cetic.br|NIC.br have confirmed this evolution: The offer of fiber optic connection by Internet service providers (ISP) grew from 49% in 2014[2] to 91% in 2020.[3]

However, access to information and communication technologies (ICT) is not homogeneous across the country. The expansion of fiber optics in different segments of society has not yet meant adequate levels of connectivity for everyone. Territorial disparities, influenced by the characteristics and dynamics of the different socioeconomic contexts in which individuals are immersed, have affected the widespread adoption of technologies. Access to and use of ICT vary between Brazilian regions, between urban and rural areas, and between groups of individuals with different levels of income and education, as shown by the historical series of regular surveys published by Cetic.br|NIC.br.

Debates on the topic have sought to understand what barriers prevent greater connectivity of the population, going beyond the discussion of infrastructure and physical access and incorporating other dimensions such as suitable devices, digital skills, etc. It is increasingly important to assess the quality of connectivity, which includes adequate frequency of Internet access, the use of appropriate devices and speed, and the greater ubiquity of connections. This also encompasses the understanding of how local capacities related to public and private organizations can reduce such barriers and are reflected in the formation of digital skills among individuals and organizations.

These barriers are more present in small Brazilian municipalities: Surveys conducted by Cetic.br|NIC.br have shown that the percentage of Internet users is lower in municipalities with up to 20,000 inhabitants. In addition, in these contexts, there is a predominance of lower local capacity in terms of ISP, since the Internet offer comes mostly from small enterprises, and local governments are characterized by lower capacity to invest in information technology (IT).

1 Brazilian Internet Steering Committee. (2021). *Survey on the use of information and communication technologies in Brazilian households: ICT Households 2020 (COVID-19 Edition – Adapted methodology)*. https://cetic.br/pt/publicacao/pesquisa-sobre-o-uso-das-tecnologias-de-informacao-e-comunicacao-nos-domicilios-brasileiros-tic-domicilios-2020/

2 Brazilian Internet Steering Committee. (2016). *Survey on the Internet service provider sector in Brazil: ICT Providers 2014*. https://www.cgi.br/publicacao/pesquisa-sobre-o-setor-de-provimento-de-servicos-de-internet-no-brasil/

3 Brazilian Internet Steering Committee. (2021). *Survey on the Internet service provider sector in Brazil: ICT Providers 2020*. https://www.cgi.br/publicacao/pesquisa-tic-provedores-2020/

Based on the data, Cetic.br|NIC.br conducted the present research, entitled *Frontiers of digital inclusion: Social dynamics and public policies of Internet access in small Brazilian municipalities,* in partnership with the National Telecommunications Agency (Anatel) and the British Embassy[4] . The objective of the survey was to understand the socioeconomic dynamics and capacities of public and private organizations and their effects on the connectivity of the population, especially in strata facing greater social vulnerability and in groups with less access, as is the case of residents in rural, remote and hard-to-reach areas, and in Brazilian municipalities with up to 20,000 inhabitants.

This report presents quantitative analyses that were carried out based on indicators from surveys conducted by Cetic.br|NIC.br and data provided by Anatel, in addition to qualitative analyses based on data collected in semi-structured interviews with local government and ISP managers and local leaders, as well as focus groups with residents in 20 municipalities distributed in the five Brazilian regions. By analyzing connectivity in small municipalities, this publication seeks to contribute to future advances in the country's Internet infrastructure, and to ensure adequate connectivity levels for all. The analysis draws attention to the role of local capacities related to ISP and local governments in reducing regional disparities and socioeconomic gaps and, therefore, to the importance of public policies that build and strengthen these capacities.

We hope that this study inspires reflections and contributions and raises new concerns for the debate on connectivity in the country, particularly in small municipalities. We also hope that it will support public policies that seek to promote more equitable access, expansion and improvement of connectivity throughout the Brazilian territory, and more diverse uses of ICT by all, especially by the most vulnerable individuals and residents in rural, remote and hard-to-reach areas, who still face important challenges.

Enjoy your reading!

Demi Getschko
CEO of NIC.br

4 This project was funded by the United Kingdom's Digital Access Programme (DAP).

Presentation by Anatel

In an increasingly connected world, more than at any other time before, universal access to broadband Internet becomes a key requirement for the full exercise of citizenship. In the knowledge society, the Internet is the main portal for job opportunities and professional training, leisure and entertainment, public and private services, health care, education, and work and income, among many others.

In the telecommunications ecosystem, Anatel represents a key link between market forces and the needs and desires of consumers. Legally established to serve the public interest and promote the development of Brazilian telecommunications, the Agency has been based, since its creation, on three basic pillars: competition, quality, and expansion of access to services.

From the first versions of the Plans of Targets for Universalization (PGMU), up to the last radio frequency bidding for the exploration of available bands for the development of 5G technology, the Agency has worked on establishing obligations to expand telecommunications networks in order to allow the access of all Brazilians to a service provided with quality and at reasonable prices.

The many regulatory instruments developed by the Agency have provided for the standardization of landline telephony and the expansion of mobile telephony, with broadband, to all Brazilian municipalities: from the aforementioned PGMU, in its five versions, through the public notices for bidding processes of 3G, 4G and 5G radio frequency technologies, to the most recent instruments such as the Conduct Adjustment Term (TAC).

However, setting goals for the expansion of telecommunications networks must be preceded by detailed studies that allow an accurate diagnosis of the broadband situation in the country, in order to allow the maximization of the use of public and private resources available for this purpose. In June 2019, Anatel approved the first version of the Telecommunication Networks Structural Plan (Pert). This is the most complete diagnosis of broadband service in the country carried out by the Agency, with the purpose of demonstrating the infrastructure gaps that must be overcome with investments in the sector.

With the advancement of telecommunications infrastructure, due to the natural expansion of the market and the new obligations imposed by the Agency, a new challenge is presented. It is related to understanding with greater precision the needs of citizens who live in areas where this infrastructure is available, but even so, they do not contract the service.

Anatel supports the research *Frontiers of digital inclusion: Social dynamics and public policies of Internet access in small Brazilian municipalities*, a project developed within the scope of the Memorandum of Understanding (MoU) signed with the United Kingdom Embassy in Brazil, and developed via the United Kingdom's Digital Access Programme

(DAP), in partnership with NIC.br. The aim is to understand the reasons that lead residents of Brazilian municipalities to connect, or not, to broadband Internet in places where the infrastructure is already available.

The purpose of the study is, therefore, to understand the challenges to connectivity in small Brazilian municipalities and the ability of public and private organizations to promote the use of ICT. The research results provide important inputs for the future implementation of public policies that may favor digital inclusion in small municipalities.

Knowledge on this topic will allow the Agency to develop, in addition to more effective public policy proposals, regulatory instruments that are more appropriate for this reality.

Carlos Manuel Baigorri

President of Anatel

Presentation by the British Embassy

Connectivity is imperative in the world we live in. While it is increasingly necessary, Internet connection is still a distant reality for almost half of the world's population. According to the International Telecommunication Union (ITU), approximately 2.9 billion people do not have access to the Internet.

In the UK, around 97% of the country's households had Internet connection in 2020. Even with high connectivity rates, challenges remain when it comes to connecting remote areas. Government and industry have been working together to explore new technologies in rural areas, and research has been equally important in understanding connectivity challenges.

In Brazil, according to data from the ICT Households 2019 survey, the percentage of Internet users among people living in municipalities with up to 20,000 inhabitants (66%) was lower than that observed among those who live in urban centers with more than 100,000 inhabitants (79%)[5]. Understanding the connectivity dynamics of these municipalities can help in the construction of evidence-based public policies.

The Digital Access Programme is a UK Government initiative that aims to: (i) catalyze inclusive, affordable, safe and secure digital access for excluded or vulnerable populations; and (ii) promote digital inclusion for a more prosperous digital ecosystem, stimulating innovation for local development challenges.

Under the Programme, the UK Government signed the MoU with Anatel in 2020, aiming to establish a technical partnership and identify priority actions. As a result of this Memorandum, we started working together with NIC.br on the project *Frontiers of digital inclusion: Social dynamics and public policies of Internet access in small Brazilian municipalities*.

The present study aims to understand how the socioeconomic dynamics of small Brazilian municipalities and the capacity of public and private organizations affect the provision of Internet access to the population, especially those living in conditions of greater social vulnerability.

It is with great pleasure that we are supporting the connectivity agenda in Brazil. As our nations continue on the journey of expanding Internet access, we look forward to continuing to work together to find solutions to common challenges. We are confident that this study will be an instrument of transformation for digital inclusion of current and future generations.

Melanie Hopkins

Acting Ambassador of the United Kingdom in Brazil

5 Brazilian Internet Steering Committee. (2020). *Survey on the use of information and communication technologies in Brazilian households: ICT Households 2019*. https://cetic.br/pt/publicacao/pesquisa-sobre-o-uso-das-tecnologias-de-informacao-e-comunicacao-nos-domicilios-brasileiros-tic-domicilios-2019/

Executive summary

Internet access, driven by the expansion of fiber optic connections, has advanced considerably in the last decade in Brazil (CGI.br, 2020a). However, small municipalities still have lower levels of connectivity when compared to large urban centers. The research *Frontiers of digital inclusion: Social dynamics and public policies of Internet access in small Brazilian municipalities* sought to explore how socioeconomic dynamics and local capacities influence the population's Internet access in municipalities with up to 20,000 inhabitants.

The research presents an unprecedented collection of data on the performance of public and private organizations, including the characteristics of ISP and their services, as well as the local governments and online public services offered and the digital inclusion policies implemented by them. It also sought to understand in greater depth the activities carried out in the digital environment by residents of these municipalities and which barriers to connectivity affect access, especially among the most vulnerable groups and those who have historically less access, such as those with lower income and education and residents in rural, remote and hard-to-reach areas.

Connectivity in small Brazilian municipalities

The analyzed municipalities underwent a recent expansion of the Internet in their territories. There was an upscaling of the infrastructure, mainly through the offer of connections via fiber optics and radio. In addition, there was a substitution of fiber optics for radio connection in some areas, mostly urban. It is therefore noteworthy that, in rural, remote and hard-to-reach areas, radio connection still prevails.

This expansion allowed the diversification of activities carried out in the online environment by the population of these municipalities. Particularly in municipalities with higher levels of connectivity, better quality of the Internet has allowed more continuous use and increased access to information, goods and services with the undertaking of practices that require greater speed – such as videoconferences, watching videos, series and movies, and playing games. The research also indicates the contact of individuals with a greater diversity of content, especially leisure and educational, and the growth of economic activities.

This expansion also influenced local governments, which intensified the use of ICT, mainly information systems and software, and the availability of public data on transparency portals. During the pandemic, greater demand led ISP to adapt their services, increasing Internet speed. Local governments also sought to develop actions for the local population to access public services, such as the contact of teachers with students and families through online social networks, and monitoring beneficiaries of social programs through online video calls.

Barriers to connectivity

According to the interviews carried out for the research, in small municipalities, the challenges to connectivity were concentrated among residents of rural, remote and hard-to-reach areas. In these locations, the cost of expanding the infrastructure is still high, as it requires, in the case of radio connection, installation and maintenance of towers and installation of solar energy and, in the case of fiber optics, construction or rental of poles throughout a large territorial area.

Geographic barriers challenge the guarantee of a stable and good quality Internet. In some areas, there is instability in the electrical grid, especially during periods of heavy rain. There is also instability in the Internet signal in mountainous and river areas, where the connection is via radio.

In addition, there are socioeconomic vulnerabilities that prevent certain groups from contracting higher speeds, affecting activities carried out online. Reports of Internet sharing by individuals of lower socioeconomic levels were common. Income also affects more vulnerable groups in accessing devices suited to their needs.

Skills are important barriers to advancing connectivity for individuals and organizations. Elderly people and those living in rural, remote and hard-to-reach areas have lower digital skills and abilities to diversify their use of ICT. This affects the activities of members of civil society organizations and local government civil servants in holding and participating in videoconferences and in the use of some computerized systems and equipment, for instance.

Local governments and public policies

Within the scope of local governments, IT activities are poorly institutionalized. There are no IT areas and there are few civil servants who are responsible for these activities. The work of these individuals is focused on supporting others in the use of ICT, the purchase of equipment, and contracting of ISP and other enterprises.

The absence of more institutionalized IT areas influences the online public services offered and the digital inclusion policies implemented by local governments. There is a predominance of more informational than transactional services, with the latter being restricted to tax services. Less than a third of the local governments interviewed have implemented digital inclusion policies by offering free Wi-Fi in public squares and buildings, such as public libraries, Reference Centers for Social Assistance (CRAS) and public schools, where computers are often available. This indicates that the presence of digital inclusion policies does little to explain the differences in connectivity observed between the analyzed municipalities.

State and federal digital inclusion policies were also rarely mentioned. It is noteworthy that the transfer of federal resources led to the creation of telecenters in several municipalities. However, with the discontinuity of the federal programs, they were closed. There is, therefore, a change in digital inclusion policies with the replacement of telecenters by

access centers via free Wi-Fi in squares and public facilities. This is important, as there are no policies that promote Internet access, make devices available, and develop digital skills, as was the goal of the telecenters.

ISP and the broadband supply

According to the interviewees, small ISP were decisive in the expansion of Internet access, including connection via fiber optics, in the analyzed municipalities. However, they faced challenges to continuing this expansion in rural, remote and hard-to-reach areas, and to improving the quality of the Internet, which involves expanding participation in Internet exchange points (IX) and IPv6 adoption, still restricted to a small group of ISP.

The ISP analyzed varied in their organizational and administrative capacities. Connectivity results were lower in municipalities where there were ISP with little professionalization, that is, they had a small number of employees, did not have an internal division into areas and departments, had owners who did not have training in the area and, in some cases, were family businesses. Better results were obtained by ISP that had a greater number of employees, had an internal division into areas and departments, had owners and managers with training in the area and, in some cases, were linked to larger enterprises that operated in the region.

These differences in organizational and administrative capacities affected access to funds and financing, although most preferred to make investments with their own resources, considering the absence of specific lines of credit for them. In addition, the differences influenced the services they offered, participation in an IX, and adoption of IPv6. Seeking to overcome some of these differences, ISP established formal and informal partnerships with other enterprises, which ranged from exchanging information to loaning equipment and joint purchases.

Methodology

The research was carried out in two stages. The first included the analysis of the quantitative data collected by Anatel, which was related to access to broadband and mobile telephony; ISP services based on indicators from the ICT Providers 2020 survey; and online public services and digital inclusion policies, according to indicators from the ICT Electronic Government 2019 survey. These data resulted in two composite indicators – connectivity and local capacities – that guided the division of the municipalities into four homogeneous groups. These groups varied in their connectivity levels and local capacities, being placed above or below the medians on the two indicators. Then, an analysis of the socioeconomic contexts of the municipalities of each group was carried out based on data related to the gross domestic product (GDP) per capita and the proportion of the population that received benefits from the Bolsa Família Program (BF) and/or the Continuous Cash Benefit Program (BPC).

In the second stage, data collected in in-depth interviews and discussion groups in 20 Brazilian municipalities were analyzed, with four municipalities per group, distributed into the five Brazilian regions. The interviews were conducted with owners and managers of ISP, IT managers of local governments, and leaders of organizations that participate in community networks or relevant organizations in the local context. Individuals 18 years old or older residing in the analyzed municipalities participated in the discussion groups, with different characteristics in relation to their education, age group and gender. In total, 60 interviews were carried out, and 161 individuals participated in the discussion groups.

Public policies for greater connectivity

The increase in connectivity levels in small Brazilian municipalities involves actions that allow both the expansion of infrastructure and the improvement of Internet quality throughout their territory, including for the most vulnerable groups. These actions cover:

- Expansion of backhaul and fiber optics, especially in rural, remote and hard-to-reach areas;
- Promotion of access for small ISP to IX;
- Facilitation of the construction and rental of poles;
- Expansion and support for the improvement of electricity networks and installation of solar energy systems;
- Specific and attractive lines of financing for small ISP;
- Digital inclusion policies that coordinate free Wi-Fi, access to devices and development of digital skills, in public facilities distributed throughout the territory, such as public municipal schools.

Introduction

The aim of this study is to understand how the socioeconomic dynamics of small Brazilian municipalities and the capabilities of their public and private organizations affect the provision of Internet access to the population, especially those who experience greater social vulnerability.

In recent decades, the rapid advance of access in Brazil – which had 133.8 million Internet users in 2019 (CGI.br, 2020a) – has not been enough to universalize its use within all strata of the population. Nationwide surveys have shown that the percentage of disconnected individuals is higher among the elderly, the low-income population, and those with lower education levels (CGI.br, 2020a). Lack of Internet access is also related to the characteristics of the places where these individuals live, a problem that is more evident in rural areas, in the North and Northeast regions, and in the outskirts of large municipalities (CGI.br, 2020a). According to data from the ICT Households 2019 survey, the percentage of Internet users among individuals living in municipalities with up to 10,000 inhabitants (64%) and up to 20,000 inhabitants (66%) was lower than that found among people living in urban centers with more than 100,000 inhabitants (79%) (CGI.br, 2020a).

Although approaches that consider territorial variables have gained relevance in the most recent debate on digital inclusion – especially when it comes to studies in metropolitan regions (Helsper, 2019) – very little is known about the challenges to connectivity in small municipalities. Among the research efforts on the subject, there have been debates regarding infrastructure, in particular, analyses that consider the challenges to the implementation of fiber optics networks to meet the demands of municipalities far from large urban centers (Mendonça & Silva, 2019). There is, however, a gap in knowledge about local capacities in relation to public and private organizations so the advancement of connectivity in these locations can be more effective.

From the point of view of the private sector, it is known that Internet access in small locations relies on the relevant performance of small ISP. The ICT Providers 2020 survey (CGI.br, 2021a) pointed out that the Internet access sector in Brazil was largely made up of micro or small enterprises operating in one or two municipalities, which had up to 1,000 connections (large enterprises had a total of 62% of connections, but with a high concentration in large municipalities)[6]. The study highlighted the territorial dispersion of smaller enterprises and their relative importance for providing Internet access in locations far from large centers. The relevance of small ISP increases in municipalities where there is little appeal for large enterprises, due to the need for investments in infrastructure and lower scale gains, but the shortcomings of these enterprises in terms of sustainability, qualification and

6 Anatel defines connection as a set of physical and logical means by which a user is connected to a telecommunications network (Anatel, 2020a). Therefore, from one connection, an enterprise can connect several customers.

organizational structure can represent challenges to the expansion of this market and the quality of the connections offered.

Within the public sector, the capacity to develop public policies for digital inclusion at the local level tends to be lower among small municipalities. According to the ICT Electronic Government 2019 survey, less than half (46%) of municipalities with up to 10,000 inhabitants had free Wi-Fi connection in public areas, such as squares and parks. The proportion was the same for municipalities with up to 20,000 inhabitants. In addition, only 30% of local governments in municipalities with up to 20,000 inhabitants had IT departments, which was lower in municipalities with up to 5,000 inhabitants (22%) (CGI.br, 2020b).

Even though fiber optic connection is already the main technology for accessing fixed broadband in the country (Anatel, 2020b), the distribution of this type of connection is still unequal among local governments. While more than 90% of local governments with more than 100,000 inhabitants had fiber optic connections, this was a reality for 66% of municipalities with up to 20,000 inhabitants (CGI.br, 2020b). State capacities can be limiting for the expansion of digital government strategies in these locations, both in terms of offering services and online information for the population and in terms of citizens' access.

Expanding knowledge about social dynamics and the capacity to implement public and private connectivity strategies in these locations is fundamental to formulating public policies whose aim is to reverse inequalities in Internet access and use. To support this reflection, this report is structured into three sections. First, based on data obtained from regular surveys by Cetic.br|NIC.br, we present the context of connectivity in small Brazilian municipalities.

Second, we present the methodological aspects that guided data collection and analysis. We start from a quantitative approach, which offers a diagnosis of the demand and supply of Internet services in small municipalities, based on the production of analyses derived from data provided by Anatel and indicators of quantitative surveys produced by Cetic.br|NIC.br and other sources. Next, we present the qualitative methods adopted for mapping local capacities.

In the last section, we evaluate the results obtained from in-depth interviews with public and ISP managers and community leaders. We also present an analysis of the discussion groups promoted with individuals who live in the selected locations.

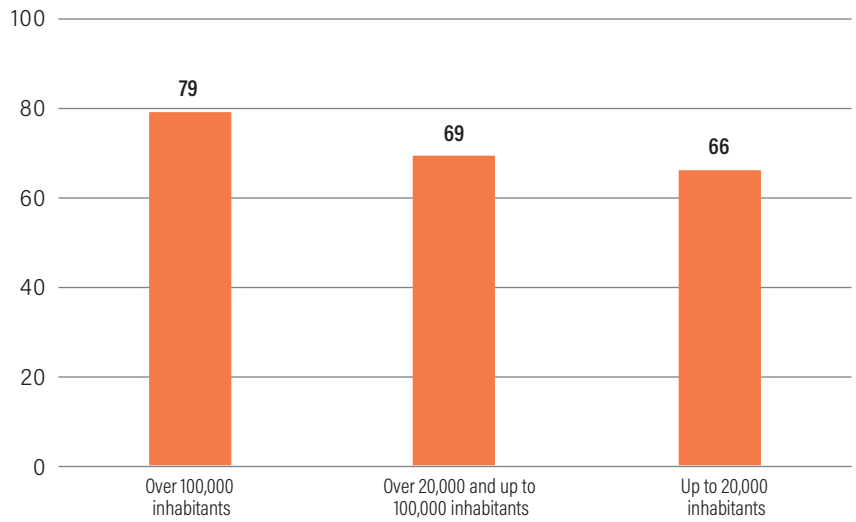
Connectivity context in small Brazilian municipalities

Data from the Brazilian Institute of Geography and Statistics (IBGE, 2021) indicated that municipalities with up to 20,000 inhabitants represented two-thirds of all Brazilian municipalities (3,770). Altogether, they concentrated 31.6 million inhabitants, which corresponded to 14.8% of the Brazilian population. In recent decades, there has been an expansion of Internet access throughout the country, including this group of municipalities. However, as pointed out previously, the percentage of Internet users among individuals living in these municipalities is significantly lower (66%) than that observed among those living in urban centers with more than 100,000 inhabitants (79%) (CGI.br, 2020a), as shown in Chart 1.[7]

CHART 1

INTERNET USERS, BY MUNICIPALITY SIZE (2019)

Total population (%)



Source: Prepared by the authors based on CGI.br (2020a).

For individuals living in municipalities with up to 20,000 inhabitants, the most common barriers to not having access referred to skills. 72% reported lack of computer skills, followed by lack of interest (63%), lack of need (56%), concerns about security or privacy (46%), price of the service (43%), and avoiding contact with dangerous content (43%). In the case of households, the most common barriers referred to the price of the service, cited by 62% of households without Internet connections, followed by not knowing how to use

7 Users are considered to be those who have used the Internet less than three months prior to the interview.

the Internet (52%) and lack of interest (51%). When analyzing only the main reason for not having Internet at home, in approximately a quarter of households without Internet connections, the price of the service was declared as the main barrier (28%) (CGI.br, 2020a).[8]

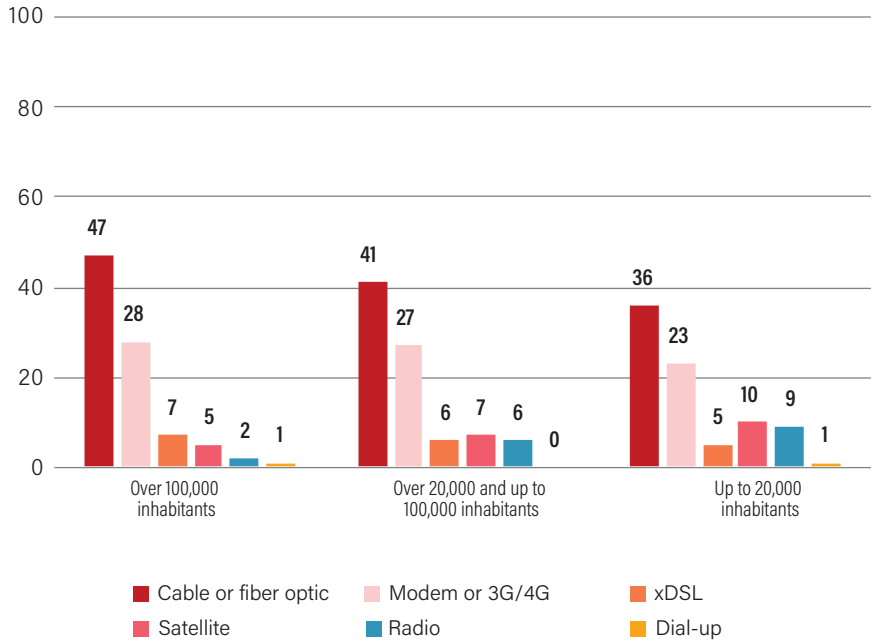
Regarding the ownership of ICT devices, the data indicated a decrease in the presence of computers in Brazilian households from 2015 onwards. In the case of municipalities with up to 20,000 inhabitants, in the three months previous to the survey, only 31% of Internet users used computers and 99% used mobile phones; among them, 69% used mobile phones exclusively and 71% used the Internet on mobile phones (CGI.br, 2020a).

Regarding the quality of the connection, considering the whole country, there was an increase in fiber optics access (CGI.br, 2021a), responsible for 47% of connections in 2020 (Anatel, 2020b), but these levels have still not been reached by small municipalities. In households in these municipalities, of the 63% with Internet access, 36% accessed it via cable and TV or fiber optics connections, 10% used satellite connection, and 9% used radio connection. Also, 23% accessed the Internet via 3G or 4G mobile modem connection (Chart 2). In addition, municipalities with up to 20,000 inhabitants faced challenges in expanding the use of appropriate devices. Most users accessed the Internet via mobile phone, and of those, 88% used Wi-Fi and 69% used 3G or 4G.

CHART 2

HOUSEHOLDS WITH INTERNET ACCESS, BY CONNECTION TYPE (2019)

Total number of households with Internet access (%)



Source: Prepared by the authors based on CGI.br (2020a).

8 Although the sample of the ICT Households 2019 survey was not designed to separate the estimate by locations of lower population, the results for respondents from municipalities with up to 20,000 inhabitants were analyzed.

From the point of view of supply, Internet access in municipalities with up to 20,000 inhabitants relies on the relevant performance of small ISP (62% of ISP have less than nine people employed), operating in a few municipalities (34% operate in one municipality and 53% in up to five municipalities) and have up to 1,000 connections (large ISP have a total of 62% of connections, but with greater concentration in large municipalities) (CGI.br, 2021a).

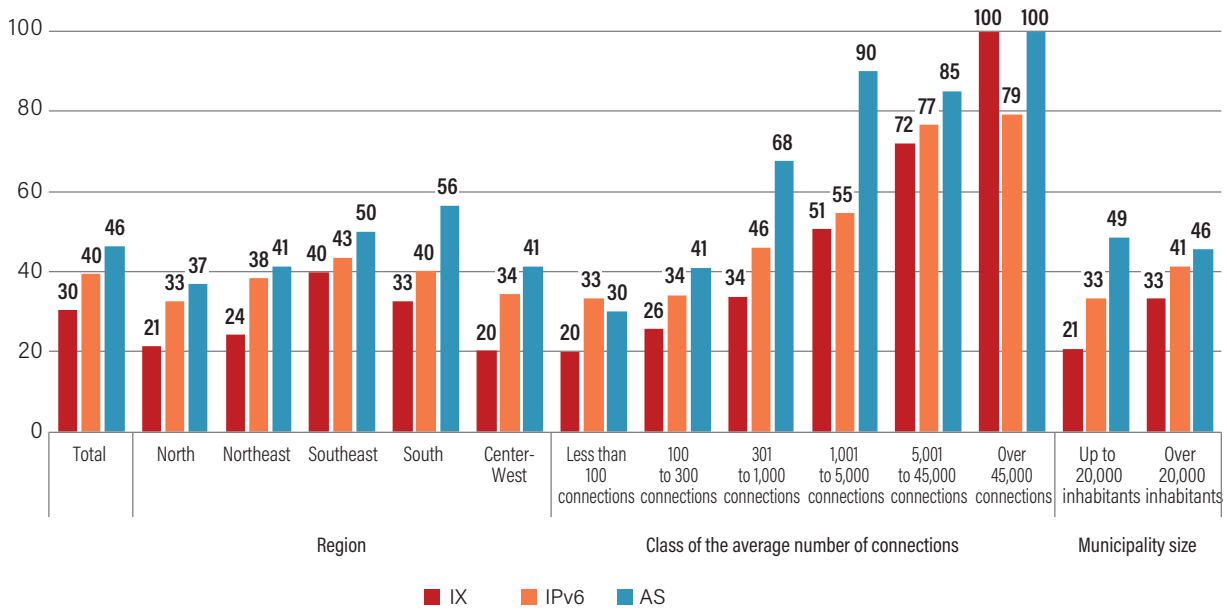
Small ISP play a key role in providing Internet access in small municipalities, especially those located in regions further away from large centers, as they are not very attractive to large enterprises. However, they can also present weaknesses in terms of their sustainability, investment capacity, qualification and organizational structure, which poses challenges for expanding access and improving the quality of the connections offered (CGI.br, 2021a).

Regarding the offer of connectivity services, some aspects, such as the availability of fiber optics, participating in an IX, having autonomous systems (AS) and adopting IPv6, are central attributes for the offer of connections with higher quality and safety – considering the current context of increased traffic with the use of services that consume more bandwidth. According to the ICT Providers 2020 survey, the expansion of fiber optics (87% of ISP offered fiber optics) was not accompanied by an increase in IPv6, which still had lower levels (33% of ISP), as can be seen in Chart 3. This was because there were difficulties related to creating an activation plan (36%), lack of trained personnel (35%), high investment cost (34%), lack of appropriate equipment (33%), and lack of IPv6 among suppliers (29%).

CHART 3

ISP THAT PARTICIPATE IN AN IX, HAVE AS AND ADOPT IPV6 BY REGION, AVERAGE NUMBER OF CONNECTIONS AND MUNICIPALITY SIZE (2020)

Total number of ISP with connection records (%)



Source: Prepared by the authors based on CGI.br (2021a).

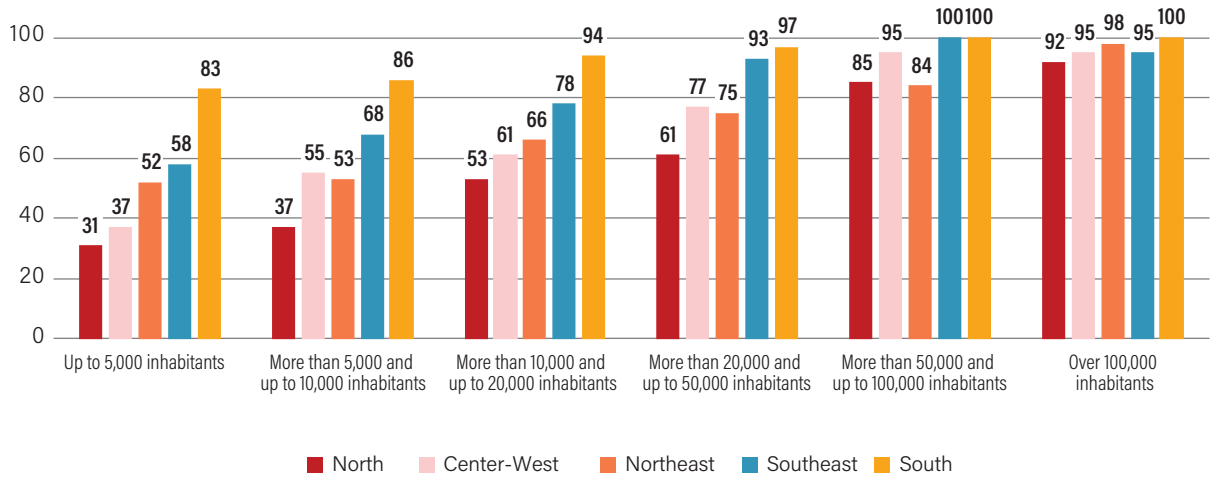
Participating in an IX and having AS, in addition to influencing the quality of the connection, can stimulate learning and encourage the creation of local initiatives. About half of the ISP in small municipalities had AS, and only 21% of them participated in an IX, with the high cost of contracting transport infrastructure from an operator being one of the main reasons for this low participation. It is also worth noting that, considering data from the entire country, this participation is marked by regional inequalities: of the 30% of ISP across the country that participated in an IX, 40% were in the Southeast, 33% in the South, 24% in the Northeast, 21% in the North, and 20% in the Center-West (CGI.br, 2021a).

Local governments are also important in the context of connectivity, not only because they are large users of broadband services in small municipalities, but mainly because they can expand the population's connectivity through the provision of online public services and the implementation of public policies aimed at digital inclusion. According to the ICT Electronic Government 2019 survey, in recent years there has been a substantial increase in fiber optics access by Brazilian local governments. In 2019, this type of connection was the most cited by them (73%). However, the increase in fiber optic connections occurred unevenly across the country: it occurred mainly among municipalities with up to 100,000 inhabitants, being present in more than 90% of municipalities of this size, and in the South and Southeast regions. In municipalities with up to 20,000 inhabitants, fiber optic connection was only present in 66% of local governments (CGI.br, 2020b) (Chart 4).

CHART 4

FIBER OPTIC CONNECTION IN LOCAL GOVERNMENTS, BY REGION AND SIZE (2019)

Total number of local governments with Internet access (%)



Source: Prepared by the authors based on CGI.br (2020b).

Regarding their IT capacities, 42% of local governments had an IT department in 2019, but this percentage was only 22% among municipalities with up to 5,000 inhabitants, 29% among those with more than 5,000 and up to 10,000 inhabitants, and 38% among those

with more than 10,000 and up to 20,000 inhabitants. In terms of the existence of formally instituted technology planning documents, they were present in only 14% of local governments in municipalities with up to 5,000 inhabitants, 14% among those with more than 5,000 and up to 10,000 inhabitants, and 16% among those with more than 10,000 and up to 20,000 inhabitants. Regarding information security practices in local governments with an IT department, they were adopted by 60% of local governments in municipalities with up to 5,000 inhabitants, 60% among those with more than 5,000 and up to 10,000 inhabitants and 64% among those with more than 10,000 and up to 20,000 inhabitants (CGI.br, 2020b).

Most local governments, including those in small municipalities, used information systems in several areas (such as finance and accounting, human resources, and purchasing) and had websites and profiles or accounts on social networks. Despite this, they presented variations in relation to the services available on the website. The local governments of small municipalities expanded some transactional services related to taxes, such as generating electronic invoices (61%). However, considering other services, there were greater advances in the informational area, such as downloading documents or forms (86%), and smaller advances in transactional services, such as registering or enrolling in public service employee exams, courses and schools (36%), and scheduling appointments, assistance, services, and others (23%) (CGI.br, 2020b). Other initiatives that were less present in small municipalities were related to digital inclusion: 56% of local governments provided public centers with free access, such as telecenters, and 46% provided free Wi-Fi connection in public areas of the municipality (CGI.br, 2020b).

Data from the ICT Households 2019, ICT Providers 2020, and ICT Electronic Government 2019 surveys showed that, despite recent advances in municipalities with up to 20,000 inhabitants, Internet access levels were lower, and the local capacities of the governments and ISP were more limited compared to those verified in municipalities with a greater number of inhabitants. Considering that these weaknesses can affect the dynamics of access and connectivity, the present research sought to deepen the understanding of the implications of socioeconomic contexts and differences in local capacities for the connectivity of the population in small municipalities. It sought to understand whether variations in local capacities are associated with higher or lower levels of connectivity among the population.

In the Internet Quality Map, it is possible to access data related to Internet quality in Brazilian municipalities, including those with up to 20,000 inhabitants, collected by the Internet Traffic Measurement System (SIMET) and made available by NIC.br. To access the Map, please see:

https://qualidadedainternet.nic.br/

Other tools allow access to data on connectivity in municipal and state public schools and public healthcare facilities in Brazilian municipalities. To access these tools, please see:

https://conectividadenaeducacao.nic.br/

https://conectividadenasaude.nic.br/

Methodological notes

This study was carried out in two stages. In the first stage, a quantitative analysis was conducted, with the objective of understanding the results related to Internet access and attributes of ISP and local governments regarding the provision of services in small Brazilian municipalities, as well as the distribution of socioeconomic characteristics among them. Based on this set of indicators, a classification of municipalities into four groups was created, according to the intersection of connectivity attributes (access) and local capacities (attributes of ISP and local governments).

The quantitative analysis guided the selection of municipalities that were analyzed in the second stage of the research, in which a qualitative study was conducted in a group of 20 municipalities. In-depth interviews were carried out with representatives of local governments, ISP and civil society organizations, and discussion groups were held with individuals over 18 years of age residing in the selected municipalities. Next, a description of the steps and methodological aspects that guided its implementation is presented.

Quantitative stage

The objective of this stage was to make a diagnosis of the demand and supply of Internet services in small municipalities, based on the processing of indicators from quantitative surveys produced by Cetic.br|NIC.br and data collected by Anatel. Initially, municipalities with up to 20,000 inhabitants were considered, since they represent about 68% of the total number of municipalities and concentrate 14.8% of the Brazilian population (IBGE, 2021). Subsequently, four different groups of municipalities were created according to connectivity attributes (access) and local capacities (attributes of ISP and municipalities).

Initially based on the population size of the municipalities, which resulted in a group of 3,770 municipalities with up to 20,000 inhabitants, there was the selection of 485 municipalities, where there are enterprises that responded to the ICT Providers 2020, and the ICT Electronic Government 2019 surveys, both produced by Cetic.br|NIC.br. Some of the indicators from both surveys, as well as access data collected by Anatel, were used to divide the municipalities into "homogeneous" groups (Table 1).

TABLE 1
INDICATORS USED IN THE QUANTITATIVE ANALYSIS

Dimension	Indicator	Source
Connectivity	Broadband connections per 100 households	Anatel
	Mobile telephony connections per 100 inhabitants	
Local capacities	Participation in an IX	ICT Providers 2020
	Having AS	
	Adoption of IPv6	
	Presence of services on local government websites (8 indicators)	ICT Electronic Government 2019
	Requests for municipal services through the websites (1 indicator)	
	Local government digital inclusion actions, including telecenters (1 indicator) and public Wi-Fi (1 indicator)	

Source: Prepared by the authors.

Next, data on broadband connections per 100 households and mobile telephony connections per 100 inhabitants collected by Anatel were used to construct connectivity scores and binary variables from the ICT Providers 2020 and ICT Electronic Government 2019 surveys to develop local capacity scores. The scores were constructed based on standardized measures for the indicators resulting from the sum of broadband and mobile telephony connections (connectivity) and for those from the ICT Providers 2020 and ICT Electronic Government 2019 surveys (local capacities). The normalization of the variables was performed by applying the following formula:

$$K_{in} = \frac{K_i - \text{minimum}\,(K_i)}{\text{maximum}\,(K_i) - \text{minimum}\,(K_i)}$$

Where

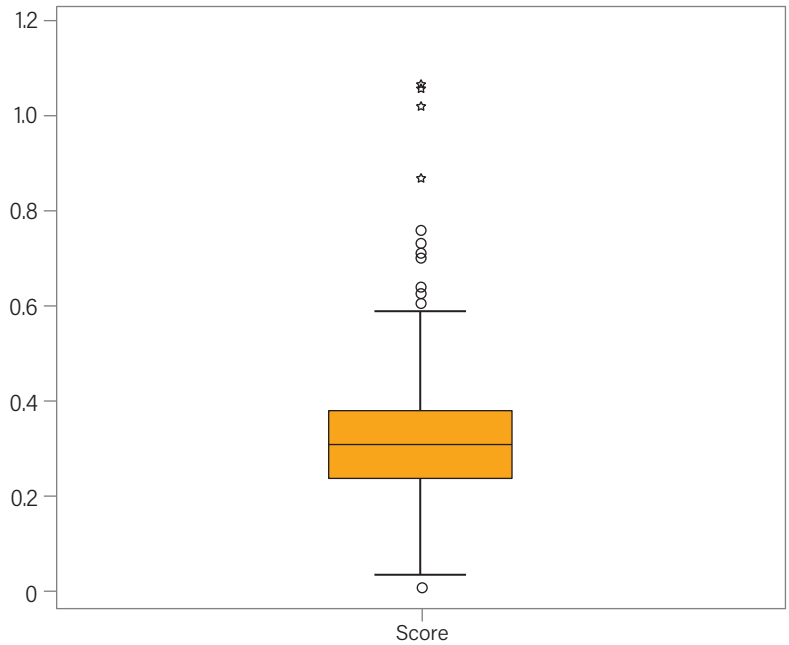
K_{in} is the normalized measure of indicator k for municipality i;

K_i is the indicator to be normalized for municipality i.

Charts 5 and 6 present the distribution of scores for both dimensions.

CHART 5

BOX PLOT OF DATA SCORES FOR THE CONNECTIVITY INDEX

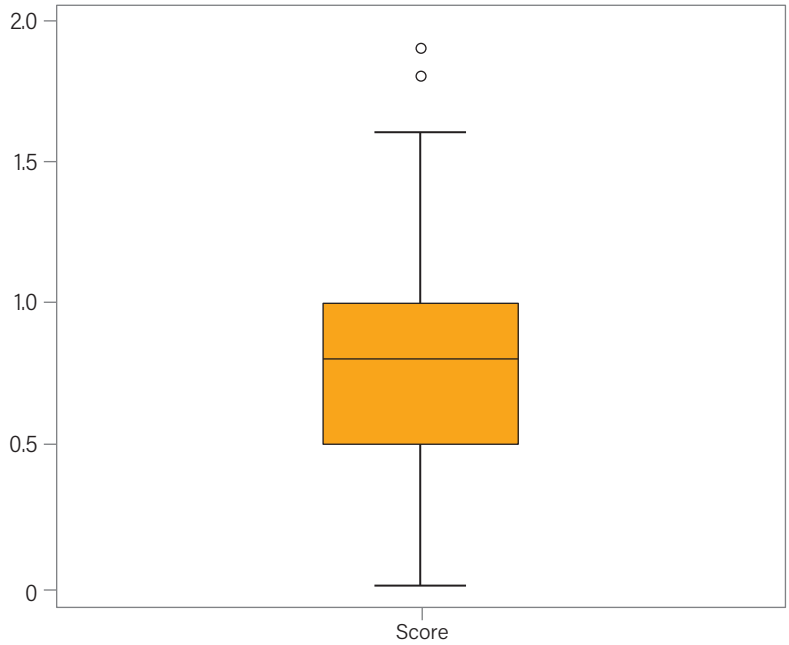


Note: Indicator created based on data on broadband connections per 100 households and mobile telephony connections per 100 inhabitants.

Source: Prepared by the authors based on Anatel (2021).

CHART 6

BOX PLOT OF INDICATOR SCORES FOR THE LOCAL CAPACITIES INDEX



Note: Indicator created based on the indicators of the ICT Providers 2020 and ICT Electronic Government 2019 surveys.

Source: Prepared by the authors based on CGI.br (2020b, 2021a).

The synthetic indicators (scores) of connectivity related to broadband and mobile telephony connections and local capacities based on the indicators of the ICT Providers 2020 and ICT Electronic Government 2019 surveys guided the division of the municipalities into four groups (Table 2). The median was used to classify the municipalities in each of the quadrants (groups).

TABLE 2
GROUPS BY CONNECTIVITY AND LOCAL CAPACITIES

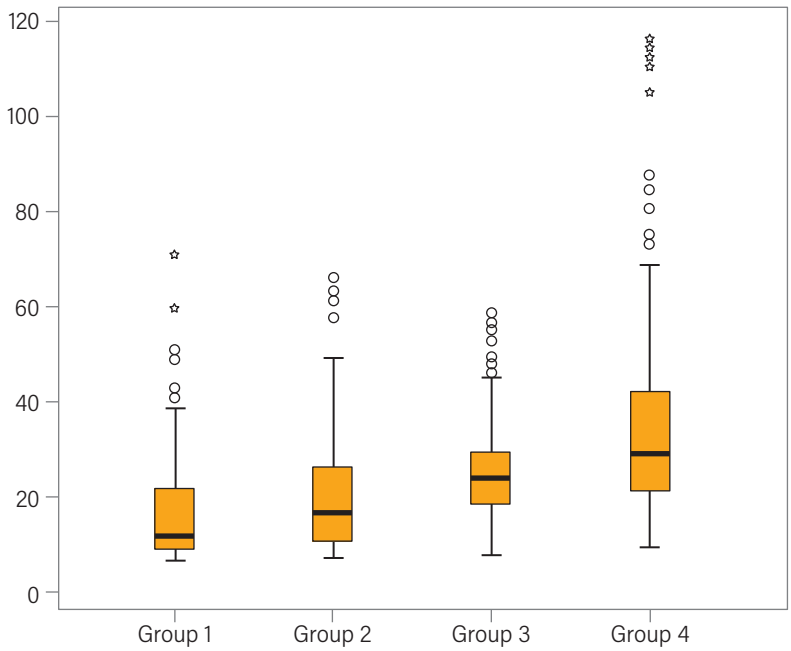
		Synthetic indicator of local capacities	
		Above the median	Below the median
Synthetic indicator of connectivity	Above the median	Group 4 153 municipalities	Group 3 90 municipalities
	Below the median	Group 2 90 municipalities	Group 1 152 municipalities

Source: Prepared by the authors.

After dividing the groups, data was analyzed related to GDP per capita, according to current prices (BRL 1.00) (IBGE, 2018) and the proportion of the population that received BF and BPC benefits (population base estimated in July 2020) in each group (Brazilian Comptroller General of the Union [CGU], 2022; Ministry of Social Development [MDS], 2021). Charts 7 and 8 show the distribution of municipalities by group in relation to these indicators. Although they point to a correlation between the classification created and socioeconomic factors – with those placed in Group 4 better positioned in terms of GDP per capita and with a smaller number of beneficiaries of social programs – the consolidated data indicates moderate differences between the groups, which suggests the need to deepen the understanding of other attributes that differentiate them in connectivity results.

CHART 7

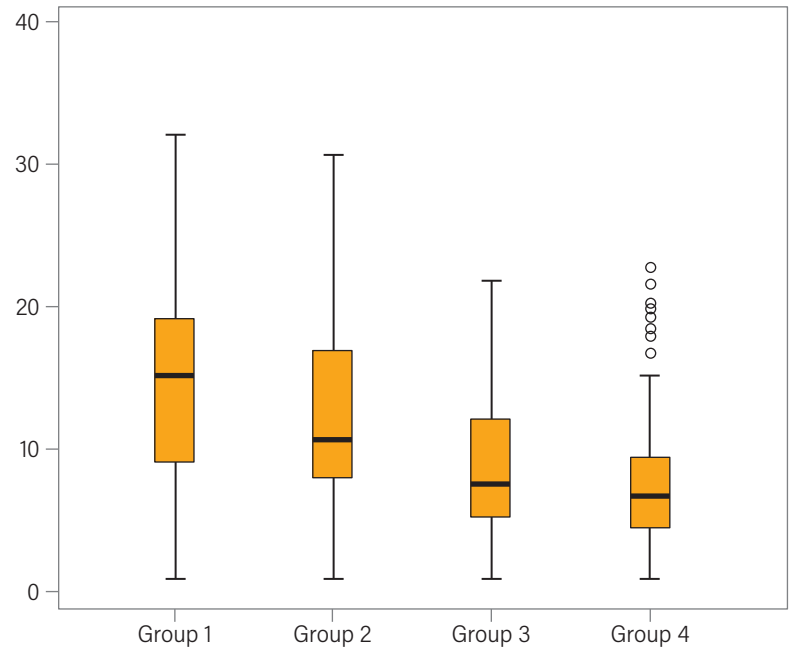
BOX PLOT OF GDP PER CAPITA DISTRIBUTION (IN THOUSAND REAIS), BY GROUPS OF MUNICIPALITIES (2018)



Source: Prepared by the authors based on IBGE (2018).

CHART 8

BOX PLOT OF THE PROPORTION OF POPULATION THAT RECEIVED BENEFITS FROM THE BOLSA FAMILIA PROGRAM (BF) AND/OR CONTINUOUS CASH BENEFIT PROGRAM (BPC) (% OF POPULATION), BY GROUPS OF MUNICIPALITIES (2020)



Source: Prepared by the authors based on CGU (2022) and MDS (2021).

Qualitative stage

At this stage, potential participants – particularly representatives of ISP and local governments – in the municipalities in the four groups were contacted. After obtaining agreement to participate and interviewing these representatives, interviews were carried out with community leaders and discussion groups were held. In cases where representatives of ISP and local governments refused or did not respond, the municipalities were replaced by others from the same groups and contact was made with potential participants. This was carried out until all interviews and discussion groups were completed in 20 municipalities in the five Brazilian regions, with four municipalities in each region, distributed in the four groups, as shown in Table 3. Regional distribution was based on the fact that there are differences in the connectivity of individuals, capacities, and services offered by ISP and local governments according to the specific contexts of each Brazilian region (CGI.br, 2020a, 2020b, 2021a).

TABLE 3
GROUPS OF MUNICIPALITIES BY REGION

	Groups				
	1	2	3	4	Total
North	17	12	6	8	43
Northeast	77	28	12	8	125
Center-West	17	10	20	24	107
South	23	22	28	66	139
Southeast	18	18	24	47	71
Total	152	90	90	153	485

Source: Prepared by the authors.

Data was collected in semi-structured interviews with representatives of ISP and local governments, community leaders, and discussion groups with the local populations, as described below:

- Managers responsible for IT departments in local governments;
- Owners or managers of ISP;
- Community leaders from organizations that participate in community networks or organizations relevant in the local context and who represent groups that face the greatest barriers to accessing the Internet, such as associations of farmers, residents and *quilombolas*,[9] cooperatives of recycled materials collectors, unions, and community radios.

9 Brazil's quilombola communities date from the mid-1500s, when groups of Africans and Afro-descendants escaped slavery and banded together in close-knit communities to resist recapture. More information on the Inter-American Foundation website. https://www.iaf.gov/content/story/making-their-own-way-brazils-quilombola-communities/

Discussion groups were held with individuals 18 years old or older who were residing in the municipalities, selected according to sociodemographic criteria (such as age, gender and education) that influence Internet access and ICT use, as shown in the ICT Households 2019 survey. Each group had five to eleven participants chosen according to the following characteristics:

- Age group (from 18 to 45 years old; over 45 years old);
- Education (up to incomplete Secondary Education; and complete Secondary Education and complete and incomplete Tertiary Education). The education level was used to select the participants because, in addition to influencing Internet access, it has a high correlation with income, another feature that is relevant to access;
- Gender (we sought to ensure a gender balance among individuals participating in each group).

The design of the organization of the discussion groups is summarized in Table 4.

TABLE 4

DISCUSSION GROUPS ACCORDING TO INDIVIDUAL CHARACTERISTICS[10]

Region	Municipality	Age	Education
Group 1	N1	Over 45 years old	Up to incomplete Secondary Education
	NE1	18 to 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	CW1	18 to 45 years old	Up to incomplete Secondary Education
	S1	Over 45 years old	Up to incomplete Secondary Education
	SE1	18 to 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
Group 2	N2	18 to 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	NE2	Over 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	CW2	Over 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	S2	18 to 45 years old	Up to incomplete Secondary Education
	SE2	18 to 45 years old	Up to incomplete Secondary Education

10 These characteristics predominated among the participants. In some cases, when it was difficult to include individuals within the age groups and levels of education previously established, others with different characteristics from these were accepted.

Region	Municipality	Age	Education
Group 3	N3	Over 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	NE3	18 to 45 years old	Up to incomplete Secondary Education
	CW3	18 to 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	S3	18 to 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	SE3	Over 45 years old	Up to incomplete Secondary Education
Group 4	N4	18 to 45 years old	Up to incomplete Secondary Education
	NE4	Over 45 years old	Up to incomplete Secondary Education
	CW4	Over 45 years old	Up to incomplete Secondary Education
	S4	18 to 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education
	SE4	18 to 45 years old	Complete Secondary Education and complete and incomplete Tertiary Education

Source: Prepared by the authors.

While the interviews sought to ensure maximum use of the participants' opinions, leaving them comfortable and safe to express themselves, the discussion groups sought to address various topics in a less standardized and more flexible way, allowing the exploration of tracks and lines of reasoning latent in public opinion and which are not always expected or known by researchers.

All participants were previously recruited by telephone and invited to participate in the discussion room on an online platform. Participants needed to be Internet users, defined as those who used the Internet in the three months prior to the survey (ITU, 2014). Recruitment also included questions related to the characteristics of individuals to ensure that those selected were within the profiles established. Recruitment and fieldwork were carried out by Ipec professionals. The interviews and groups had an average duration of 90 to 120 minutes and were carried out through online platforms. In total, 60 interviews were conducted, and 161 individuals participated in the groups.

Analytical dimensions

The survey design and scripts that guided the interviews and focus groups followed four analytical dimensions. These dimensions, included in some of the questions in the scripts, are presented below:

- **Local IT capacities** – Analysis of previous local capacities makes it possible to understand how they affect connectivity in municipalities and the possibilities of expanding access and improving quality;

- **Digital inclusion policies** – Analysis of digital inclusion policies makes it possible to understand whether they increase Internet access, especially in the case of individuals who have less access, such as those living in rural areas, with low education levels, in classes D and E, and the elderly;
- **Use of ICT** – Analysis of the use of ICT highlights aspects related to the quality of connections, types of available devices, and the capabilities and skills of individuals and organizations necessary for the use of ICT;
- **Barriers to connectivity** – Deeper analysis of barriers to connectivity allows to understand the influence of barriers related to Internet access, connection quality, types of devices used, and capacities and skills of individuals and organizations, as well as the influence of socioeconomic factors on connectivity in the selected location.

The interviews with representatives of ISP and local governments aimed to collect data related to local capacities in relation to connectivity. In the case of ISP, the topics included their organizational and administrative capacities, their access to public and private funding, their formal and informal relationships with other ISP, the quality of their services, and the challenges in their service provision. In the case of local governments, the topics included their organizational capacity, quality of access in different public facilities, use of ICT, and the barriers associated with access and use in different public facilities and the provision of access to the population.

The objective of the interviews with community leaders and the discussion groups was to understand in greater depth the barriers related to access and use by the population, as well as to validate the data collected on the quality of the services offered by the ISP and the provision of access by the local governments. In case the leaders who participated in any community networks, the organizations' provision of access was also explored.

The interviews were transcribed and analyzed qualitatively. Names and positions of the participants were not mentioned to maintain their confidentiality. It is important to point out that the research was carried out according to protocols adopted by research institutes to guarantee privacy and protection of personal data.

Characteristics of the analyzed municipalities

Table 5 presents a characterization of the selected municipalities. It is noteworthy that the municipalities presented intragroup variations in relation to all the indicators presented: population size (except for Group 3, in which all municipalities have between 10,000 and 20,000 inhabitants); GDP per capita; proportion of the beneficiary population that receives BF or BPC; Municipal Human Development Index (HDI); and distance from the capital city. It should also be noted that the municipalities presented similar values in relation to the Municipal HDI. This allowed analysis of the influence of other dimensions of the contexts of the municipalities, particularly local capacities, on the different levels of connectivity, going beyond the relationships between socioeconomic, population and geographic characteristics and connectivity.

TABLE 5

CHARACTERISTICS OF THE CONTEXTS OF THE ANALYZED MUNICIPALITIES

Municipality and region	Estimated population (2021) (inhabitants)*	GDP per capita (2019) (BRL)	Proportion of pop. with BF and BPC (%)**	Municipal HDI (2010)***	Distance from the capital (km)*
N1	Up to 5,000	12,000	13	0.60	From 300 to 500
NE1	From 5,000 to 10,000	37,000	20	0.61	From 300 to 500
CW1	Up to 5,000	16,000	7	0.71	From 300 to 500
S1	From 5,000 to 10,000	30,000	6	0.70	From 300 to 500
SE1	From 10,000 to 20,000	17,000	6	0.68	From 50 to 300
N2	Up to 5,000	22,000	10	0.65	Up to 50
NE2	From 10,000 to 20,000	12,000	20	0.64	Over 500
CW2	From 5,000 to 10,000	28,000	13	0.67	From 50 to 300
S2	From 10,000 to 20,000	22,000	9	0.64	From 300 to 500
SE2	Up to 5,000	19,000	5	0.66	From 50 to 300
N3	From 10,000 to 20,000	16,000	15	0.59	Up to 50
NE3	From 10,000 to 20,000	8,000	16	0.58	Up to 50
CW3	From 10,000 to 20,000	19,000	7	0.71	From 50 to 300
S3	From 10,000 to 20,000	21,000	6	0.67	From 300 to 500
SE3	From 10,000 to 20,000	29,000	4	0.74	From 300 to 500
N4	From 10,000 to 20,000	29,000	7	0.69	Over 500
NE4	Up to 5,000	24,000	10	0.64	From 50 to 300
CW4	From 5,000 to 10,000	36,000	5	0.71	From 50 to 300
S4	From 10,000 to 20,000	19,000	8	0.64	From 50 to 300
SE4	From 5,000 to 10,000	33,000	6	0.72	Over 500

* Approximated values (IBGE, 2018).
** Approximated values (CGU, 2022; MDS, 2021).
*** Approximated values (United Nations Development Programme [PNUD], 2010).

Source: Prepared by the authors.

Regarding connectivity levels and local capacities, at one extreme, Group 1 has the lowest levels of connectivity and local capacities and, at the other extreme, Group 4, the highest levels of connectivity and capacities. Between them, there are Group 2 and 3, which present low levels of connectivity and high levels of local capacities (Group 2) and high levels of connectivity and low levels of local capacities (Group 3). The data for each municipality is presented in the following Table:

TABLE 6

CHARACTERISTICS OF CONNECTIVITY AND LOCAL CAPACITIES OF THE ANALYZED MUNICIPALITIES

Municipality	Connectivity		Local capacities			
	Broadband density	Mobile telephony density	AS	IX	IPv6	Online public services and digital inclusion policies (total of 15)
N1	3.0	62.5	No	No	No	7
NE1	35.5	54.8	No	No	No	4
CW1	16.1	66.5	No	No	No	2
S1	32.6	31.1	Yes	No	No	5
SE1	15.3	71.1	Yes	No	Yes	3
N2	2.9	85.0	Yes	Yes	Yes	4
NE2	5.9	64.6	No	No	No	9
CW2	50.1	68.6	No	No	Yes	8
S2	15.3	80.1	Yes	Yes	Yes	6
SE2	4.4	5.1	Yes	Yes	Yes	4
N3	30.9	87.9	No	No	No	2
NE3	10.3	84.4	Yes	No	No	3
CW3	47.6	72.5	No	No	No	2
S3	59	87.8	Yes	No	No	5
SE3	49.2	96.0	No	No	No	7
N4	17.7	101.3	Yes	No	Yes	5
NE4	85.3	259.2	No	No	No	9
CW4	27.6	93.1	No	No	Yes	6
S4	32.7	79.2	Yes	No	No	7
SE4	77.2	92.7	Yes	Yes	Does not know	5

Source: Prepared by the authors based on Anatel (2021) and CGI.br (2020b, 2021a).

Main results

In this section, the organization of the data collected in the interviews and discussion groups is presented according to four axes, guided by the aforementioned dimensions of analysis. They are: connectivity in the analyzed municipalities, which includes the general characteristics of connectivity and the use of ICT by the local population; main barriers to connectivity; the role of public policies and local governments in connectivity; and the role of small ISP in Internet access.

Connectivity in the analyzed municipalities

Analysis of the data collected in the interviews and discussion groups in the 20 selected municipalities shows that there has been a recent expansion of fiber optic networks in their territories, confirming a trend verified in the ICT surveys carried out by CGI.br (CGI.br, 2020a, 2021a). In Groups 1, 2 and 3, this expansion, for the most part, occurred in the last decade as a result of an effort undertaken, mainly, by small ISP. It involved not only increasing fiber optic infrastructure for regions that did not have Internet access, but also replacing other types of connections, particularly radio, with fiber optics, allowing access to higher speeds and improving the quality of the Internet.

Changes in connectivity standards have allowed for more continuous use of ICT and increased access to information, goods and services by local populations. In municipalities with greater connectivity, there was diversification of online activities, which includes access to a greater variety of content, particularly related to leisure and education, and expansion of economic activities. Considering that, since the beginning of 2020, the mitigation of the pandemic has led to the adoption of social distancing measures, the use of ICT has been associated with carrying out activities for a wide range of purposes. Access to the Internet was crucial for guaranteeing access to education, health services, cultural practices, and other social policies, such as the emergency financial relief implemented, and the expansion of work and economic activities, such as buying and selling products, holding meetings, and establishing long-distance partnerships.

This process also had implications for the actions of local governments. Interviewees from local governments reported that the expansion of fiber optics led to an increase in the use of ICT by their employees, enabling the adoption and more intensive use of information systems and software related to different aspects of management, such as the provision of online public services, mainly tax-related, such as generating Urban Land and Building Tax payment slips, electronic invoices and permits, and advances in the transparency of public data through the adoption of transparency portals.

According to the interviewees, these changes also contributed to local governments being able to respond to the demands for using information systems to access federal programs and resources, such as Cadastro Único and DataSUS, and to comply with legislation

related to data transparency, which has been demanded by control bodies. These changes also made it possible for local governments to be more prepared for the challenges presented by the pandemic. Respondents from the analyzed local governments mentioned that there was an expansion of online public services and, in some cases, the offer of new services with the creation of their own systems, such as scheduling appointments.

Another change made in recent years, which was intensified in the context of the pandemic, refers to the use of social networks, especially instant messaging applications, to interact with the population. WhatsApp, for example, allowed for more intense and closer communication with citizens, which was critical, in the case of education, to enable contact between schools, students and families during remote teaching.

However, there are still huge challenges to guaranteeing Internet access throughout the territory of the analyzed municipalities. Next, we present some of the main conclusions obtained from the interviews and discussion groups, which reinforce the relevance of local capacities for further advances in connectivity.

Main barriers to connectivity

In the four groups of municipalities, it was reported that there is less access in rural, remote, and hard-to-reach areas. In these areas, there are two cases: places without any access because they do not have infrastructure; and those with access to the Internet via radio connections. In this second case, the interviewees from the ISP pointed out that the expansion of fiber optics is very expensive, as it involves the construction of poles throughout a large territorial area, making it impossible to replace radio with this type of connection. There are cases where even the towers were paid for by residents in these areas, as the ISP did not have the infrastructure installed, and other cases where residents had to pay for solar energy systems, as there was no electricity infrastructure in the region.

Respondents also reported that other geographic features create barriers to access, such as mountainous regions and rivers, as they make it difficult to receive the signals or hinder their stability. This occurs, especially, in rural, remote, and hard-to-reach areas with radio connections that, therefore, depend on good visibility around the towers.

In addition, respondents, especially from Groups 1, 2 and 3, reported that rain can result in instability in electricity or Internet signals, increasing barriers to regular access. It was reported that in periods of more intense rain, the population experiences Internet outage for a few hours, while in the case of electricity, lack of it can persist for a few days.

Another barrier that affects access, especially for the most vulnerable groups, is the financial cost. First, it is important to point out that there are differences in the prices of broadband and mobile telephony plans between the analyzed municipalities. In Group 1, for example, considering the speed and the data plans contracted, prices are higher than in Group 4. Secondly, there was a consensus among the interviewees and participants in the discussion groups that the prices of broadband and mobile telephony are an impediment to the access of individuals with lower income in all municipalities. Even among those who can afford these services, there are some who share the signal with their neighbors.

Therefore, in addition to infrastructure, the quality, speed and stability of the Internet influence the use of ICT, creating differences between municipalities and groups of individuals within the same municipality. While online activities are more diversified and could be expanded in some contexts, especially that of the pandemic, in others, activities such as sending instant messages and using social networks are more frequent, and activities such as holding and participating in videoconferences, playing online games, and watching videos, shows, movies and series online are less frequent.

Two other factors that affect the connectivity of local populations were pointed out by the interviewees and participants in the discussion groups. The first refers to access to suitable devices. ISP respondents said that, in some cases, their customers' devices do not allow access to higher speeds, nor access through IPv6. Participants in the discussion groups recognized that some problems related to access are more linked, for example, to the low memory of their mobile phones than to the quality of the Internet.

The second concerns the skills and abilities needed among individuals and organizations. Some interviewees and focus group participants reported that elderly people, especially those living in rural, remote, and hard-to-reach areas, do not have the necessary skills and abilities to diversify their use of ICT. This was also reported by the members of civil society organizations, whose managers were interviewed in this study, who have difficulty holding and participating in meetings through online video calls, for example, and local government employees, who have difficulties in the use of some information systems and equipment, such as printers.

The role of public policies and local governments in connectivity

The analysis also showed that public policies addressing inequalities in access to and use of ICT in small municipalities are not a priority on the agenda of governments at different levels – federal, state and municipal. Less than a third of the analyzed local governments implement digital inclusion policies by offering free Wi-Fi in public squares and buildings, such as public libraries, CRAS and municipal schools. In the case of public buildings, free Wi-Fi is often combined with the availability of computers for the population to use. However, these policies are still absent in most municipalities, and they are poorly institutionalized and fragmented, that is, they are not coordinated with other relevant strategies to promote digital inclusion. They do not counter the inequalities in access to and use of ICT that mark the analyzed municipalities and, therefore, do not explain the differences in their connectivity levels.

Federal and state policies also do not have a strong impact on tackling these inequalities. In several of the analyzed municipalities, there were telecenters managed by local governments, which were created with the encouragement of the federal government, that transferred them resources for these actions. However, the discontinuity of federal programs and, consequently, of funding, led to the closure of these facilities in all the municipalities. Although respondents believed that offering free Wi-Fi in squares and public buildings is a more effective strategy for expanding access, it is not necessarily accompanied by actions that seek to develop the skills and abilities necessary for full use of ICT and the availability of devices, such as desktop and portable computers, suitable for this.

Regarding state policies, there is variation among municipalities in different states. In some of the municipalities analyzed, the interviewees pointed out that there are state programs that seek to expand access to and use of ICT. An example of this is programs created in the context of the pandemic to guarantee access for students of state schools, involving the distribution of SIM cards for their mobile phones. However, in most municipalities, respondents reported that there was no relevant state program in this area.

Regarding the use of ICT by the municipalities themselves, this survey showed that, despite the aforementioned advances, there are challenges in relation to the administrative capacity of the local governments, which do not have specific areas or departments responsible for these activities. All local governments have one, two or three employees, in some cases, selected by public examinations and, in others, politically appointed, who answer to the mayors' offices. Their activities include providing technical assistance to other sectors, especially in the process of purchasing equipment, and monitoring the services of ISP and software enterprises contracted by local governments.

Regarding online public services, although there have been advances, services that involve transactions were restricted to the offer of some tax services and the presence of local governments on social networks, especially on WhatsApp. In general, most interactions between local governments and citizens are more informational, that is, they are more related to the dissemination of information, mainly via transparency portals.

It is noteworthy that, during the pandemic, social distancing measures gave centrality to connectivity for access to social policies implemented by municipalities, such as health care, education and social assistance. Interviewees from local governments and participants in discussion groups pointed out that technologies were fundamental in the registration and monitoring of users of social programs, such as BF, and in the implementation of remote teaching. In this case, they enabled continuous communication and closer relationships among schools, students, and parents or legal guardians; access to classes, in cases where municipal education networks offered online classes; and the elaboration of pedagogical content that allowed the distribution of materials and activities for students who did not have access to the Internet and/or adequate devices to attend classes. However, the distribution of printed materials and activities and contact via WhatsApp prevailed, reinforcing the results of the ICT in Education 2020 survey (CGI.br, 2021b). Few local governments managed to keep classes online consistently over time, and one of the reasons reported was the fact that there were significant numbers of students who did not have access to the Internet.

Weaknesses in the institutionalization and professionalization of IT areas in local governments lead to an overload of work on the few existing civil servants. This burden is reinforced by the lack of skills and abilities of staff from other areas necessary for the use of ICT. These weaknesses also compromise the creation of public policy agendas related to both increasing connectivity and strengthening the use of ICT by local government employees themselves, as well as offering online public services and implementing public policies for digital inclusion for local populations. This points out that the development and strengthening of the administrative capacities of the IT areas in local governments are fundamental for the advancement of public policies that seek to ensure access to the Internet and expand the use of ICT.

The role of small ISP in Internet access

Although there has been expansion of access to, and improvement in the quality of, the Internet in these municipalities, driven mainly by the performance of small ISP, they face challenges to the continuity of this process, especially in contexts where there is less connectivity. Respondents reported challenges related to the financial cost of expanding fiber optics, as well as building solar energy towers and systems, when there is no electricity, and maintaining networks in municipalities that have extensive, remote, and hard-to-reach rural areas.

ISP also face challenges in ensuring high speeds and minimum standards for other measures that affect quality, such as latency.[11] The intensifying use of the Internet during the pandemic has required network infrastructure with the capacity and resilience for high demand, reinforcing these challenges. As reported by the interviewees, ISP did not lose customers, but had to provide them with greater speed, without necessarily charging more for it.

Regarding participating in IX, having AS and adopting IPv6, which are essential for offering connections with higher quality and security in a context of increased traffic and use of services that consume more bandwidth, the ISP interviewed vary enormously. They are divided in relation to having AS, showing greater advances than in the other cases. Regarding participation in IX and adoption of IPv6, there are those who are unaware of their operation and benefits, who are concentrated in Group 1, and those who know their operation and benefits, but do not yet participate in IX and/or have not adopted IPv6. There are few who know their operation and benefits, participate in IX and adopt IPv6.

Regarding expansion of IX and IPv6, two points are important. Participation in IX depends on enterprises operating in the region and providing a link to small ISP that offer Internet in small municipalities. This means that any progress in this process depends on changes that involve the entire sector. The adoption of IPv6 was pointed out by the interviewees as fundamental for improving quality and security. Regarding security, respondents pointed out that, in the case of IPv4, monitoring and controlling the network is very difficult. However, they reported that they faced challenges to their expansion, as their customers' devices are not suitable for IPv6.

The analysis also shows that ISP with greater organizational and administrative capacities are the most advanced in terms of participation in IX and adoption of AS and IPv6. At one extreme, in Group 1, there are ISP that are family businesses that emerged from previous professional experiences with LAN houses and computer stores, among others. They have few employees, do not have an internal division into specific areas or departments, and are managed by people without training in the area. At the other extreme, in Group 4, ISP are managed by professionals with training and professional experience in the area, have a greater number of employees, an internal division into specific areas or departments, and more formalized processes. In some cases, they are formally linked to larger enterprises, and, in others, they have hired consultants to adapt to changes in the area, including the adoption of IPv6.

11 Latency refers to the "[...] time that information takes to go to its destination and back" (NIC.br, 2020, p. 4).

It is noteworthy that, unlike variations in organizational and administrative capacities, the issues related to financing are similar. Few ISP accessed private financing and public funds – most respondents declared that they prefer to invest with their own resources. This is because, in the case of private financing, respondents pointed out that there are no specific lines for ISP, and interest rates are high. Furthermore, the amounts needed to invest in the expansion of infrastructure are high, but their revenues and guarantees are not sufficient to be granted loans. In relation to public funds, the interviewees declared that the processes are very "bureaucratic," but some, concentrated in Group 4, accessed financing granted by the Brazilian Development Bank (BNDES), which was important for the expansion of fiber optic infrastructure and purchase of equipment.

The ISP interviewed also reported that it is common to establish formal and informal partnerships with other enterprises. These partnerships include various actions, such as infrastructure sharing, including towers, loans, joint purchase of equipment and information exchange, which seek to overcome some barriers related to weaknesses in their organizational and administrative capacities, lack of access to financing, and other contextual challenges.

Connectivity in the four groups of municipalities

This section presents data analysis organized in groups. The main dynamics and characteristics of both the contexts of the municipalities of each group and their local capacities are discussed, mainly related to those of ISP and local governments. This organization by group allows understanding of the dynamics and characteristics that are common to small municipalities and of those that vary between them and that, therefore, explain their different levels of connectivity.

Table 7 summarizes the main similarities and differences between the groups. The results show that they vary mainly in relation to the use of ICT by individuals, the organizational and administrative capacities of ISP and, consequently, the services they offer. However, there are similarities related to their geographic and socioeconomic contexts, which reinforce and increase barriers to connectivity, online public services, and local public policies for digital inclusion.

TABLE 7

EXPLANATORY FACTORS OF CONNECTIVITY BY GROUP

	Group 1	Group 2	Group 3	Group 4
Socioeconomic and territorial contexts	° Geographic characteristics ° Lack and/or instability in electricity ° Little access in rural, remote and hard-to-reach areas ° Greater barriers to access in the most vulnerable groups	° Geographic characteristics ° Lack and/or instability in electricity ° Little access in rural, remote and hard-to-reach areas ° Greater barriers to access in the most vulnerable groups	° Geographic characteristics ° Lack and/or instability in electricity ° Little access in rural, remote and hard-to-reach areas ° Greater barriers to access in the most vulnerable groups	° Little access in rural, remote and hard-to-reach areas ° Greater barriers to access in the most vulnerable groups
Connectivity	◦ More informational activities that require lower speed	° More transactional and diversified activities	° More transactional and diversified activities	° More transactional and diversified activities

		Group 1	Group 2	Group 3	Group 4
Local capacities	ISP	◦ Low capacity, which results in low participation in IX and adoption of IPv6	◦ Average capacity, which results in medium levels of participation in IX and adoption of IPv6	◦ Low/average capacity, which results in medium levels of participation in IX and adoption of IPv6	◦ High capacity, which results in high participation in IX and adoption of IPv6
	Local governments	◦ Low capacity ◦ More informational services ◦ Fragile digital inclusion policies	◦ Average capacity ◦ More informational services ◦ Fragile digital inclusion policies	◦ Average capacity ◦ More informational services ◦ Fragile digital inclusion policies	◦ Average capacity ◦ More informational services ◦ Fragile digital inclusion policies

Source: Prepared by the authors.

Group 1: Low connectivity and reduced local capacities

In general, Group 1 includes municipalities that have more recent expansion of fiber optics. Several barriers, particularly geographic and socioeconomic, still prevent them from having higher levels of connectivity. For example, problems with signal stability, power outages, and the high cost of plans offered by ISP were reported. As a result, local populations generally report more restricted performance of online activities, indicating less diversification in the use of ICT.

In this set of municipalities, local capacities are also more limited, as ISP demonstrate low organizational and administrative capacities, which can reduce the quality and speed of the services offered. Local governments, in turn, have low IT capacity, which influences the provision of online public services and the implementation of more structured digital inclusion policies.

Context

The interviews showed that, in these municipalities, there have been advances in Internet infrastructure, as well as processes for improving its quality, in recent years. This involved expansion of fiber optics and replacement of Internet connection via radio with fiber optics, especially in urban areas, and the expansion of Internet connection via radio in rural areas. Despite this, there are areas that do not have access, and others where the signal is not constant and the speed is low, which occurs especially in rural areas, where radio connection predominates.

> *The biggest challenge is faced by residents of rural areas, they have more difficulty, there are communities that do not have Internet service like we do in the city, their access is via radio, it is not fiber optics, so theirs is that old system, not all rural communities are served, so the rural community does have more difficulty. The telephone does not work everywhere, so there are communities where the telephone does not work, the person would have to have an antenna to be able to capture the signal, but in the city, everyone has the same access* (DG SE1).

The geographic characteristics of the municipalities, such as terrain, can also act as barriers to advances in infrastructure and improvements in the quality of the Internet, affecting connectivity in some areas, as one of the interviewees pointed out in the following excerpt. In addition, in hard-to-reach and remote areas, the cost of installing the infrastructure is higher, which makes it unfeasible for ISP to expand.

> *Now if we talk about rural areas, I have a small problem because [...] there are mountains, it's complicated, really complicated, because you have to put several towers in several places and that ends up being a little more expensive. [...] Yes, there are, but they are practically inaccessible places, very inaccessible, for example, there is a village here [...], it is hill after hill, after hill, there is no place high enough to put a tower to include all that place, these difficulties exist* (ISP SE1).

Other factors related to the contexts of the municipalities were also mentioned by the interviewees. Among them, rain was identified as a challenge, not only to the stability of the signal, but also for the functioning of electrical energy, as in situations that occurred in municipalities of this group in the North and Southeast regions.

> *If it's sunny, only sunny all the time, the Internet is good, but if it thunders, flashes, storms, then it's not cool* (DG N1).

> *We hired a 300 Mbps service plan. Nowadays, it's better, but the initial problems hit any ISP [...], it can't start raining, if it starts raining, everything is out. We really out of access* (Leader SE1).

Other relevant barriers are more related to the socioeconomic characteristics of local populations, which affect their ability to contract a plan with higher speeds and acquire devices that are more suitable for their use. Individual attributes also matter, that is, lack of digital skills of certain groups, especially the elderly, for the use of ICT.

> *They have a mobile phone, they have Internet, but they don't use it, they don't know how to use it, to use it someone needs to put it here: "Send an audio here" or "Let's make a video" and other people help, but the actual person does not use it, but has the device or Internet at home* (Leader N1).

In these municipalities, it was more common to find reports of individuals who share the Internet with neighbors and family members. Less diversified activities were also observed than in the other groups. These two dynamics can be explained by these barriers and the characteristics of local capacities that will be discussed below.

Despite this, according to the interviewees, expanding access to the Internet and improving its quality proved to be fundamental to guaranteeing access to social policies, especially in the context of the pandemic. They also influenced the expansion of the use of ICT by the population and the forms of participation and organization of civil society. This occurred, for example, by holding meetings and assemblies and sending messages via social networks and other online platforms. One interviewed leader (N1), linked to a *quilombola* association, pointed out that access to the Internet and the use of social networks were fundamental for holding a debate among the members on the topics that the association would take to the meeting of the Coordination of Quilombola Communities. Another leader pointed out the importance of the Internet for carrying out core activities for the organization of which they are a part:

> *As I said at the beginning, our territory was expropriated, so we made a request to INCRA [National Institute for Colonization and Agrarian Reform] to open the process of identification, regularization and delimitation of the community's territory [...]* (Leader N1).

ISP

There was a prevalence in the analyzed municipalities of large enterprises that offered mobile telephony and small ISP that offered broadband. In relation to these small ISP, in the municipalities of Group 1, they had different trajectories. Most respondents had some previous experience working in ISP, IT enterprises and LAN houses. There was also a case in which the interviewee was a military policeman and dedicated himself to communication and geoprocessing activities. One of the interviewees (N1), who owned a LAN house, stated that, with the expansion of mobile phone use, there was not as much demand for the use of computers in LAN houses and, as a result, they decided to open an ISP, which was also reported by other interviewees.

Most ISP were characterized by small organizational structures, with no division between areas, and had up to ten employees. Some were even family businesses, as one of the interviewees pointed out:

> *My wife is an employee too, she is a teacher and in her spare time she helps me in this financial area, registering people, monitoring [...]. She not only works in the field, but here in the bureaucratic part at home, because our office is in our house, we have our place for equipment and we have a place for a little shop to serve customers, but that's all in our house. [...] The other employee does the fieldwork, installation, maintenance and I go along with him* (ISP N1).

Regarding supply, the ISP interviewed pointed to the expansion of fiber optics and said that they intended to expand its coverage in areas that still do not have infrastructure, including rural areas. However, there are some challenges. The first is the cost, given that expansion depends on financial planning for one or two years, as they do not rely on loans from banks. The interviewees also mentioned costs related to the rental and construction of poles, as well as difficulties in complying with the different regulations and procedures for this, which can be time-consuming, depending on their location.

> *For me to be able to connect one city to another, if it is a state concession highway, there is a specific legislation allowing me to place poles in unbuilt areas. [...] But if it is a federal concession highway you need to ask for the DNIT [National Department of Transport Infrastructure], then you get ready because it's not easy* (ISP SE1).

Regarding the quality of the services offered, the ISP interviewed participated in IX indirectly, that is, the enterprises that provided links to them participated. One of the interviewees (NE1) pointed out that the closest IX is in the state capital, and the second, in Brasília. Their enterprise is linked to both indirectly, stemming from the supplier enterprises, since it would be extremely expensive to be linked to these IX directly.

It is noteworthy that the interviewees showed little knowledge about the functioning and benefits of IX, which also occurred in the case of IPv6. Only one ISP (SE1) reported participating in IPv6. In this case, they acknowledged its benefits, such as quality and speed, but pointed out some challenges to its use, since not all servers have IPv6.

Local governments and policies

In the field of local governments, the interviewees highlighted the recent replacement of Internet via radio with fiber optics in the municipality, which also affected the connectivity of public facilities. Regarding this, one of the interviewees (SE1) highlighted that there was an expansion of fiber optics two years ago, stemming from a partnership between the ISP and the local government, in which the local government allowed the ISP to use the highway to expand the infrastructure. Before that, the connection was via radio; the signal from neighboring municipalities, where there was fiber optics, was passed on to the towers.

It was acknowledged by the interviewees that, as a result, there has been an expansion in the use of ICT by local governments and in the provision of public services to citizens on local government websites over the last few years. This expansion was also influenced by

other processes, such as the encouragement of the federal government for more intensive use of information systems, pressure from controlling organizations, and political changes in local management.

> *We have two websites, two domains, we have the domain [...] which has a political character to show especially what is being done, more advertising, and we have Transparency [...] which is monitored by the Court of Accounts and the Public Prosecutor's Office, we have access to everything, but also information, accounts payable, what is being paid, how much is spent, employees. [...] But we intend to at least provide the ITBI [Property Transfer Tax] soon, enabling to generate the ITBI payment slip online, the Urban Land and Building Tax payment slip online* (Local government SE1).

However, the municipalities of this group depend, primarily, on outsourced enterprises to carry out internal IT activities, such as maintenance of computers and information systems, provision of Internet for various public facilities, and management of information systems. Generally, they do not have formally institutionalized technology areas or departments. In the municipalities of the Center-West, Northeast and South regions, all the technology services provided by the local governments are outsourced, and there are one or two civil servants without specific training in IT who are responsible for monitoring these services. In the local governments of the North and Southeast, the people responsible for the technologies have degrees in the IT area.

Employees responsible for IT in local governments support and assist with the purchase of technologies in various areas; in general, they verify the need to purchase devices and determine the specific characteristics of the equipment to be purchased, such as computers. In most cases, the mayors' offices carry out approval of purchases, and other departments are responsible for the bidding and procurement process. These employees also monitor the work of outsourced enterprises that are hired to manage the information systems and ISP. It is common that, if there is any problem with these services, employees from other areas directly contact those responsible for IT, who then contact the enterprises providing services to the local governments.

During the pandemic, the efforts of local governments were aimed at guaranteeing access to public policies, especially in the social area. In the case of education, it is worth noting that remote teaching was restricted to the preparation of materials by teachers, who used computers and the Internet in schools, and distributed them to students, contacting their families through instant messaging applications. This occurred, especially, due to the lack of Internet access and adequate devices for many students, as one of the interviewees pointed out:

> *Due to the pandemic, we had a lot of difficulty related to the students, because many could not access the activities, they did not have Internet, they did not have a mobile phone to access the activities* (Local government CW1).

Among the connectivity barriers mentioned for the adoption of fiber optics in municipal facilities – such as schools, health centers and CRAS – respondents from the local governments of Group 1 pointed out, mainly, problems related to location and terrain (rural areas and mountainous regions). Difficulties in fiber optic connections in certain regions of these municipalities are also associated with lack of competition among enterprises that provide this type of service to the local governments. In addition, municipal managers highlighted some possible difficulties for populations to access the Internet, such as lack of financial resources to hire the service and lack of digital skills, especially for the most vulnerable populations.

It is important to point out that few local governments in this group have strategies to increase Internet access and reduce these barriers. One of the exceptions is the local government of a municipality in the North region, where there are computers and free Internet for the population in a public library. In this same municipality, the local government also offers free Wi-Fi in public spaces. In another municipality, located in the Southeast region, there is free Wi-Fi, but it is offered by a civil society organization. In this case, the interviewee pointed out that the local government had a digital inclusion policy through the existence of telecenters in the municipality. However, this policy was discontinued, a situation that was also found in municipalities of the other groups.

> *Before, in the square, [...] there was always Wi-Fi, but later, under the new management, it got cut and we don't have it anymore* (Leader CW1).

Group 2: Low connectivity and higher local capacities

Group 2 is made up of municipalities that, as in Group 1, are characterized by recent expansion of fiber optics. There are also geographic and socioeconomic barriers that prevent the access of some groups of individuals within the territory of the municipalities. However, unlike Group 1, there is greater diversification in the use of ICT by the local population.

This group is made up of municipalities with higher local capacities. This means that ISP are more professional than those in Group 1, but their professionalization is part of a recent process resulting from their growth over the last few years. In addition, it is more common to find formal and informal partnerships with other enterprises, which made it possible to overcome some geographic and socioeconomic barriers. Local governments are also characterized by recent processes for increasing their IT capacity, which influenced the provision of online public services and the implementation of digital inclusion policies. However, these services and policies still have a limited scope.

Context

As reported by respondents in all regions, there was recent expansion of Internet access in the municipalities, which involved replacement of the Internet via radio with fiber optics. Despite these advances, small ISP face numerous barriers, especially those related to the geographic characteristics of the municipalities, to the expansion of fiber optics. Barriers such as great distances between urban and rural areas – which, in one case, reaches about 50 km – were reported, as was lack of asphalt on the roads that connect urban to rural areas, the presence of mountains, which make the range and stability of the signal difficult, and lack of electricity.

In rural areas, especially in communities far from urban areas, some located in hard-to-reach and remote areas, these barriers increase the cost of expanding fiber optics and installing and maintaining radio towers. Facing these barriers in areas where there are few customers is financially unfeasible, as reported by ISP's respondents. One of them pointed out:

> *Imagine that you make a 100-km network, you will invest in around a thousand poles to meet a demand of 100 contracts, so the cost gets in the way, the project doesn't pay it back* (ISP N1).

In places where there is no electricity, costs also increase, as residents need to install solar energy systems. One of the ISP's interviewees (NE2) pointed out that solar panels work with batteries, but as there are no paved roads leading to the towers, they must travel on horseback to change the batteries. Still related to electricity, one of the interviewees from local governments (N2) stated that there is instability, disrupting the Internet signal via radio.

In the case of poles, their construction and rental across the entire distance between urban and rural areas increase the cost of expanding the Internet throughout the territory

of the municipalities, especially in the most remote areas. One of the interviewees (NE2) stated that there was still no charge for the poles used by the ISP, but that they know they will have to pay for the rent in the short term.

One of the leaders interviewed (CW2) reinforced what was reported by ISP: There is a high cost for installing the Internet in rural areas. They pointed out that the towers must be in high places so that the signal can be passed on to the repeater antennas. However, the cost of towers and antennas is high; according to him, the total cost was BRL 300,000.

In rural areas, the high cost prevents the most vulnerable populations from accessing and carrying out some economic activities, as one of the interviewees pointed out:

> *People say, "Ah, farming doesn't require Internet." It's needed, today there are machines, there are a series of things that are all connected. So, you are 10 km, 20 km from the city and there is no Internet there, and you need it to connect one machine to the other, this is important, very important. Today [...], we have satellite, but if we had the Internet there in the region with a higher capacity, it would be of paramount importance* (Leader CW2).

Other barriers faced by the population were mentioned in the interviews. The first was Internet speeds, via both radio and fiber optics, which are generally considered low. The others are socioeconomic inequality and lack of skills to use ICT. It was commonly reported that the plans were expensive for individuals with lower income, and that some groups, especially the elderly, face greater difficulties in accessing the Internet and diversifying their use of ICT.

It is observed, in this group of municipalities, that expansion of Internet access and, mainly, improvement of its quality allowed the local population to use ICT for a wide range of purposes, such as selling and buying products and making online payments and transfers. In one of the municipalities (N2), the participants in the discussion group pointed out that there is no bank branch and, therefore, they use banking apps and Pix (an instant electronic payment system) quite frequently.

ISP

As in Group 1, in the municipalities of Group 2, mobile telephony is offered by large enterprises and broadband by small ISP. In relation to ISP, their trajectories are diverse. In three cases (N2, NE2 and S2), the enterprises were created from previous experiences with LAN houses and, in one of the cases, one of the owners worked in this field. In another municipality (CW2), the owners had no previous experience, but had training in information systems. In only one municipality (SE2), the owner had no previous experience or training in the area, as they owned a lighting and sound system enterprise for events.

Currently, ISP have small numbers of employees, and one is family owned (N2). Different from Group 1, a recent trend toward expansion and professionalization can be observed among the enterprises. In one of the ISP (CW2), their growth led to an internal division with the creation of several areas: customer service, finance, technical and con-

trollership, with managers responsible for each area. In another (SE2), initially, the manager worked in all activities, including installation, but with ISP's growth, there was a division of activities. They were responsible for administrative activities and part of the technical activities, and hired two employees, one to manage part of the technical activities and the other to inspect the fieldwork.

Expansion and professionalization were mostly carried out with their own resources, although some ISP had access to some financing. According to the interviewees, as reported in Group 1, ISP would need to have a higher turnover to access financing in public and private banks:

> *[...] They provide lines of credit, and with lines of credit over BRL 500,000, for example, you get an amount of BRL 500,000 or BRL 1 million, but you must have huge revenues, otherwise you cannot access these lines* (ISP SE2).

ISP overcome some of these barriers through formal and informal partnerships with other enterprises, which seems to be more common in these municipalities than in Group 1. These partnerships occur between small ISP, as well as between them and medium enterprises. They involve sharing infrastructure, such as towers, equipment and technical support. In these last two cases, the interviewees mentioned the loan of equipment, which is fundamental due to the delay in deliveries done by mail in these municipalities. They also mentioned that there is knowledge and information sharing.

> *We've already borrowed a lot, we've lent a lot of equipment. [...] The mail takes a long time. Mail only arrives here twice a week, when the pouches arrive. Imagine you have to wait X days, until the equipment arrives, to be able to make the replacement so that the customer can have Internet again* (ISP NE2).

> *Basically, exchange of experience, we had monthly meetings and always brought someone to present a lecture to us on a subject that had already been decided, or we would bring a supplier with a new solution that we needed, some collective purchase that we were going to do, people got together and tried to buy from a single supplier to try to lower prices, things like that* (ISP S2).

Regarding IX, unlike Group 1, in Group 2, all interviewees highlighted its importance for increasing the quality of the Internet. Some of them pointed out that they participate indirectly in an IX, insofar as the enterprises that provide the link participate in an IX. However, one of the interviewees highlighted that regional enterprises have no interest in small ISP connecting to an IX:

> *When it comes to IX, you can buy links from other operators, so the price tends to drop, this is a trend that is inevitable, you have dozens of ISP there that offer IP links, CDN [content delivery network], so regional operators don't seem to want this* (ISP SE2).

In Group 2, access through IPv6 is more widespread than in Group 1. Respondents in Group 2 know the importance and benefits of IPv6, especially regarding security, as they could allocate an IP for each customer and improve problem detection. They are implementing IPv6; only one of the ISP does not offer IPv6 access, but said that they will hire a consultant to implement it. However, respondents pointed out that its effective implementation is hampered by the limitations of customer equipment.

Local governments and policies

The municipalities are divided in relation to the adoption of digital inclusion strategies. In two cases (CW2 and SE2), there is free Wi-Fi available in public squares and, in one of these cases, there is also a telecenter, as reported by respondents from local governments. In others, the offer of free Internet still does not exist, but this topic seems to have recently entered the agenda of local governments. In one of the cases, the local government received funds from the state government to offer Internet in a public square (NE2).

As pointed out, municipal policies for digital inclusion were identified based on the offer of free Internet in some cases, but there are no policies that involve the coordination of different strategies and actions to effectively reduce barriers to access and use by local populations, especially the most vulnerable. Local governments are still characterized by fragile, under professionalized and poorly institutionalized structures, and are very dependent on the outsourcing of ICT services – which makes it difficult to formulate and implement more coordinated policies. However, unlike Group 1, local governments have greater numbers of IT civil servants (S2, SE2 and NE2).

Despite this, local governments seem to have advanced in expanding their own use and strengthening their IT capacities, both by hiring civil servants and by creating their own systems. The expansion of access via fiber optics was essential for municipalities to be able to use information systems related to various federal or state programs. Connectivity was also identified as relevant for compliance with regulations related to data transparency and other requirements of controlling organizations, which induced the increase in the use of ICT by local governments over time.

> *Around 2005 and up to now, there was no way of not having Internet anymore, because there were these programs from the SUS [Unified Health System] and some of the social assistance work since then, we could no longer work without Internet* (Local government N2).

In addition, the interviewees' reports show that, in the absence of more effective digital inclusion policies, the priority is to expand the use of ICT by the most vulnerable population to access social policies, which was especially relevant in the context of the pandemic. It was common for teachers to use ICT to produce materials that were distributed to students via contact with their families through social networks, mainly through applications such as WhatsApp. One of the interviewees (S2) reported that there was a need to buy computers for that, which reveals greater demand for digitalization in the context of the health crisis. In some cases, teachers gave classes or guidance through videos or online broadcasts.

Group 3: High connectivity and reduced local capacities

Group 3 includes municipalities in which there has been a recent expansion of fiber optics, as occurred in the municipalities of Groups 1 and 2. Geographical and socioeconomic barriers, especially present in rural and more remote areas, were also highlighted by the interviewees as impediments to expansion of infrastructure and access for the most vulnerable groups. Unlike the other groups, respondents highlighted the high cost of links in these municipalities.

These municipalities have reduced local capacities compared to those observed elsewhere in the country. ISP have lower organizational capacities and less professionalization, which influences the quality of the services offered. Local governments are also characterized by low administrative capacity in IT, but there has been an effort to strengthen their capacities, increase the offer of online public services, and implement digital inclusion policies, especially during the pandemic. However, as in Group 2, these actions are still sporadic and fragmented.

Context

As in Groups 1 and 2, in Group 3, there is an expansion of Internet access via fiber optics and the replacement of Internet via radio with fiber optic connections in the municipalities. One of the interviewees (SE3) pointed out that an expansion of the fiber optic network was carried out, reaching 100% of the urban area in the last year. According to them, fiber optics are available in areas that are up to three to four kilometers away from downtown.

Like the municipalities in Groups 1 and 2, small ISP face barriers to the expansion of fiber optics, especially in rural areas, due to the large distances between urban and rural areas and mountainous terrain. In these areas, expansion is more expensive. Again, the costs of installing and maintaining towers and solar energy systems were mentioned in places where there is no electricity, and construction and rental of poles, as one of the interviewees pointed out:

> *However, we have rural customers that are in the other direction, where we don't have backbone. [...] So I don't have poles to make the FTTH [fiber-to-the-home] network [...], because the electrical network comes from another direction. These are unable to use fiber, at least at this time. It's not ruled out, but it's not something simple to do* (ISP S3).

Regarding the poles, one of the interviewees (CW3) drew attention to the high cost of renting them and to the difficulty of expanding the network due to lack of space on existing poles, problems different from those presented by the interviewees of the other groups. Another barrier that increases the cost of the Internet offered by ISP, mentioned by interviewees in this group, but absent in the reports of Groups 1 and 2, is the cost of the links. Due to the distance of some of these municipalities from larger ones, they said that they pay more for the links than in other locations. The ISP located in a municipality in the

North region pays about five times more for one Mbps than in a municipality located in another region. According to some of the interviewees, the high cost of renting poles and links makes it impossible to expand the infrastructure.

> *You end up not being able to expand that much because you are stuck there with an extremely high monthly fee for a pole and you commit all your income to it, with a link. In a remote city, the link is expensive, so it is one of the difficulties we have* (ISP CW3).

Respondents pointed out that the increase in cost reinforces barriers to access for the most vulnerable populations, especially those living in rural areas. They also stated that these populations cannot afford the cost of installing a tower, for example, as well as the monthly fees. However, individuals with higher incomes, such as owners of ranches and farms, can afford both – the installation and the monthly fees. One of the interviewees pointed out that, to improve the quality of the Internet, they organized a group of farmers and paid for the installation of a tower near their residence.

> *Three thousand [BRL] for each producer, there were seven producers and three thousand [BRL] and some more for each one. [...] Just for the tower, apart from the router, the equipment around their house* (DG SE3).

In the urban area, the interviewees also mentioned difficulties in paying for the plans, reported sharing the Internet with neighbors and, in one case (NE3), the interviewee pointed out that this is a common practice in the municipality.

In addition, respondents reported that there are still challenges related to Internet quality and speed. According to the participants in the discussion groups, the contracted Internet speeds, both via radio and fiber optics, still restrict the activities carried out in the virtual environment, especially in the case of those that require greater speeds, such as video transmission and participating in videoconferences.

Despite this, as in Group 2, greater diversification of the use of ICT was observed. Several interviewees – leaders and participants in the discussion groups – highlighted that they use social networks to buy and sell products. One of the participants pointed out that they sell fruit and vegetables, and another, that they sell snacks through social networks. Another participant, a truck driver, reported that they buy truck parts over the Internet, and make deliveries through an application. A leader pointed out that the cooperative in which they are a member started to schedule the collection of recyclable materials through WhatsApp during the pandemic.

> *We go and collect one day at Mrs. Maria's house; Mrs. Maria's neighbor Mrs. Joana also has material to donate, and she wants to join the group to let us know when the material is ready for us to go there to collect it; we include Mrs. Joana too. Mrs. Joana has a relative on the other end of town who also wants to donate recyclables, she wants selective waste collection, she passes on the contact, and we also include the other person and so on* (Leader NE3).

ISP

As in Groups 1 and 2, the Internet offer in these municipalities is made by large enterprises in the case of mobile telephony and by small ISP in the case of broadband. Unlike Groups 1 and 2, in all ISP, owners have professional experience or training in the area and, in only one of them, the owner had a LAN house. However, in relation to their professionalization and organizational capacity, Group 3 is closer to Group 1, as they have small numbers of employees, there is no division into areas or departments, and they are not being expanded or professionalized, as is the case with the enterprises of Group 2.

> *So, in our structure today in each city, we have an attendant and a technician and, in the internal part, in the back end, I am in the administrative area, my wife in the financial and there are two friends of mine, one takes care of the operational part, coordinates the people who are working out there, and the other does the technical part* (ISP S3).

As in Groups 1 and 2, ISP have mostly operated with their own resources. The challenges are similar to those reported by respondents in Groups 1 and 2: there is a lack of specific lines of credit, the amounts provided by banks are incompatible with those required for the expansion of infrastructure, and interest rates are too high. In addition, one interviewee pointed out that banks do not understand "networks" as goods, that is, guarantees, which makes loans more unfeasible.

> *So, we almost always end up being forced to take more expensive lines that are created for a general purpose, not for financing Telecom infrastructure, and this is a barrier that we have in practically all banking agents and cooperatives that we work with* (ISP S3).

Similar to what happens more intensely in Group 2, ISP participate in formal and informal networks with other enterprises. These partnerships involve the sharing of information and knowledge, through participation in groups on social networks, and joint loan and purchase of equipment. One of the ISP interviewed (S3) also reported participating in associations, which connect ISP from neighboring municipalities, enabling the contracting of bandwidth for lower prices. According to him:

> *So, the difficulty we had, we took it away. Because today the owner of the transport network is no longer Copel or any big Tele, we own our own structure. We built infrastructure for that* (ISP S3).

Regarding IX and IPv6, Group 3 is at a more advanced stage than Group 1, but worse than Group 2. Like Group 2, most respondents are familiar with IX, and especially IPv6, and acknowledge their importance. As in Group 1, most do not participate in an IX (N3, NE3, CW3 and SE3), but some have already started the process of adopting IPv6 (only in the North region, the ISP has not started this process), but have not consolidated it.

Local governments and policies

Regarding the capacities of the local governments, Group 3 does not present great differences in relation to the previous groups. Its IT capacities are fragile, as there are few civil servants responsible for various activities, such as helping other areas, supporting the equipment purchase process, and managing contracts with ISP and enterprises responsible for the software used by local governments. However, all municipalities have hired at least one person with an IT degree.

As in the other groups, the expansion and improvement of the quality of the Internet made it possible to intensify the use of ICT, including information systems related to federal programs and data transparency mechanisms. However, the services available on the local governments' websites focus on the tax sector, such as generating electronic invoices and payment slips, and on disseminating information through the transparency portal.

In addition, the use of ICT also made it possible to provide services and make information available during the pandemic. In relation to the other groups, the local governments in Group 3 pointed out more strategies for using the Internet to ensure contact with the population, such as the use of instant messaging applications (S3, N3, NE3 and SE3) and online registration for vaccination (SE3).

As in the other groups, it is observed that ICT was used to guarantee access to social policies and education during the pandemic, with calls being made to monitor the beneficiaries of social programs and the use of computers and the Internet to prepare educational materials and social networks to organize their distribution by teachers to families and students. It was reported that, in the case of state schools, there were short online classes in which teachers explained the content and activities to be carried out by students.

It is important to point out that the municipalities are divided in relation to the adoption of digital inclusion strategies. In the municipality in the South region, there is a telecenter with computers and free Internet access in a state school, and there are computers available in the library and in social assistance facilities for the use of beneficiaries of social programs. In the municipality in the North region, one of the interviewees mentioned the existence of a state program to provide free Wi-Fi, which would have been essential to expand Internet access in that region. However, at the time it was available, the population did not have access to devices, and the program was later discontinued. In this municipality, the local government allows access to the Internet at the city hall headquarters and in a rural school.

> *In the case of the school, those who live close to the school end up using the school's Internet, it is a village town, these Internet hotspots that I was saying will be installed, will be via satellite, then the population uses this Internet, which is the only way of communication because there is no phone signal in this area. It is more difficult in rural areas* (Local government NO3).

In the context of the pandemic, one of the municipalities created a joint effort to help citizens register for the government's emergency financial aid at the Social Assistance Department, a strategy aimed at overcoming barriers to access and lack of skills of some groups of individuals in the use of ICT.

> *Internet signal was available, the person would get there and connect their own mobile phone, using the Caixa bank app. But there was a team there available to help register in Caixa Tem [a Brazilian state-owned bank application for welfare payments and bank transactions]. It's just an example of access* (Local government SE3).

In two other municipalities (CW3 and SE3), there were also centers that provided computers and free Internet access, but they were discontinued. Finally, in the municipality in the Northeast region, the offer of free Internet still does not exist.

Group 4: High connectivity and greater local capacities

Group 4, in general, includes the municipalities that have more consolidated paths of fiber optics expansion. They are also municipalities characterized by geographic and socioeconomic contexts that make it difficult to access the Internet, especially for more vulnerable groups in rural areas. However, these are not considered by the interviewees as barriers that make access unfeasible. The biggest challenges, according to them, are more related to the quality and speed of the Internet. Even though connectivity conditions are better than those of the municipalities in Group 1, for example, the demands of local populations are greater, given that they have a more diversified use of ICT.

In this set of municipalities, local capacities are greater, which is reflected in the professionalization and organizational capacity of ISP, as well as in the services they offer. Despite this, the local governments' IT capacities, the offer of online services by them and their digital inclusion policies do not stand out in relation to Groups 2 and 3, that is, they are more advanced than Group 1, but still limited.

Context

The interviews showed that the expansion of fiber optics and the replacement of the Internet via radio with fiber optics had taken place longer before in these municipalities than in the municipalities of the other groups. However, as in Groups 1 and 2, barriers to connectivity associated with the geographic characteristics of the municipalities were mentioned. Respondents drew attention to signal instability and low speeds in rural areas and those with mountainous terrain. As reported by one of the interviewees (CW4), in urban areas, speeds vary from 100 to 500 Mbps and, in rural areas, from 5 to 10 Mbps. However, reports pointing out that there is lack of infrastructure in these areas were not common, that is, the provision of Internet, even if via radio, is ensured by the ISP.

As reported by respondents in Group 3, in rural areas, the cost of installation is high, increasing barriers to access for populations living in these areas, especially the most vulnerable. However, there are farmers who have paid for the infrastructure. According to the interviewee of the ISP enterprise in the municipality in the Southeast region, the costs of installing a tower and the necessary equipment vary between BRL 5,000 and 15,000, which is considered an affordable expense for some of these farmers.

In urban areas, contrary to the other groups, respondents did not point out problems with signal stability and Internet quality, but there was greater need for Internet speed during the pandemic. This greater demand was a challenge for ISP, who had to increase speeds without changing plan prices. There is a difference between Groups 1 and 4 in the relationship between speed and cost. Although respondents reported problems, contracted plans generally have higher speeds and are proportionately cheaper than those contracted by individuals in Group 1.

It is important to highlight that, unlike Groups 1, 2 and 3, rain was not mentioned by the interviewees as a relevant barrier to connectivity, indicating better infrastructure in relation

to that existing in the municipalities of the other groups. In addition, few respondents pointed out low income of the population, lack of skills of certain groups, such as the elderly, and low quality of devices as critical factors for Internet access.

As in the other groups, the ISP's interviewees drew attention to problems related to poles. As reported, their rent can make it unfeasible to expand in areas further away from the center of municipalities. As was reported in the other groups, one of the interviewees (CW4) pointed out that the further the areas are from the center of municipalities, the greater the cost for ISP. If there are not many potential customers, it is unfeasible for them to offer the service. This interviewee suggested that a one-time payment license could encourage infrastructure expansion.

The interviewees pointed out difficulties related to the links that are available to them, as did the interviewees in Group 3. Some reported that there was improvement with an increase in competition between the enterprises that provide the links, because they can contract larger links for lower prices. However, others still believe that this is a challenge to improving the quality of the Internet in the region, as municipalities are very far from the backbone and an IX, and this distance increases latency.

> *The further we are from São Paulo, the greater the latency, one of the technical problems that sometimes generates cancellations, the customer who plays games, they will play on a server that is in the United States, ok, but even up to São Paulo we know that the latency is already 30 milliseconds, 40, they will play on the international server, so it reaches 150, 200, but it is not on us, it is not our connection that's poor, it's our location that's not good for this type of use* (ISP SE4).

As in the other groups, the interviewees pointed out that expanding access to the Internet and improving its quality were important for carrying out their activities, which involve a broader and more diversified range of purposes. Two leaders (N4 and SE4) stated that they can carry out activities that require higher speeds, such as video transmission, and in one of the cases, the interviewee referred to access in the rural area.

ISP

As in the municipalities of the other groups, mobile telephony is offered by large enterprises and broadband by small ISP. In relation to these small ISP, the trajectories differ between those in the North and South regions and those in the Center-West, Northeast and Southeast regions. In the first cases, enterprises originated from computer enterprises; thus, the owners have professional experience in the field. In the other cases, the interviewees were technicians with training, previous professional experience in the field, had worked in larger ISP, or already had considerable experience in the ISP they worked for, as can be seen in the report of one of the interviewees:

> *My main and complete degree is in electrical engineering. I am completing a postgraduate course in IT governance, and I am starting my studies for the LGPD [Brazilian General Data Protection Law] certification, I intend to be certified by the EXIN as a DPO [Data Protection Officer], at least by the end of the year, that's the goal. I've been working here for 11 years, so the ISP itself, we are present in 20 cities* (ISP SE4).

It is observed in this report that the ISP is more professionalized than those in Groups 1, 2 and 3. This greater professionalization is common to the other ISP analyzed, since they have a greater number of employees, including technicians, and an internal division into areas or departments and more clearly defined processes.

> *Today, within the company, there is this administrative and financial area that I take care of. We have a contract manager who takes care of the contracts, contracting clients, in short, all the bureaucratic part of their payment. We have a secretary. We have the technical manager and an engineer who take care of all these parts of the network, the technical part, from projects for new Internet hotspots, and projects to send to the concessionaire for approval of poles, to projects that go to Anatel; this is handled by these two men on the technical side. And then the fieldworkers, there are eight men in the field, they are installation technicians* (ISP S4).

As in the other groups, the interviewees pointed out that the ISP prefer to expand the network using their own resources, since there are no specific credit lines for them, and the interest is high. However, some of them (CW4, S4 and SE4) accessed BNDES financing. One of them reported that they used the resource at the beginning of the expansion of fiber optics, and another (CW4) bought servers, fiber optics and cables. One of them (NE4) pointed out that the group they belong to financed some of their activities.

Another similarity with Groups 2 and 3 refers to formal and informal partnerships with other ISP. However, in this group, this involves more information and knowledge sharing than equipment loan and infrastructure expansion partnerships. This is because, in this case, ISP are not as fragile in terms of their capacities.

Regarding IX, ISP vary. There are two that participate in an IX (CW4 and SE4) and two that do not (N4 and NE4) (the interviewee of the ISP in the South region was unable to provide that information). ISP highlighted the benefits of participating in an IX in relation, mainly, to improving the quality and stability of the signal. They also pointed out that they participate directly and indirectly – and in cases where participation is indirect, the reason is their distance from the IX, as the interviewee of the ISP in the Southeast region reported:

> *We are interconnected to three [...], directly. It arrives indirectly at the IX in Rio Preto, so, oh, it's cool, it's a very low-cost traffic aid, which is where the big players are. Today most of our traffic comes from the big players, so Google, Facebook, Netflix, and the fact that everyone is together there only improves the quality* (ISP SE4).

IPv6 seems to be more widespread among ISP in this group, as at least four of them (N4, NE4, CW4 and SE4) have adopted IPv6. In addition, two ISP highlighted that they hired another enterprise to provide training and support. However, the report on IPv6 is similar to that of respondents from the other groups: They acknowledged the benefits but highlighted the enormous challenges to its effective implementation. One of the interviewees (SE4) pointed out that the enterprise tried to adopt IPv6 on all connections but faced technical barriers to do so. According to him, ISP sell "high bandwidth" to their customers and IPv4 is no longer available, but the equipment is not adequate for this change.

> *IPv6, technically speaking, has the lowest packet overhead, its routing part is much simpler than a match, it takes up less router processing, perfect, perfect world, and in a 120 Mbps client, it provided 80 Mbps, 60 Mbps, 50 Mbps. And when we started working on the network: "It's not the signal, it's a fiber problem, it's an OLT [optical line terminal] problem, it's an authentication author problem and such," and nothing and nothing, "Oh, let's disable IPv6? Let's go," I disabled IPv6, all normal* (ISP SE4).

Local governments and policies

As with the other groups, the expansion of fiber was essential for improving connectivity in public facilities and expanding the use of ICT by local governments. The pandemic also induced local governments to expand online public services, mainly tax services, such as generating Urban Land and Building Tax payment slips, and to use ICT more intensively, seeking to guarantee the population's access to social policies. In the case of education, the elaboration and distribution of materials by teachers prevailed. Combined with this, in one case, there were online classes, and in another, SIM cards were distributed to students. Participants in the discussion groups reported that, in the case of some state networks, there was also SIM card distribution to students for remote teaching.

As in the other groups, the local governments' IT capacities are still fragile. There is no institutionalized structure that formulates and implements IT and digital inclusion policies. Groups 2 and 4 have a greater number of civil servants, but their activities are restricted to supporting different areas of local governments in everyday issues and demands, in the purchase and installation of equipment, and contract management.

This fragility is reflected in the absence of digital inclusion policies. Few municipalities have adopted strategies to increase Internet access. In two municipalities (SE4 and CW4), there were telecenters, a result of the induction of federal policies, and, in some cases, state policies. However, with the discontinuity of federal and state programs, local governments did not continue to pay for the telecenters, which then closed. In one municipality (S4), computers and free Internet are available to the population at public libraries, and, in another (NE4), Wi-Fi is free in some public facilities, but this is not an action formalized as an inclusion policy.

> *It stays open because there are many students, many people who use it and there is no way to provide the password to everyone, it is open. Here at the administrative center, there is an open Wi-Fi network. Everyone arrives and already connects their mobile phone* (Local government NE4).

Final considerations

The analysis of the set of small municipalities shows that the expansion of infrastructure, especially fiber optics, was considered essential to expand access to the Internet. However, the results regarding the connectivity of the population presented significant variations. There are socio-digital inequalities between individuals in different territorial contexts, which affect the diversification of activities carried out online and full use of ICT. Socioeconomic vulnerabilities increase barriers to contracting higher speeds and having access to devices suitable to their needs. In addition, certain groups, especially the elderly and residents of rural, remote, and hard-to-reach areas, also face challenges because they do not have the digital skills necessary to use ICT.

This shows that infrastructure improvements can play a key role in this process, including expanding backhaul and fiber optics, especially in rural, remote, and hard-to-reach areas; facilitating the construction and rental of poles; and expanding and supporting the improvement of electrical networks and installation of solar energy systems. Furthermore, reducing socioeconomic inequalities is central to more equitable access.

This study also draws attention to the importance of local capacities in order to ensure higher levels of connectivity and, therefore, to counter the influence of territorial and socioeconomic diversities and inequalities that affect connectivity and socio-digital inequalities. Connectivity is a complex problem that involves the action of various public and private organizations. In a context of reduced action by local governments in the implementation of more systematic and coordinated digital inclusion policies, ISP seem to play a decisive role in the levels of connectivity in municipalities. Their organizational and administrative capacities are associated with the services they offer and, therefore, with access to the Internet by local populations.

The continuous improvement of the quality of the Internet in small municipalities also requires strengthening the organizational, administrative and financial capacities of small ISP. Actions that affect the regulation and financing of ISP, including promoting their access to an IX and offering specific and attractive financing lines to them, are important to strengthen their capacities and improve the services they offer.

Regarding public policies for digital inclusion, this study showed that they are essential to increase connectivity levels, especially those that coordinate free Wi-Fi, access to devices, and development of digital skills, in public facilities distributed throughout the territory, such as municipal schools. The provision of these policies involves the action of the three levels of government – federal, state and municipal – and, in the case of municipal governments, the strengthening of their IT capacities.

The construction and strengthening of local capacities are central in order for technologies to enable expansion of democratization of access to information and social participation, mitigation of socioeconomic and territorial inequalities, reduction of displacement barriers for access to public services and cultural facilities, and promotion of socioeconomic development.

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