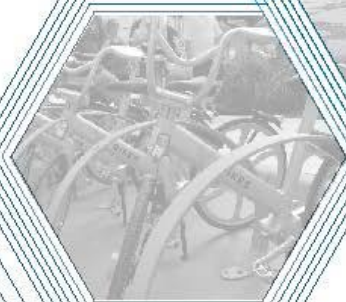

SUSTAINABLE AND EQUITABLE INNOVATIVE FUNDING STRATEGIES FOR ENHANCING BROADBAND INITIATIVE IN UNDERSERVED AND DISADVANTAGED COMMUNITIES

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FINAL REPORT

CENTER FOR TRANSPORTATION EQUITY, DECISIONS & DOLLARS

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FINAL PROJECT REPORT

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16. Abstract

The overarching objective of this project is to create an economically sustainable and socially equitable business model to utilize innovative funding strategies for enhancing broadband access in rural areas, and underserved and disadvantaged communities. This research will apply a mixed-method research methodology, combining quantitative and qualitative techniques to identify and evaluate innovative funding strategies in the practical context of broadband connectivity in underserved and disadvantaged communities. The data in this study will be collected from three primary sources: (1) a survey and , (2) semi-structured individual interviews, and (3) a focus group interview. This research aims to develop an interactive map-based GIS prototype application in a relevant environment as per TRL 6. The research report will identify A guidebook of best practices will be developed to assist transportation agencies, Metropolitan Planning Organizations (MPOs), and local governments in deploying innovative funding strategies to enhance equality for broadband access and reduce the unproportionate allocation of cost to underserved and disadvantaged communities. The guide will include model contracts for establishing a public–private partnership (P3) agreement between a private developer and a government entity to deliver broadband projects. The research report P3 model contract will include appropriate risk mitigation and allocation measures that are proven to be effective to (1) broaden the participation of private-sector developers, (2) enhance competition in the broadband market, especially in rural areas, and underserved and disadvantaged communities, and (3) ensure that the benefits and costs of broadband development projects do not disproportionally impact the underserved and disadvantaged communities. This research will make scholarly contributions to the academic domain of infrastructure project finance through (1) the identification and characterization of innovative funding strategies for broadband initiatives, and (2) the creation of a new class of risk registers P3 models for balanced risk allocation and mitigation for broadband project delivery in rural areas, and underserved and disadvantaged communities.

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Abstract

The overarching objective of this project is to create an economically sustainable and socially equitable business model to utilize innovative funding strategies for enhancing broadband access in rural areas, and underserved and disadvantaged communities. This research will apply a mixed-method research methodology, combining quantitative and qualitative techniques to identify and evaluate innovative funding strategies in the practical context of broadband connectivity in underserved and disadvantaged communities. The data in this study will be collected from three primary sources: (1) a survey and , (2) semi-structured individual interviews, and (3) a focus group interview. This research aims to develop an interactive map-based GIS prototype application in a relevant environment as per TRL 6. The research report will identify A guidebook of best practices will be developed to assist transportation agencies, Metropolitan Planning Organizations (MPOs), and local governments in deploying innovative funding strategies to enhance equality for broadband access and reduce the unproportionate allocation of cost to underserved and disadvantaged communities. The guide will include model contracts for establishing a public–private partnership (P3) agreement between a private developer and a government entity to deliver broadband projects. The research report P3 model contract will include appropriate risk mitigation and allocation measures that are proven to be effective to (1) broaden the participation of private-sector developers, (2) enhance competition in the broadband market, especially in rural areas, and underserved and disadvantaged communities, and (3) ensure that the benefits and costs of broadband development projects do not disproportionally impact the underserved and disadvantaged communities. This research will make scholarly contributions to the academic domain of infrastructure project finance through (1) the identification and characterization of innovative funding strategies for broadband initiatives, and (2) the creation of a new class of risk registers P3 models for balanced risk allocation and mitigation for broadband project delivery in rural areas, and underserved and disadvantaged communities.

Chapter I: Broadband P3 Models Review

Critical Review of Public-private Partnership (P3) Business Models for Enhancing Broadband Initiatives in the United States

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Sustainable and Equitable Innovative Funding Strategies for Enhancing Broadband Initiative in Underserved and Disadvantaged Communities

Introduction

While access to fast and affordable broadband infrastructure is widely acknowledged as the sine qua non of future economic growth and social inclusion, the economic reality of high investment costs and uncertain demand has limited their deployment [1,2]. This reality has led to different levels of internet connectivity and penetration in urban and rural areas, resulting in a persistent urban-rural digital divide [3,4]. To fill this gap, governments have made deliberate efforts to intervene in the deployment of broadband infrastructure [5]. This trend has been further accelerated by the COVID-19 pandemic, as broadband access has become essential for individuals to carry out their basic socioeconomic activities. [6]. For example, during the pandemic, the United States government has allocated substantial federal broadband funds through public agencies such as the Federal Communications Commission (FCC), the National Telecommunications and Information Administration (NTIA), and the United States Department of Agriculture (USDA). These funds have helped local governments to leverage the deployment of broadband projects in their communities.

In urban areas, the deployment of broadband infrastructure is typically fully funded by the private sector or jointly funded by partnerships with the public sector. In the past, these Public-private Partnerships (P3) were more likely to involve private-led investment with public support [7]. However, unlike metropolitan areas and large cities, local communities lack the large population and market demand that would attract private investment in broadband infrastructure [8]. As a result, these communities often rely on public funds and form partnerships with the private sector to deploy broadband infrastructure. While local communities are not attractive markets to private investors, they still need partnerships with the private sector to deploy their broadband infrastructure, often investing more public funds under relatively unfavorable conditions.

Still, the private sector plays a crucial role in supporting new entrants in the broadband market through their technology and industry expertise [9]. Private companies engage in partnerships that involve assuming risks, such as commercialization, even when they do not share actual financial risks. The extent of their involvement depends on factors like community size and contractual conditions. Moreover, broadband infrastructure is increasingly being likened to a utility infrastructure [2,10,11]; broadband access is now understood as critical to individuals' and communities' ability to function and can no longer be considered optional by public service providers.. It has become indispensable to innovation, economic opportunity, healthcare, and civic engagement in today's modern society [12]. Failing to provide broadband access not only undermines public entities' commission to provide necessary public services to their constituents but exacerbates existing inequities for communities without access. These inequities impede economic growth [13], undermine social welfare, and intensify distributional justice issues which are already a major problem in many areas of the US [14]. Therefore, it is essential to find ways of constructing broadband infrastructure and establishing affordable partnerships to connect communities and businesses effectively.

The objective of this research is to investigate P3 business models for enhancing broadband initiatives in the United States. To achieve this goal, we conducted a comprehensive literature review and carried out interviews with subject-matter experts. The structure of this research is as follows: Section 2 provides an overview of the research background. Section 3 presents the research framework. Section 4 presents the results derived from the literature review and interviews. Section 5 offers discussions of the key findings. Finally, Section 6 presents the conclusions drawn from this study.

Research Background

According to the FCC [15], 82.7% of Americans in rural areas had coverage from fixed terrestrial broadband at 25 Mbps download and 3 Mbps upload speeds, as compared to 98.8% of Americans in urban areas. The speed of 25/3 Mbps is the standard for unserved areas from NTIA [16], and 25/3 Mbps indicated minimum requirements of the high-speed internet. In the case of the faster speed tiers, the gap between urban and rural areas is much larger. While 95.0% of Americans in urban areas had coverage at 250/25 Mbps, only 55.6% of Americans in rural areas had coverage at this speed. This disparity is the result of critical factors of broadband infrastructure, such as cost to pass per household and rate of unserved areas, that are closely tied to population and household density. Given that fixed terrestrial broadband connects homes and most networks are built along roads, either buried or on utility poles, rural areas face higher costs to build the infrastructure per household due to low density and higher road miles per housing unit [12,17]. Furthermore, since most revenue models for broadband services are subscription-based, they are highly dependent on the size of the populations. As a result, private sector investment in broadband infrastructure has been primarily focused on urban areas rather than rural areas.

This gap in access to quality services has major implications for communities without access to appropriate infrastructure. Not only does it set back economic growth [13,18], but it handicaps individual workers, lowering their productivity [19], making it harder for them to find work [20], and creating barriers to their career development. Lack of broadband access is also associated with a bevy of social disadvantages, reducing individuals' welfare and ability to lead healthy fulfilled lives. Those without access are met with challenges in education [21,22], worse access to public health services [23], and added difficulties in accessing and using information, altering civic behavior [24]. These issues severely constrain individuals and communities without broadband access, while exacerbating well-documented inequities in the low-income, rural, and minority communities which are more likely to lack broadband infrastructure in the first place [25].

To narrow the broadband gap, the United States government has been taking various measures, including funding and subsidizing initiatives aimed at improving broadband access in rural areas. As examples from the past few years, the FCC launched the Rural Digital Opportunity Fund (RDOF), a $20.4 billion program to provide broadband to unserved and underserved areas in 2020 [26]. The USDA launched ReConnect Loan and Grant Program, and it supports loans and grants to provide funds for the costs of construction, improvement, or acquisition of facilities and equipment needed to provide broadband service in eligible rural areas [27]. The American Rescue Plan Act of 2021 includes $10 billion in funding for broadband infrastructure in order to help bridge the digital divide [28]. The NTIA has provided funding for state and local broadband planning and implementation through programs like the Broadband Infrastructure Program. In addition to these efforts, the US government has also taken steps to make broadband more affordable. In 2021, the FCC established the Affordable Connectivity Program, which provides a monthly subsidy for broadband service to eligible households. The program is funded by the Infrastructure Investment and Jobs Act (IIJA), and it provides a discount of up to $30 per month for broadband service [29]. The government is committed to ensuring that all Americans have access to reliable and affordable broadband services, and its support can serve as a lever to undertake broadband projects in rural areas.

The collaboration between the US government and local communities has played a vital role in initiating broadband projects in rural areas. On the other hand, the involvement of the private sector through strategic partnerships is essential to leverage their technological advancements and industry expertise in supporting new entrants in the broadband market [9]. P3 in broadband projects share similarities with other infrastructure initiatives, where P3s have proven effective in stimulating investments in broadband infrastructure, mirroring their utilization in traditional infrastructure projects [30]. However, when the government assumes the role of network funder, distinct patterns may arise, separate from the actions of the regulator [31]. P3 broadband projects in rural areas often entail unique challenges compared to those in urban areas, necessitating thorough feasibility assessments across various factors, including geographical areas, population densities, high-speed service demands, take rates, service prices, and user willingness to pay, to ensure robustness in financial projections [32]. Moreover, it is crucial to develop effective business models that may deviate from existing frameworks (Gerli and Whalley 2021). Challenges specific to rural areas can include limited population density, longer distances to cover, and the need for additional infrastructure development to reach remote communities. Additionally, the economic and financial viability of broadband projects in rural areas can be more challenging due to lower revenue potential and higher deployment costs in sparsely populated regions. Similar trends and challenges have been observed in other countries like the UK and South Korea, underscoring the significance of exploring diverse approaches and business models to optimize broadband infrastructure deployment in rural areas [6,33]. Therefore, comprehensive research and analysis of business models are imperative to enhance broadband deployment strategies and narrow the digital divide in rural communities throughout the United States.

Existing studies on broadband business models have indeed pointed out limitations in their categorization and consideration of relevant factors, often leading to an incomplete understanding of the intricacies involved. For instance, a previous study proposed a triad of models—municipal broadband, private investment with public support, and P3 [35]. Although these models provide insightful perspectives, they lacked a systematic and comprehensive comprehension of the entire spectrum of broadband business models, potentially omitting pivotal factors. Other studies incorporated an excessive number of factors, occasionally diving into superfluous intricacies while neglecting other crucial elements essential for a holistic comprehension of broadband initiatives. For example, the inclusion of the Bulk capacity purchase model in one study [36] speaks to specific projects but may not be eligible for application in rural areas. Furthermore, it is worth noting that the existing studies and business models often carry an inherent bias towards urban areas, leaving a gap in addressing the distinctive requirements of rural contexts. This bias underscores the necessity for exploring diverse approaches and business models that are specifically tailored to optimize broadband infrastructure deployment in rural areas, thereby acknowledging and addressing their unique challenges and opportunities.

In this regard, the primary objective of this research is to identify the key challenges faced in broadband projects and examine various broadband business models. Subsequently, the research aims to propose categorized solutions that address these challenges aligned with each specific business model for the rural areas. This research contributes to the body of knowledge in the broadband development by identifying several important decision-making dimensions that can be used to organize broadband business models into 10 distinct categories. Through an in-depth analysis of identified issues and exploration of diverse business models, this research provides practical guidance and valuable recommendations for stakeholders involved in broadband deployment. This study presents a robust framework that can help stakeholders to analyze alternative business development models and select appropriate business models to effectively implement their broadband projects to bridge the digital divide in their communities. Moreover, the significance of this study lies in how the public, especially people in underserved communities and rural areas, can benefit from the value of our research through helping public officials in those areas make more effective decisions to enhance connectivity and affordability in their communities.

Research Framework

This study proposes a research framework to analyze broadband business models as shown in Fig. 1. The research framework includes three main phases: (1) capture common themes and issues related to broadband business models through a comprehensive review of relevant literature and conducting content analysis; (2) identify specific challenges and provide valuable input for suggesting categories relevant to P3 broadband business models; and (3) the overall findings based on the identified categories and analyzing major issues associated with each category.

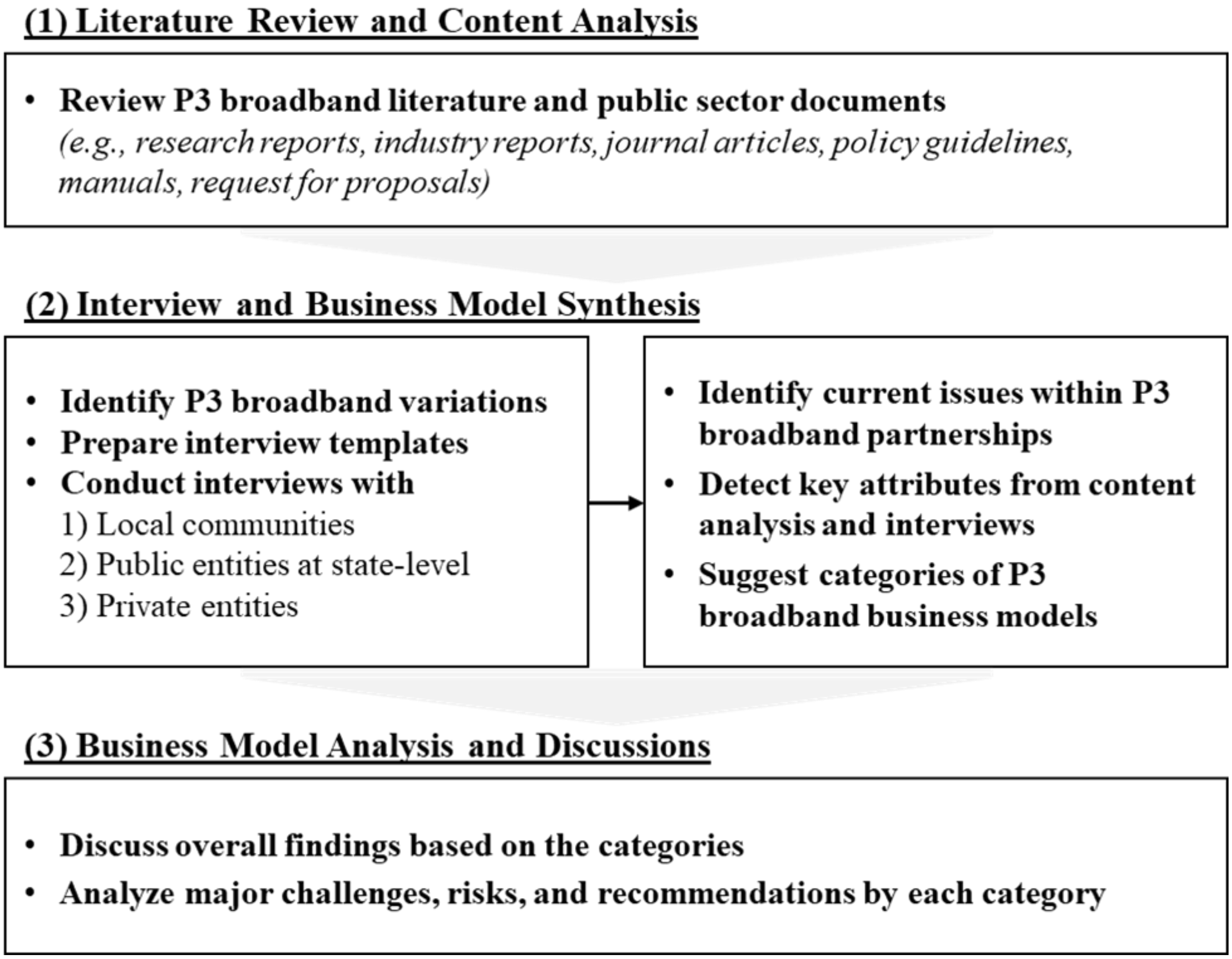

Figure 1. Research Framework

This research first conducted an extensive literature review to capture the current state of practices and trends in the broadband business. We employed content analysis to analyze various contexts regarding infrastructure and partnerships [37,38]. This analytical approach allowed for a systematic examination of relevant data sources, such as documents, reports, and publications, to extract meaningful insights and identify key themes and patterns. Based on the knowledge acquired from the literature, interviews were then conducted with subject-matter experts representing a diverse range of stakeholders. Table 1 provides an overview of the different stakeholders involved in the interviews, including local communities, private entities, and public entities at the state level. The interviews aimed to gather different perspectives and experiences related to broadband projects. The local community representatives participating in the interviews were involved in either ongoing or completed fixed terrestrial broadband projects. Administrators, directors, engineers, and managers at town or county levels participated in the interviews. Public entities at the state level were engaged in middle mile projects with a specific emphasis on public purposes, such as improving transportation systems or expanding middle mile infrastructure to connect rural communities. The interviews with private entities encompassed individuals with expertise in middle and last mile projects, serving in various roles such as consultants, contractors, operators, service providers, and project/program managers. We primarily reached out to identified interviewees by conducting online searches for broadband projects and by contacting relevant associations, such as the Association for the Improvement of American Infrastructure (AIAI) and Design-Build Institute of America (DBIA).

Table 1. Interview List

Local communities (6)	Public entities at state-level (5)	Private entities (11)	
Gloucester County, NJ	Georgia DOT	Pleanary	AIAI
Garett County, MD	PA_Turnpike	Cruzio	RSnH
Leverett, MA	Arizona DOT	CTC	Broadband Group
Chesterfield, MA	Southern Georgia Regional Commission	EntryPoint	HDR
City of Ammon, ID	Georgia Technology Authority	BDO	KPMG
Breckenridge, CO		AECOM	

The interviews were conducted for a duration of 60 minutes using online meeting tools. One of the authors managed and participated in all the interviews. We prepared a question list before starting the first interview; however, interviews were not limited to the question list. The main categories of the questions are project information, project delivery method, financing strategies, funding strategies, risk management strategies, major concerns, and additional questions based on interviewees' backgrounds and expertise. Each interview group had distinct focuses based on their specific roles and involvement in the broadband projects. This research employed the concept of thematic analysis to ensure the validity and reliability of the semi-structured interviews [39]. The textual information was extracted from the interviews and subsequently analyzed manually, involving the organization of data into spreadsheets and the identification of recurring themes. Techniques such as topic modeling, labeling, assessing the frequency of certain phrases, and identifying similarities in the topics covered by the interviewees were employed to uncover underlying patterns in the interviews. These results were then integrated with findings from literature reviews. This comprehensive approach allowed us to effectively pinpoint current issues within P3 broadband partnerships and extract key attributes through content analysis and interviews.

P3 Broadband Business Models

The combination of a comprehensive literature review and interviews with key stakeholders has facilitated a thorough understanding of the current landscape of broadband initiatives, including their practices, challenges, and opportunities. The results derived from this research serve as a foundation for further analysis and the development of recommendations aimed at enhancing the deployment of broadband infrastructure in rural areas. In this session, first, the major issues surrounding broadband business models were identified through content analysis and interviews.

This comprehensive approach allowed for the identification of the key issues that contribute to the success of broadband projects in rural areas. Second, based on these major issues, the research then determined the key attributes that need to be considered when selecting strategies for different conditions. These key attributes were compiled in a results table, organized in descending order of frequency. Lastly, this research proposes categories for broadband business models that encompass the majority of the key attributes identified in the previous step. These suggested categories provide a framework for designing effective and tailored business models that can address the unique challenges and opportunities of broadband deployment in rural areas.

Major issues of broadband business models from content analysis and interviews

This research commenced with an extensive literature review and content analysis to establish a comprehensive understanding of the subject matter. Subsequently, interviews were conducted to identify the major issues related to broadband initiatives. The goal was to categorize and subsume these issues under broader categories. The result of the interviews, comprising both major and minor issues, was compiled and categorized based on their significance. Efforts were made to group the issues into major categories at similar levels. Table 2 presents the major issues, their descriptions, and a list of literature references that address these issues. By structuring the major issues and providing supporting literature references, this section aims to provide a comprehensive overview of the key challenges and considerations in broadband initiatives.

Table 2. Identified key issues of broadband business models

Major Issue	**Description**	**Source**
Partnership	Broadband projects often require collaboration between multiple entities, including government agencies, private companies, and community organizations. Establishing effective partnerships and navigating the complexities of multi-party relationships is essential for success. It requires effective communication, clear roles and responsibilities, and a shared vision.	[40], [41], [42], [43], [44]
Risk allocation and identification	Risks associated with broadband projects must be identified and allocated among partners, taking into account legal and financial implications. Identifying and managing these risks and	[45], [40], [41], [42], [46], [7]

	ensuring that they are allocated fairly among project partners, is crucial for project success.	
Investment and Financing	Broadband projects typically require substantial upfront investments, and securing financing can be a major challenge. Identifying potential sources of funding and developing a financing strategy that balances risk and return is critical.	[45], [47], [41], [48], [42], [35], [7], [43], [44]
Revenue Generation	Broadband projects need to generate sufficient revenue to cover their operating costs and provide a return on investment. Developing effective revenue models and identifying key drivers of revenue growth is essential.	[45], [48], [44]
Ownership	Ownership of broadband infrastructure can have significant implications for the long-term sustainability and profitability of a project, including property rights, regulatory requirements, and operational control.	[45], [36]
Technical Capabilities	Broadband projects require significant technical expertise and capabilities, from network design and deployment to ongoing maintenance and support. Ensuring that project partners have the necessary technical skills and resources is essential.	[47], [49], [48], [42], [35], [50], [7], [36], [44]
Key Driver	Identifying the key drivers of broadband adoption and usage is essential for developing effective marketing and outreach strategies, as well as for maximizing the social and economic benefits of the project.	[42], [46], [43], [36]

	Clear goals and a strong business case are essential to drive investment, engagement, and support for broadband initiatives.	
Network Operations	Building and operating a broadband network requires ongoing management and monitoring. Developing effective network operations and maintenance procedures is crucial for ensuring reliable and high-quality broadband services, such as optimal network performance and minimizing downtime.	[45], [40], [50], [46]
Market Dynamics and Segmentation	Understanding customer needs and market demand is crucial for designing and implementing effective broadband services, including targeting specific customer segments such as residential customers, businesses, and public institutions.	[45], [47], [40], [48], [42], [46]
Policy and Regulation	Broadband projects are subject to a range of regulatory and policy frameworks, including local, state, and federal regulations. Navigating these frameworks and ensuring compliance with applicable laws and regulations, such as rights-of-way, licensing, and service obligations, is essential.	[45], [42], [35]
Existing Infrastructure Assets	The availability and quality of existing infrastructure assets, such as utility poles, can have a significant impact on the feasibility and cost of broadband projects. Identifying and leveraging existing infrastructure assets can help reduce costs and improve project viability.	[45], [41], [44]

Competitive Landscape	Broadband projects may face competition from other providers, such as cable companies or wireless providers. Understanding the competitive landscape and developing strategies to differentiate the project from other offerings is essential for developing effective business models and marketing strategies.	[45], [49], [46]
Innovation and Technology	This includes both radical innovations, which involve entirely new technologies and business models, and incremental innovations, which involve improvements to existing technologies and processes. The ability to innovate and stay up-to-date with technological advancements is a crucial factor in the success of a broadband business model.	[49], [46], [44]
Sustainability and Impact	Broadband projects can have significant social, economic, and environmental impacts. Ensuring that projects are sustainable and have a positive impact on communities is essential for long-term success.	[49], [46], [7], [44]

Key attributes for categorizing broadband business models

In order to identify the key attributes for categorizing broadband business models, this research conducted a thorough examination of the main issues to be considered when selecting a broadband business model for rural areas. This analysis was based on a comprehensive literature review and insights gained from interviews. By synthesizing the literature and interview findings, a set of key attributes was identified and presented in Table 3. These attributes represent important considerations for choosing a suitable broadband business model in rural areas with different conditions. The research considered existing categories or classifications to ensure a comprehensive coverage of relevant attributes. Table 3 serves as a valuable resource for stakeholders involved in broadband initiatives, providing a clear overview of the key attributes to be considered when selecting a business model tailored to the unique conditions and challenges of rural areas.

Table 3. Identified key attributes of broadband business models (descending order of frequency)

Key attributes	Description	Source
Technology layers	This refers to the different layers of technology that make up a broadband network. These layers are generally classified into three categories: network passive equipment, network active equipment, and services. Depending on their specific combination, these three categories can be organized into various models, including but not limited to the Vertical Integration Model, Wholesale Model, and Dark Fiber Model.	[45], [49], [51], [50], [52], [53], [54], [55]
Funding Sources	This refers to the primary funding source for a broadband project. It encompasses the various entities or sources that provide financial support for such a project, such as public-led or private-led funding models. Some references included government grants, private investments, and community contributions.	[47], [42], [35], [46], [56], [57]
Ownership	This pertains to the legal and regulatory framework for owning and managing broadband infrastructure. It typically involves the different ownership models, including private, mixed, and public ownership, as well as other components like right-of-way and contract periods.	[47], [49], [41], [46], [43], [56]
Open Access	This typically refers to the practice of allowing multiple service providers or a single internet service provider to use a	[45], [47], [49], [41], [53]

	broadband network to provide services to end-users.	
Network Operations	This pertains to the entity or entities responsible for operating and managing the broadband network infrastructure. This may include tasks such as maintenance, upgrades, troubleshooting, and service delivery.	[45], [49], [41], [46], [57]
Partnership and Collaboration	This pertains to the various types of collaborative arrangements between entities involved in a broadband project. These arrangements may include operator models, concession models, cooperation models, Design-Build-Operate, and other P3 models.	[56], [11], [58], [36], [57]
Customer Targeting and Segmentation	This refers to the process of dividing the broadband market into different customer segments, such as residential customers, enterprise customers, small businesses, or public sector entities.	[45], [46], [11], [36]
Revenue Model	This pertains to the strategies and models utilized to generate revenue for a broadband project including subscription fees and value-added services. The revenue model typically outlines the pricing structure for broadband services and the corresponding revenue streams.	[46], [44]
Leadership and Governance	This refers to the individuals or organizations that are driving the strategic direction of a broadband project. It typically involves private-led, mixed, and public-led.	[43]

Categories for P3 Broadband Business Models

This session culminates in the proposal of categories for broadband business models, which encompass key attributes identified in the previous step as shown in Table 4. First, the focus of the study is on residential customers with the key attribute of "Customer targeting and segmentation." Second, the categories consider the source of funding for the project. Third, as corresponding categories to the "Fund" attribute, actual benefits from projects, such as ownership, network operator, and open access, are included in the categories. A total of ten categories for P3 broadband business models are suggested based on these considerations.

It is worth noting two critical points related to Table 4. Firstly, the attribute "Layer," the most frequent key attribute, was identified as a dependent factor based on the categories. Further discussion on this aspect will be presented in the following discussion sessions. Secondly, it is recognized that Model 6 appears unrealistic due to the absence of incentives for the private sector to invest without ownership and a guaranteed single ISP. A comprehensive examination of these issues will be provided in the discussion sections. The proposed categories and attributes in Table 4 serve as a foundation for future deliberations and decision-making processes related to broadband business models in rural areas. They provide a framework for assessing the feasibility and suitability of different approaches, considering the various factors and dynamics involved in the implementation of P3 broadband initiatives.

Discussions

This session encompasses two main discussions: an overall discussion on the categories of broadband business models and discussions for each category. The overall discussion delves into the broader aspects of broadband business models. It examines the relevance and applicability of the proposed categories, considering the specific context and characteristics of the suggested categories. This discussion aims to provide a comprehensive understanding of the overarching considerations and challenges associated with implementing broadband projects. Additionally, additional discussions are conducted for each category of broadband business models identified in Table 4. These discussions delve into risks and challenges of each category. By examining the merits and limitations of each model in detail, these discussions facilitate informed decision-making and strategic planning for the deployment of broadband infrastructure in rural areas.

Table 4. Ten categories of broadband business models

Model Number	1	2	3	4	5	6	7	8	9	10
Fund	Funded by Private		Jointly Funded				Funded by Public			
Ownership	Owned by Private		Jointly Owned		Owned by Public					
Network Operator	Operated by Private								Operated by Public	
Open Access	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Example	Boston, MA	Fullerton, CA	Lincoln, NE	Huntsville, AL	Westminster, MD	-	Leverett, MA	Rockport, ME	Chattanooga, TN	Ammon, ID
Layer	Vertical Integration		Conduit and Maintenance	Dark Fiber and Maintenance					Vertical Integration	

Overall discussions on the categories of broadband business models

In general, jointly funded projects can be classified as traditional P3s projects, and models 3 to 6 align with this traditional P3 framework. Models 3 and 4 stand out from the other models as they involve a significant financial contribution from the private sector. In contrast, models 5 and 6 may allocate the financial risks to the private sector only in the event of specific cases such as a low return on investment. Models 7 and 8, on the other hand, are fully funded by the public sector but still include partnerships with private entities to leverage their technology and expertise. While not all literature and interviews explicitly refer to models 7 and 8 as P3 broadband projects, these models lie on the boundary of P3 frameworks. Local communities often require these partnerships as they lack the capacity to undertake broadband infrastructure projects without private sector involvement. It is important to note that the categorization of models and their alignment with traditional P3 concepts may vary depending on the specific context and regional dynamics in broadband business compared to other infrastructure projects.

Private sectors can indeed benefit from their involvement in broadband projects through three primary roles: network owners, network operators, and internet service providers (ISPs). In models 3 and 4, which involve joint ownership, it is commonly observed that the public sector owns the middle-mile infrastructure, while the private sector owns the last-mile infrastructure. This division of ownership allows for a combination of public and private resources and expertise in delivering broadband services. From model 5 to 10, the idea of publicly owned network infrastructure is often associated with the goal of creating a sustainable society. Public ownership of network infrastructure can provide benefits such as increased control over pricing, service quality, and equitable access to broadband services. It allows the government or public entities to shape the direction and priorities of broadband deployment to serve the broader interests of the community. In the case of network operators, most of broadband infrastructure was operated by private sectors, and only models 9 and 10 involve the operation of networks by public sector entities. However, the distinction between a single ISP and open access is an important consideration for every broadband project. A single ISP model involves a specific provider delivering broadband services exclusively to end-users. This model offers simplicity and ease of management as the responsibility for service provision lies with a single entity. On the other hand, open access models allow multiple ISPs to operate over the same network infrastructure. This approach promotes competition among service providers and gives end-users a choice of ISPs. Open access models have the potential to enhance service quality, encourage innovation, and drive down subscription rates for consumers. However, it is worth noting that open access may be less attractive to private sector entities due to the increased competition and potentially lower profit margins.

Technology layers were often considered as important attributes to categorize broadband projects. The way these layers are combined can influence the overall model of the project, such as vertical integration or wholesale models. Additionally, the configuration of the physical infrastructure, including options like dark fiber, conduit, and lit approaches, can also impact the model chosen for the project. This research identified different types of layer models are dependent on the categories suggested earlier. Models such as model 1 or 9, which are fully led by either private or public entities, can take benefits from a vertical integration model where different layers of the technology stack are controlled by a single entity. On the other hand, projects categorized as model 3 tend to be associated with a conduit and maintenance approach. This means that the focus is on utilizing existing conduit infrastructure and ensuring proper maintenance the network. Similarly, model 4 projects are often related to dark fiber and maintenance approach models, where dark fiber is leased or deployed to support broadband connectivity, and maintenance is a critical aspect of ensuring network performance. By understanding the interplay within the suggested categories and models, stakeholders can make informed decisions about the most suitable model for their broadband project.

In the context of rural communities, it is crucial to focus on models 5, 7, and 8 for their broadband projects. Rural areas are often not seen as attractive markets for private sectors due to factors such as low population density and household income. Therefore, to attract partnerships with private sectors and leverage their technologies and expertise, rural areas may need to provide funding for the projects. This funding can be in the form of fully or partially shouldering the financial risks associated with the project. In such cases, while the ownership of the infrastructure may lie with the public sector since it is fully funded by them, rural communities can negotiate certain aspects of the project. For example, they can negotiate the level of financial risk they are willing to take on and the extent to which the network is open for access by multiple service providers. However, it is worth noting that there is limited evidence or examples of model 6, where private sectors invest without ownership and no single guaranteed ISP. This further reinforces the importance of rural communities finding a balance between financial risk and open access or exploring alternative models that align with their specific needs and goals. By focusing on models 5, 7, and 8, rural communities can foster partnerships with private sectors while ensuring that their broadband projects meet the unique requirements of their communities and drive economic growth and development.

Risks and Challenges associate with each model.

Model 1 represents a traditional broadband business model commonly found in urban areas, where the project is funded, owned, and operated by private sectors. While this model does not involve financial risks for the public sector, it is important to consider certain challenges related to the monopolistic characteristics of the broadband market. Most broadband projects show that capital expenditure is relatively higher than operational expenditure and incumbent providers in such a model may have an advantage in terms of retaining subscribers, which can result in higher subscription costs for consumers. This could easily occur in mid-size or small urban areas where incumbents have enough advantages and limited competition from private sectors. Additionally, government control over subscription costs can be challenging, potentially affecting the affordability and accessibility of broadband services for the broader population. These factors pose sustainability concerns for the society in the long run.

Model 2 shares similarities with Model 1, but with the addition of open access to the infrastructure. One example of this model is Fullerton, CA (SiFi). However, despite having open access, this model still has limitations as it lacks local control over the infrastructure. This means that there is no guarantee that the network operator will prioritize addressing the digital divide issues or align with the community's objectives for the network. Another concern with private ownership of infrastructure is the possibility of industry consolidation. For example, in situations where independent fiber networks may eventually be merged or acquired by larger entities, there is a potential impact on local control and decision-making over the network. This can result in cities being left with a private monopoly network provider although it is an open access [49]. In this model, it is crucial for the government to explore effective strategies to promote the use of open access as an opportunity to foster a competitive market and ensure the delivery of broadband infrastructure to citizens. By encouraging multiple service providers to utilize the open access infrastructure, competition can be stimulated, leading to improved service quality, affordability, and options for consumers.

Model 3 represents a joint funding and ownership approach where both public and private sectors contribute to the project. In many cases, public sectors own and operate the middle mile infrastructure, while private sectors take responsibility for the last mile connectivity. This model can be advantageous for large cities, as they can save costs on middle mile broadband projects and have the opportunity to generate revenue as network operators and exclusive internet service providers. One of limitations of this model is that subscription rates cannot be easily monitored or lowered through market competition, potentially impacting affordability for consumers. The city of Lincoln demonstrated a successful partnership model by investing $2,000,000 in maintaining and updating its middle-mile infrastructure, particularly conduits. This investment allowed the city to collaborate with a private company, Allo Communications, to provide high-speed internet access to all residential and business establishments within the city. This partnership proved beneficial for both parties involved. Under the agreement, Allo Communications agreed to offer its services to residents and businesses in Lincoln. For each residential customer that purchases internet service from Allo, the city receives a monthly payment of $3. This revenue-sharing arrangement provides a steady income stream for the city while ensuring that residents have access to high-quality broadband services. Furthermore, this partnership has also attracted corporate customers to the city. The availability of reliable and high-speed internet infrastructure provided by Allo Communications makes Lincoln an attractive location for businesses seeking a favorable digital environment.

In the case of model 4, similar to with model 3, but there are some distinct differences, particularly in how the middle and last miles are managed. Public sectors tend to focus more on the middle mile infrastructure, while private sectors compete in providing last mile connectivity through open access arrangements. One important difference in model 4 is that this model relinquishes control over the connection from the curb to the premise, which can limit the usability of each fiber strand [49]. Additionally, model 4 may face challenges in scaling easily due to the difficulty in anticipating the required fiber count to meet future demand, creating complications for the network operator. Nevertheless, this model is commonly used in many cities. The public sector's ownership of the base infrastructure, such as middle miles, combined with the private sector's involvement in extending the last mile, allows each sector to focus on what they do best. This collaborative approach leverages the expertise and resources of both sectors to provide broadband access to all residents. However, it is important to recognize that for sustainable and affordable broadband access, intervention from the public sector is still necessary. While the involvement of the private sector can drive innovation and competition, such issues from model 1 and 2 may occur if there is no intervention from the public sector. The public sector's role in ensuring equity, affordability, and regulating the network can help address gaps and ensure that broadband services are accessible to all residents.

Model 5 is owned by public sectors for both middle and last miles. This model is often adopted by smaller cities and towns compared to the previous models discussed. In model 5, private sectors bear relatively fewer financial burdens compared to models 3 or 4. While private sectors may have limited financial risks in terms of revenue generation and commercialization, this model can make rural communities more attractive for partnerships with the private sector. For example, in the case of Westminster, MD, they formed a partnership with Ting Inc., which brought fiber internet to their community. In this partnership, Ting shares the financial risks by paying the city a monthly fee based on the amount of fiber that has been built. This ensures a steady revenue stream for the city to cover its construction costs [51]. However, it is important to note that this model can result in higher prices for consumers due to the presence of a sole internet service provider. With limited competition, the pricing power of the provider may increase, potentially leading to higher subscription costs for consumers. Additionally, in Model 5, the burden of commercialization falls on the private sector, as they need to minimize their risks and ensure profitability. This highlights the importance of negotiation and establishing clear agreements between the public and private sectors before the project starts.

Although appealing in theory, Model 6 has not been exercised in the broadband development industry. This is primarily due to the absence of compelling incentives for private sectors to undertake financial risks without commensurate advantages or benefits in return. As of now, practical instances of Model 6 being implemented are unlikely. The concept of public sector-led deployment through partnerships lacks a strong rationale for private sector involvement, as there is limited motivation for them to engage without clear advantages. This underscores the importance of exploring the contributing factors behind the lack of adoption of Model 6. Factors, such as unclear financial returns, risk aversion among private entities, and the absence of mutually beneficial arrangements have inhibited the realization of this model. Policy makers and decision-making authorities in public and private sectors should clearly understand the critical barriers in implementing Model 6 and uncover potential strategies to overcome the barriers hindering the implementation of this model.

Model 7 is frequently adopted by small communities to attract private sector involvement. In this model, public sectors fully fund the projects, while private sectors could generate revenue as network operators and internet service providers. However, it is common for these small communities to lack the expertise and resources necessary to effectively manage such projects. To address this challenge, public entities at the state level, such as Massachusetts Light Plant (MLP), often intervene as consultants or project managers to support these communities. Additionally, grant money plays a crucial role in leveraging projects for small communities in Model 7. These grants provide additional funding to support the initiatives. For example, Leverett, MA, received grants amounting to $806,000 out of a total funding of $3,733,734. The combination of public sector funding and private sector involvement in Model 7 allows small communities to benefit from broadband infrastructure. At the same time, the support of state-level entities and the availability of grants are crucial for the successful implementation and affordability of broadband services in these communities.

Model 8 shares similarities with model 7, demanding full funding by public sectors, but it can be challenging to find practical examples of this model like model 6. This is primarily due to the limited advantages or incentives available for private sectors to participate in projects under this model. An example of Model 8 is Rockport, ME, where they initiated a fiber optic cable project to stimulate economic growth and provide improved broadband access to their citizens. This was a relatively small-scale project, covering 1.6 miles and the estimated cost of installing the network was $60,000. As a result of this project, following the implementation of the fiber optic cable project in Rockport, ME, the community now benefits from the availability of multiple internet service providers, providing residents with a range of options for their broadband services. Although practical instances of Model 8 may be scarce, the Rockport case exemplifies the potential of community-led initiatives on a smaller scale, facilitated through collaborations between public and private entities. One notable advantage of Model 8 is that it places communities in control of their broadband infrastructure, allowing them to tailor solutions to their unique needs and objectives. This level of local autonomy empowers communities to make decisions that align with their long-term interests, such as fostering economic development and ensuring equitable access to high-speed internet services.

Models 9 and 10 represent fully public-led broadband projects, where the funding, ownership, and operation of the networks are solely undertaken by public sectors. These models typically apply to larger communities or areas where there is sufficient capacity and resources within the public sector to manage and maintain the projects effectively. Models 9 and 10 prioritize the direct involvement and control of public entities throughout the entire project lifecycle. This level of public ownership allows for greater oversight and decision-making authority, ensuring that the network infrastructure aligns with the community's specific objectives and requirements. However, it's worth noting that models 9 and 10 may not be suitable or feasible for smaller communities. Implementing and operating a broadband network at such a scale requires a significant investment in terms of technical expertise and administrative capacity. Smaller communities may face challenges in meeting these requirements.

In summary, the analysis of diverse broadband business models has revealed a range of risks and challenges that warrant consideration during strategic decision-making. Each of the 10 models presents distinct characteristics that shape the landscape of broadband infrastructure deployment. The following encapsulates the inherent risks and challenges associated with these models:

- Model 1: Monopolistic dynamics, limited control, and sustainability considerations.
- Model 2: Reduced local autonomy and potential industry consolidation.
- Model 3: Challenges in monitoring subscriptions and potential private sector dominance.
- Model 4: Challenges related to fiber infrastructure utilization and scalability, and the necessity of public sector’s substantial investment.
- Model 5: Restricted competition, private sector burden, and the significance of negotiation.
- Model 6: Absence of incentives, ambiguity in financial returns, and risk aversion.
- Model 7: Fiber infrastructure utilization challenges, scalability issues, and the need for substantial participation of the public sector.
- Model 8: Fiber infrastructure usability concerns, scaling difficulties, and the role of the public sector.
- Model 9: Feasibility for larger communities, and substantial requirements for technical and administrative capacity.
- Model 10: Suitability for larger communities, and substantial requirements for technical and administrative capacity.

The process of selecting a suitable broadband business model is complex, influenced by factors like community size, goals, and available resources. The diverse range of models offers unique benefits for rural broadband deployment. Communities must tailor their decisions to their specific circumstances, considering aspects like population density, financial capabilities, and technological expertise. Models involving joint funding with private partners leverage external resources while addressing financial risks. Models led by public entities grant control and customization opportunities, and open access frameworks promote competition and innovation. Ultimately, successful rural broadband projects hinge on stakeholders' adaptability within each model's parameters, ensuring inclusive access and bridging the digital divide. By thoughtfully considering these factors, communities can pinpoint the optimal model that suits their needs, utilizing resources efficiently to achieve equitable broadband infrastructure deployment.

Conclusions

The overall contribution of this research lies in its comprehensive analysis of broadband business models and their significance in the deployment of broadband infrastructure in rural areas. This analysis is important as it provides a systematic examination of the various factors and considerations that cannot be easily detected without a comprehensive and interconnected perspective. By conducting an extensive literature review, content analysis, and interviews with key stakeholders, this research has identified major issues, key attributes, and proposed categories for broadband business models.

Business models play a crucial role in shaping the strategies, partnerships, and financial frameworks that drive the successful implementation of broadband projects. They provide a framework for understanding how different stakeholders, including public entities, private companies, and local communities, can collaborate and leverage their resources to bridge the digital divide in rural areas. This allows a deeper understanding of strategies that can be successfully deployed to facilitate implementation of broadband infrastructure in underserved areas, addressing the critical inequities that lack of access causes.

This research highlights the need for tailored and effective business models that address the unique challenges and opportunities of broadband deployment in rural areas. The proposed categories for broadband business models offer a structured approach for stakeholders to evaluate and select the most suitable model based on their specific conditions and requirements. By providing a comprehensive overview of the key issues, attributes, and categories, this research equips stakeholders with valuable insights and guidance for decision-making processes related to broadband initiatives. It contributes to narrowing the digital divide, enhancing connectivity, and promoting economic and social development in rural communities.

While the study offers valuable insights, acknowledging limitations is essential due to the emerging nature of the P3 broadband industry in the U.S. This restricted the pool of U.S.-experienced subject matter experts available for interviews, impacting both the depth and breadth of findings. Additionally, experts' opinions can be influenced by cognitive biases and errors, potentially affecting research outcomes. Future research directions should encompass evaluating broadband policy effectiveness and analyzing real-world impacts on bridging the digital divide. Comparative studies of international broadband markets or diverse U.S. states and cities could provide strategies for equitable deployment. By acknowledging these limitations, the study fosters nuanced understanding, tailored strategies, and further research for effective digital divide reduction. Investigating model scalability and long-term impacts also offers vital guidance for diverse contexts.

Overall, this research contributes to the body of knowledge on broadband business models and serves as a valuable resource for policymakers, industry practitioners, and researchers involved in the planning and implementation of broadband projects in rural areas. Selecting an appropriate business model is crucial in reducing the overall cost of broadband projects and achieving connectivity for rural communities. By carefully considering different business models, we will be able to achieve connectivity and affordability as well. For example, stakeholders can optimize their resources and effectively deploy broadband infrastructure with a best model for them. This, in turn, enables the provision of affordable subscription prices for the communities, making broadband services more accessible and promoting digital inclusion. The choice of a well-aligned business model ensures the efficient utilization of funding, efficient deployment of infrastructure, and effective collaboration among various stakeholders involved in the project. By minimizing costs and maximizing the impact of broadband initiatives, the right business model contributes to the sustainable development and long-term success of connectivity projects in rural areas.

Chapter II: Survey Analysis Report

Initial Analysis of Survey Responses

Based on responses till May 26, 2023
The report will be updated if more responses are received.

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Project Title:
Sustainable and Equitable Innovative Funding Strategies for Enhancing Broadband Initiative in Underserved and Disadvantaged Communities

Introduction

The survey was created to collect information about the different financial strategies, models, challenges, and successes related to recent broadband development projects in the United States. The broadband development survey is made up of sixteen questions. Before reaching the first question, a short description of the project is displayed for participants, then they are asked to enter their contact information. The survey was distributed among different advisory teams, service providers, and municipalities. A total of thirty-six responses were collected from seventeen states, and the District of Columbia (DC). These seventeen states comprise Arizona, California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Maryland, Massachusetts, Michigan, Missouri, New Hampshire, Pennsylvania, Texas, Utah, and Virginia. The online platform, QuestionPro, was used to develop and distribute the survey. The survey questionnaire can be found in Appendix A of this report.

Survey Questionnaire Structure

The survey starts with a brief description of the project, then participants are asked to provide their contact information. To ensure the validity of collected responses, the first question inquires whether the participants have prior experience in implementing broadband initiatives. If the respondents confirm possessing such experience, the survey proceeds; otherwise, it terminates. Questions two, three, and four inquire about general details about the specific broadband initiative that the respondent have experience with. These include details such as state, cities and/or towns, and (expected) completion year. The fifth question inquires about the broadband technology(s) used in the broadband initiative. Questions six and seven ask about the parties that assumed ownership of the middle-mile and last-mile, respectively. The survey then moves on to ask about the development (contribution) model that best describes the project (question 8). Questions nine, ten, and eleven investigate the different types of financing models used by the private sector, public sector, and community, respectively. The respondents are then asked about the types of revenue models used in the broadband project (question 12). Question thirteen inquires about the types of financing support (e.g., reduction in the cost of devices) that users received, if any. Question fourteen asks if the project included measures for enabling market entry, improving competition, and lowering user cost. Question fifteen investigates the barriers that limited the ability to reach underserved and disadvantaged communities in the project. Finally, question sixteen explores the project's measures of success. The questions that follow question 5, inclusively, included a set of predefined answers, as well as the option of 'other', which allows respondents to provide their own unique answers.

Survey Responses

A total of thirty-six (36) responses were collected from seventeen states and the District of Columbia (DC). The collected responses encompassed both the public and private sectors, with twenty respondents representing the public sector and fourteen respondents representing the private sector. Figure 1 displays the states the projects took place in, the number of respondents in each sector, and the respondents' positions.

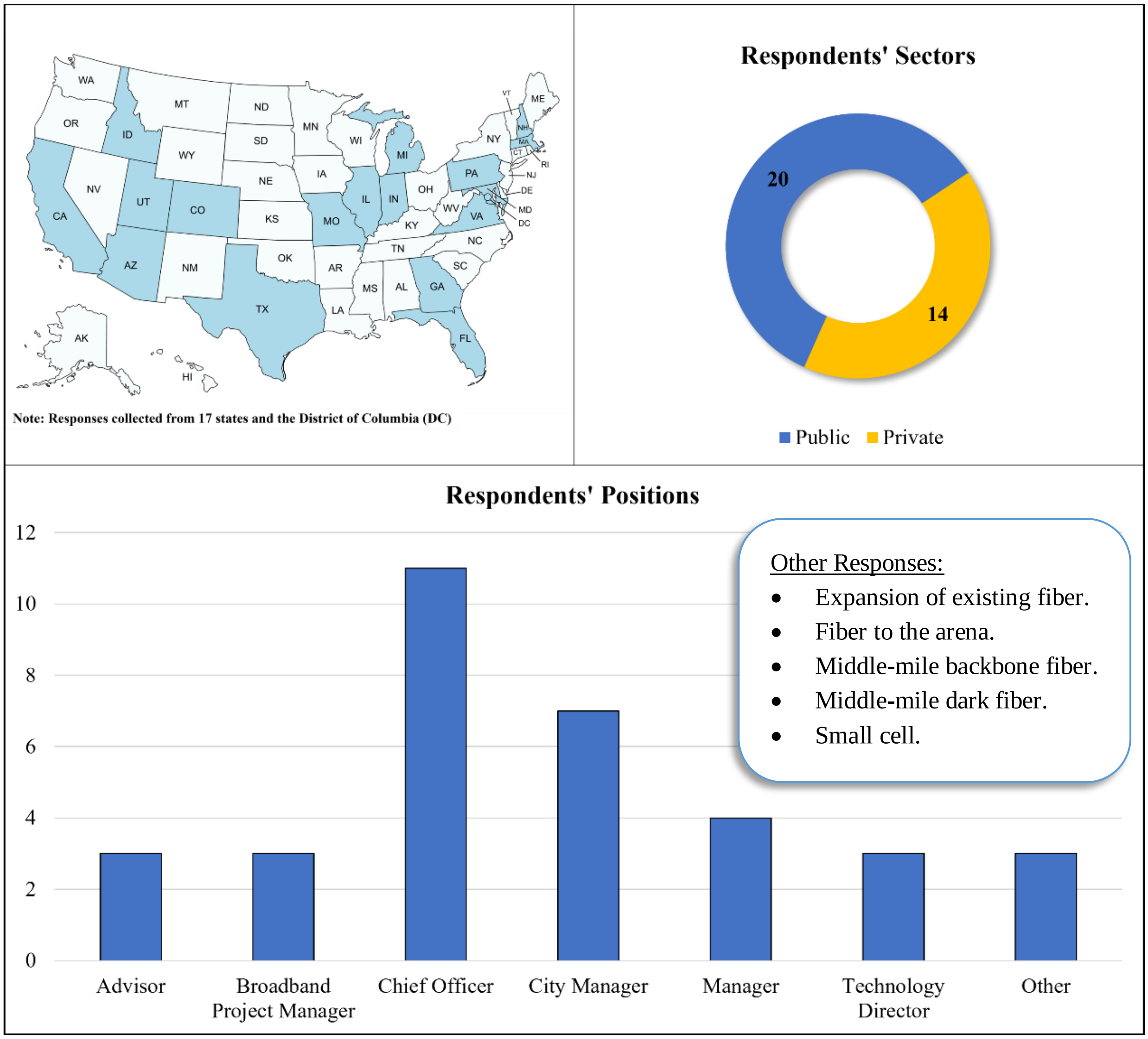


Figure 2. Respondents' states (top left); respondents' sectors (top right); and respondents' positions

The participants were asked to indicate the broadband technology (being) developed for their project. Among the various broadband technologies deployed, the highest number of responses, totaling twenty-five, indicated the utilization of 'Fiber to the Home (FTTH).' This was followed by 'Wireless Assets', which received seven responses. Figure 2 summarizes the different broadband technologies deployed in the broadband initiatives described by the respondents.

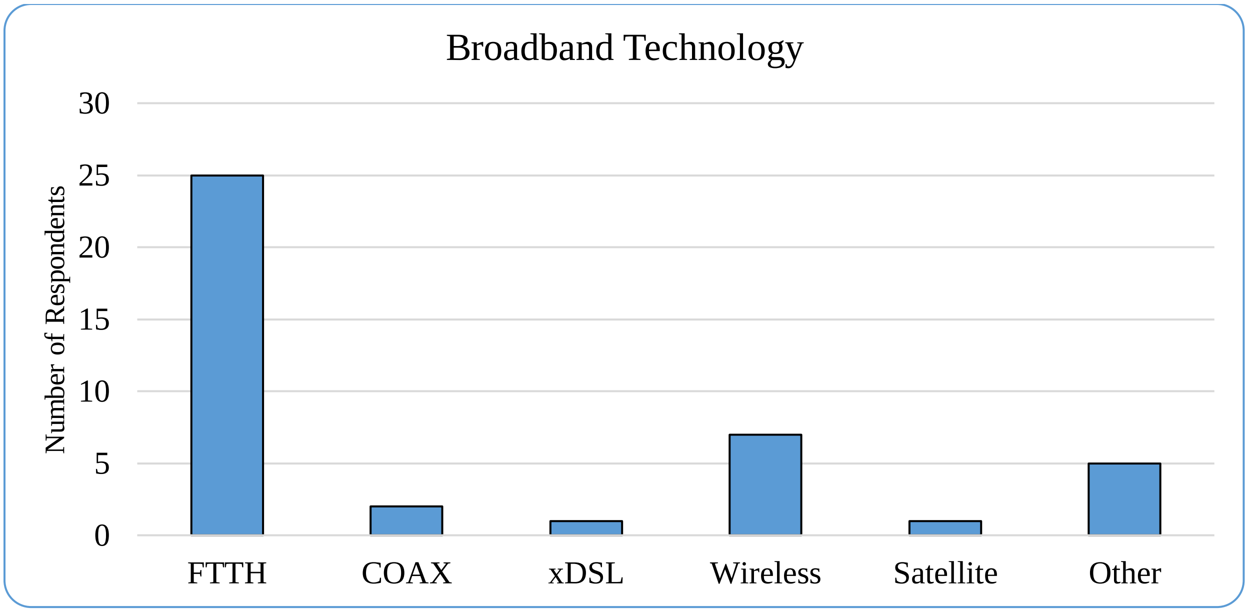


Figure 3. Broadband technology developed

The two questions following the broadband technology question inquired about the middle- and last-miles owners in each project, respectively. Figure 3 presents the summary of the collected responses pertaining to the ownership of developed middle- and last-miles. The results revealed that in the majority of projects, private entities assumed ownership for the last-mile. Specifically, nineteen projects had the last-mile ownership assigned to private entities, while only ten projects had it assigned to public entities. In contrast, both public and private entities had a similar number of projects with ownership of the middle-mile. In fourteen projects, the middle-mile ownership was assumed by public entities, whereas private entities took ownership in fifteen projects. Furthermore, one respondent indicated that the middle-mile was state-owned but operated and maintained by a private entity. Another respondent mentioned that the broadband development project was only for middle-mile development, in which the middle mile was municipality owned, operated, and maintained. Finally, one respondent indicated that a public-school corporation owned both the middle- and last-miles in their project.

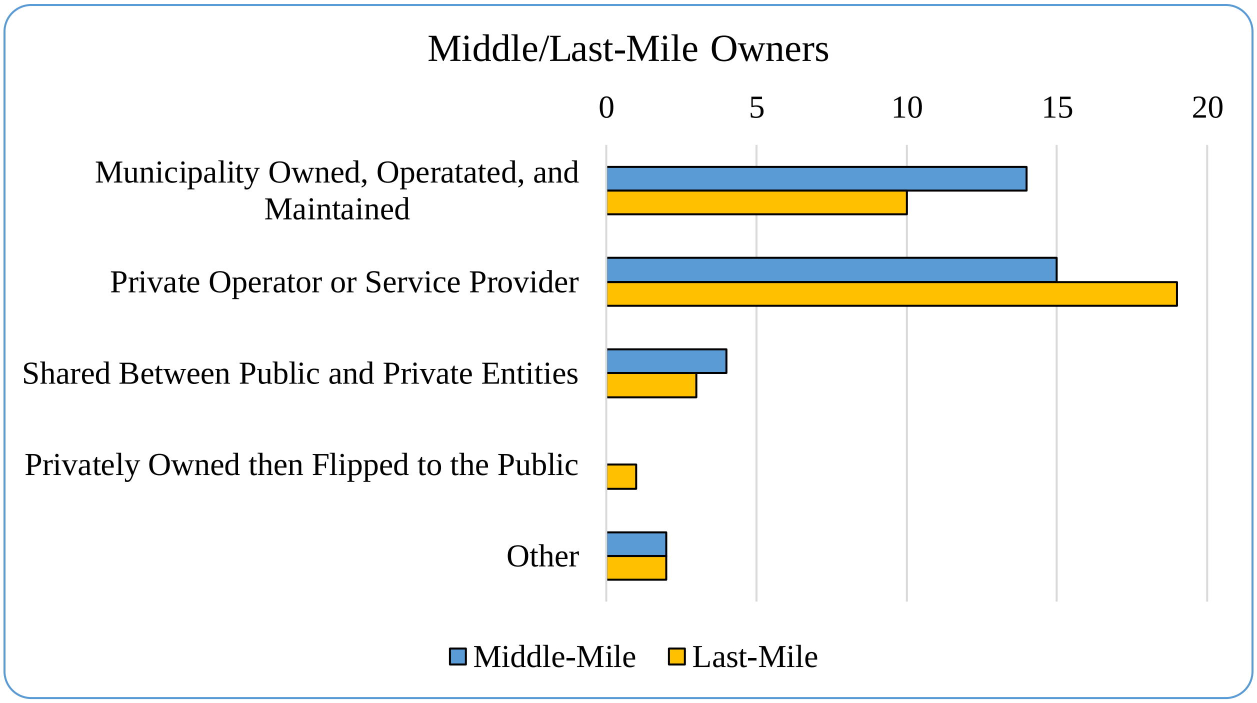
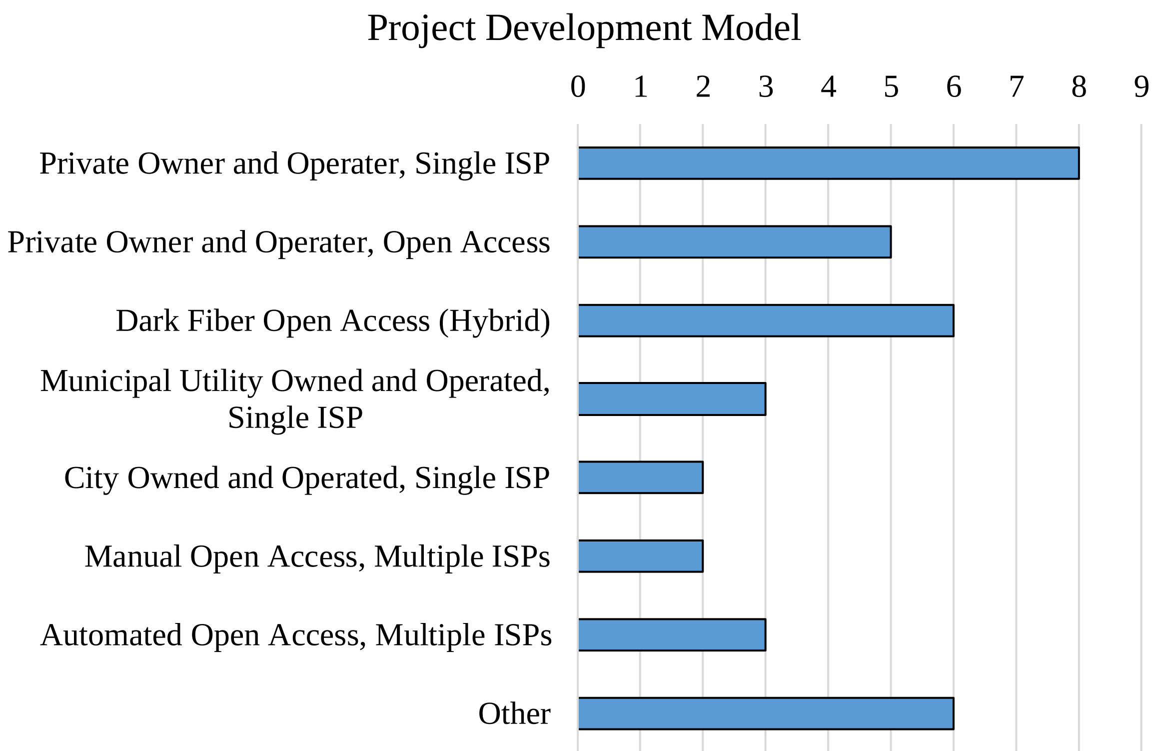


Figure 4. Middle- and last-miles owners in broadband projects

Figure 4 presents the responses concerning the development model of each project. The results indicate that among the projects, thirteen were owned and operated by private entities. Among these, five were open-access networks, while eight were single ISP networks. Additionally, unlit (dark) fiber for open access was deployed in six projects.

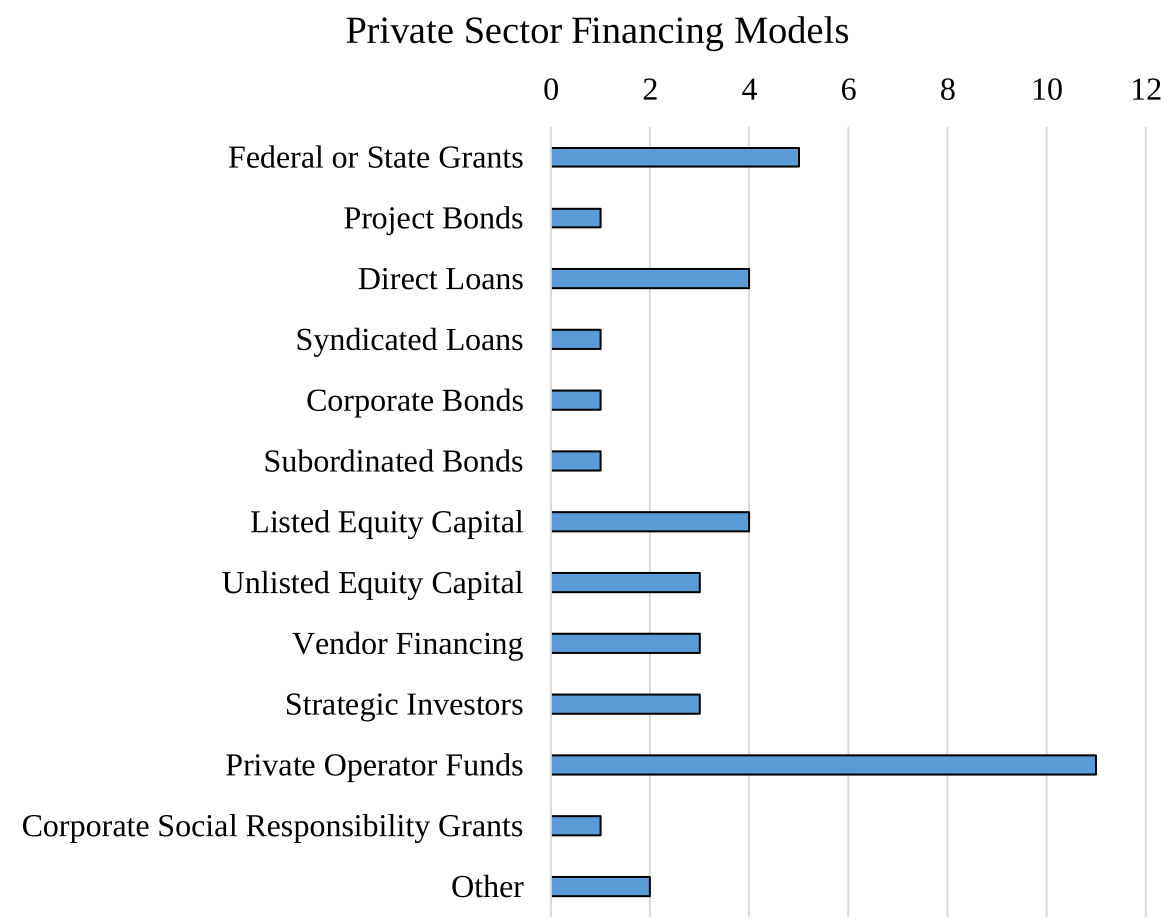


<u>Other Responses:</u>

- ARPA funds provided to ISP (private, single ISP).
- ARPA funds to build wireless towers to be leased to ISPs.
- Municipality owned infrastructure, private provider anchor tenant.
- P3 model.
- Private LTE network owned by public school corporation.
- State owned open access middle-mile backbone lit fiber, privately operated, maintained, and commercialized to attract ISPs and lower service cost.

Figure 5. Broadband projects' development (contribution) models

The survey then moved on to ask about the financing models of the private sector, public sector, and communities in each project, respectively. The responses related to the private sector's financing models are summarized in Figure 5. The majority of respondents, totaling eleven, selected 'Private Operator Funds' as the financing model of their broadband initiative. This was followed by 'Federal or State Grants', which were chosen by five respondents.

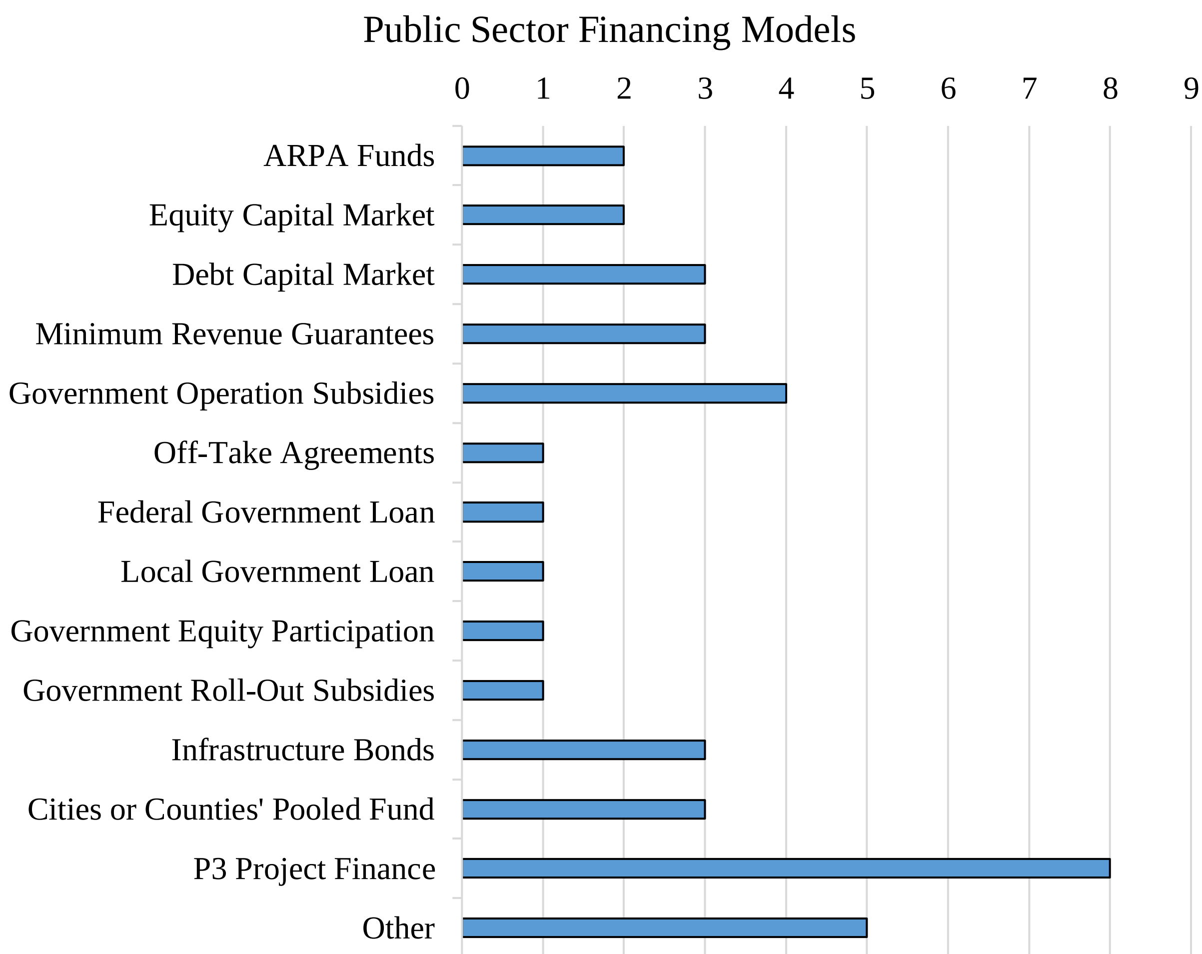


Other Responses:

- California Advanced Services Fund (CASF).
- County funds.

Figure 6. Private sector financing models' responses

Furthermore, Figure 6 illustrates the collected responses concerning the financing models in the public sector. Most public sector entities utilize a Public-Private Partnership (P3) model (8 responses) as part of their financing model. Four respondents selected 'Government Operation Subsidies' as part of their financing models. Other provided answers mostly consisted of public funds and grants.

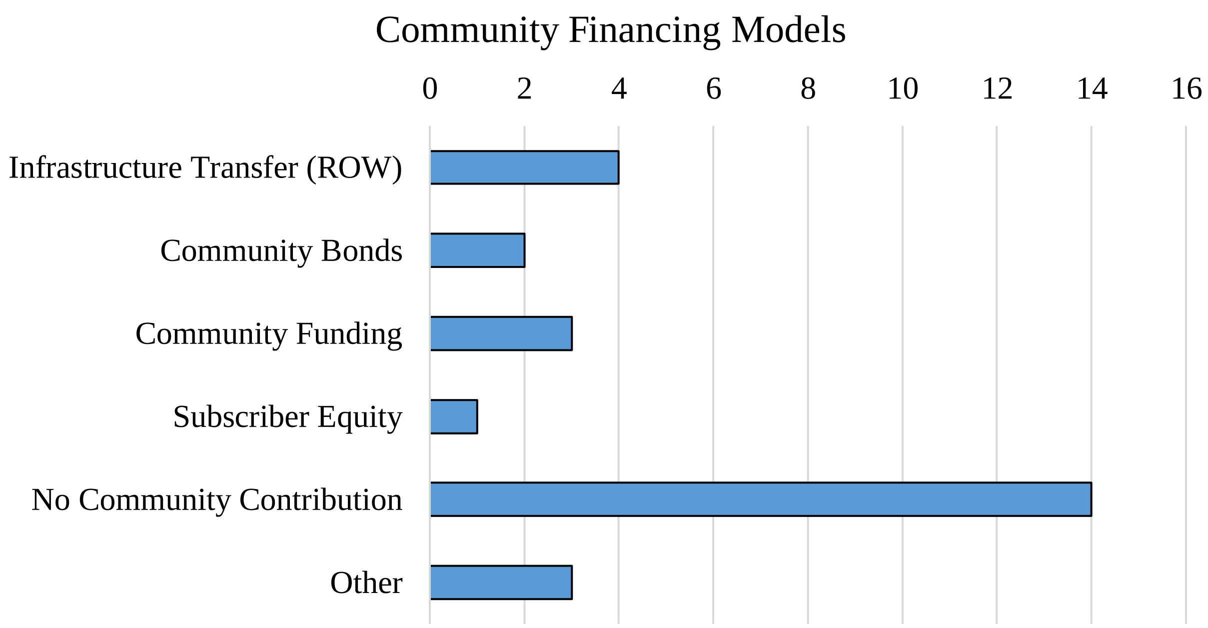


Other Responses:

- CARES funds and private philanthropy.
- Financed by private company.
- Public grant.
- State grant and town program.
- US EDA grant.

Figure 7. Public sector financing models' responses

The responses received concerning community financing models used for broadband development projects are shown in Figure 7. Fourteen respondents have not observed any community contribution during their broadband development projects. Four respondents selected ‘Infrastructure Transfer’ and three selected ‘Community Funding’.

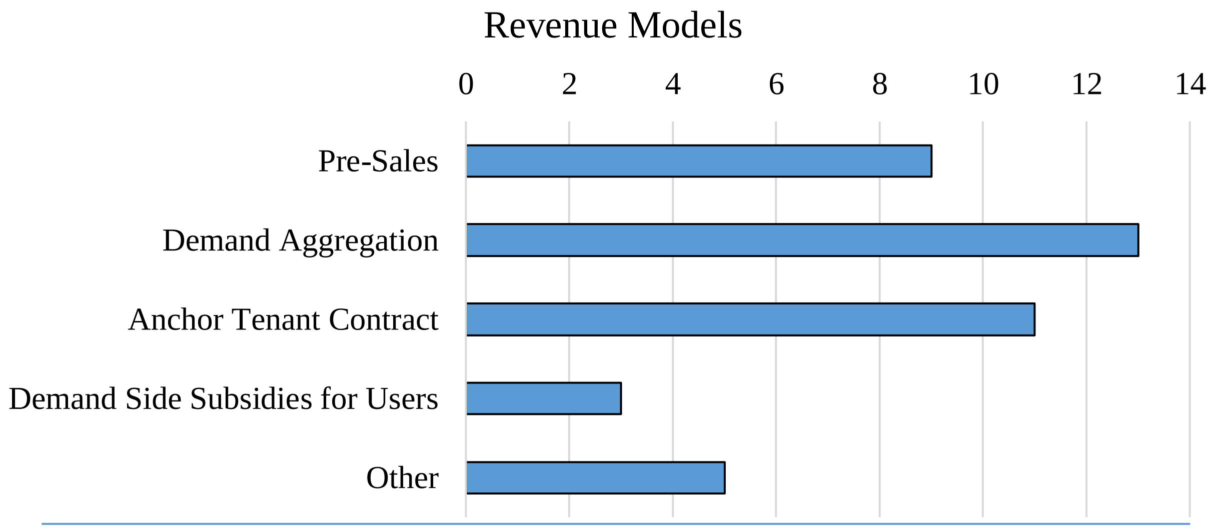


Other Responses:

- Community donations and business sponsorships.
- Homeowners pay what they can, and county grant covers the remaining cost.
- Temporary tax increase.

Figure 8. Community financing models' responses

The next question in the survey enquires about the revenue models used for broadband projects. In Figure 8, a summary of the responses regarding the revenue models of the projects is presented. 'Demand Aggregation', 'Anchor Tenant Contract', and 'Pre-Sales' were selected by thirteen, eleven, and nine respondents, respectively.

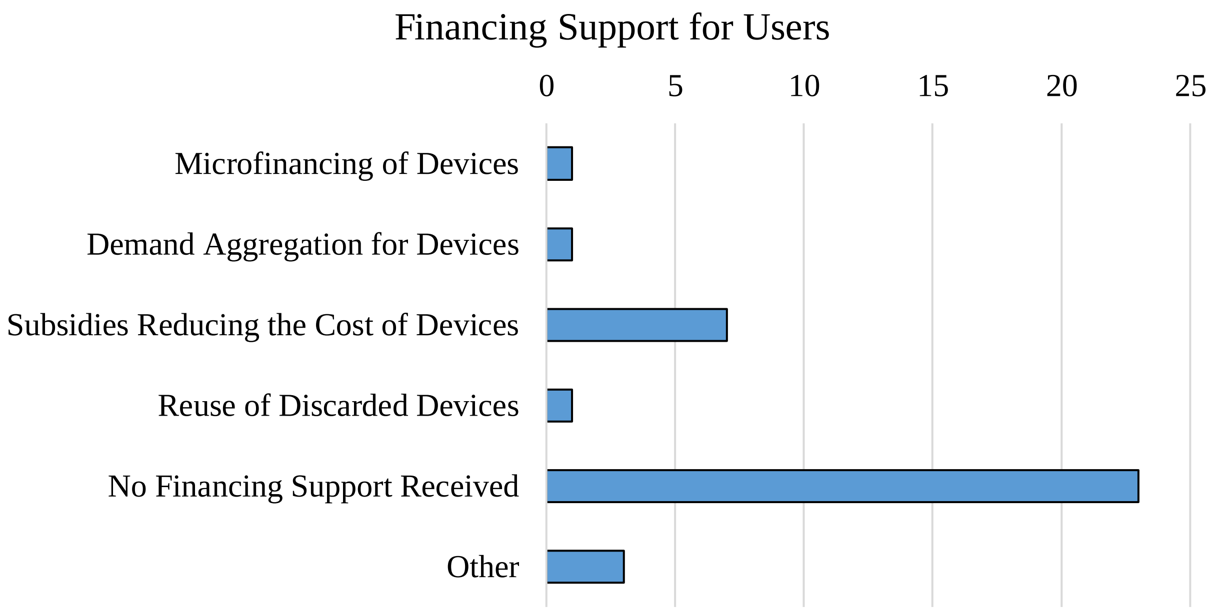


<u>Other Responses:</u>

- Future commercial value.
- Government subsidy of capital funds and subscriber fees to cover business operations and profit.
- No revenue model used.
- Not applicable: project only served public sector locations (e.g., parks).
- Reallocation of existing budgets from anchor institutions for connectivity.

Figure 9. Broadband development projects' revenue models

Responses regarding financing support provided for broadband users are summarized in Figure 9. The majority of respondents, totaling twenty-three, chose 'No Financing Support Received' as their answer, indicating a lack of financial assistance. In contrast, seven respondents selected 'Subsidies Reducing the Cost of Devices' as an option, suggesting the provision of subsidies to alleviate the expense of devices.

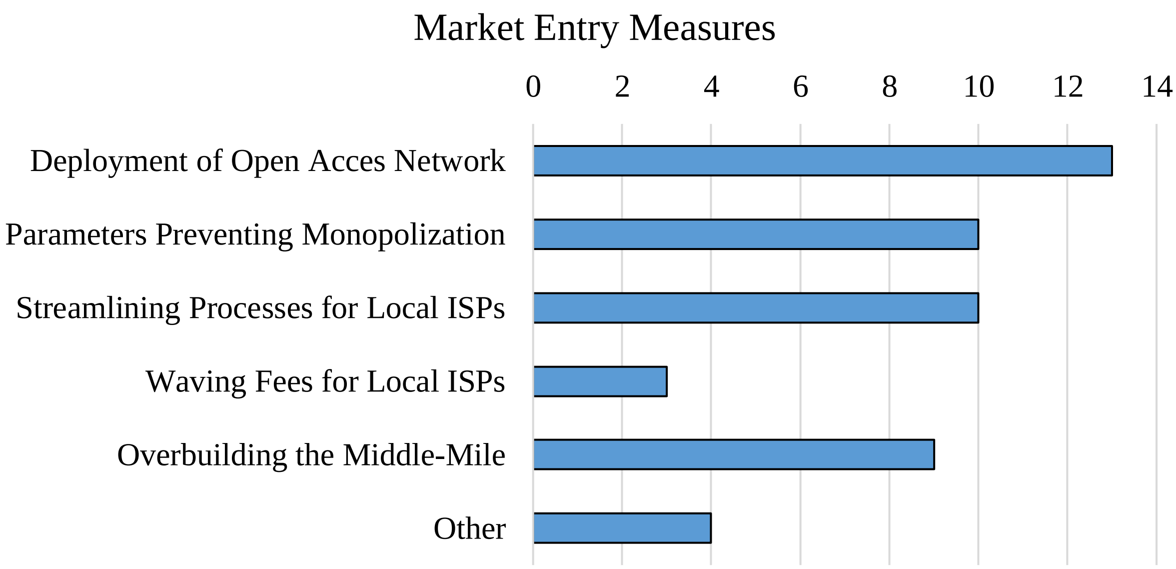


<u>Other Responses:</u>

- ISPs paid a subsidy to connect customers with high building costs.
- Network and devices were provided for free.
- Town's revenue used to pay for drops.

Figure 10. Users' financing support

Figure 10 provides an overview of the responses obtained from participants about the measures taken to enable market entry for different ISPs, improve competition, and reduce user costs in their respective projects. 'Deployment of Open Access Network' was selected by thirteen respondents. Setting parameters and guidelines to prevent the rise of monopolies, as well as removing barriers and streamlining processes for local ISPs were both selected by ten respondents. Additionally, nine respondents picked 'Overbuilding the Middle-Mile' as part of their answers.

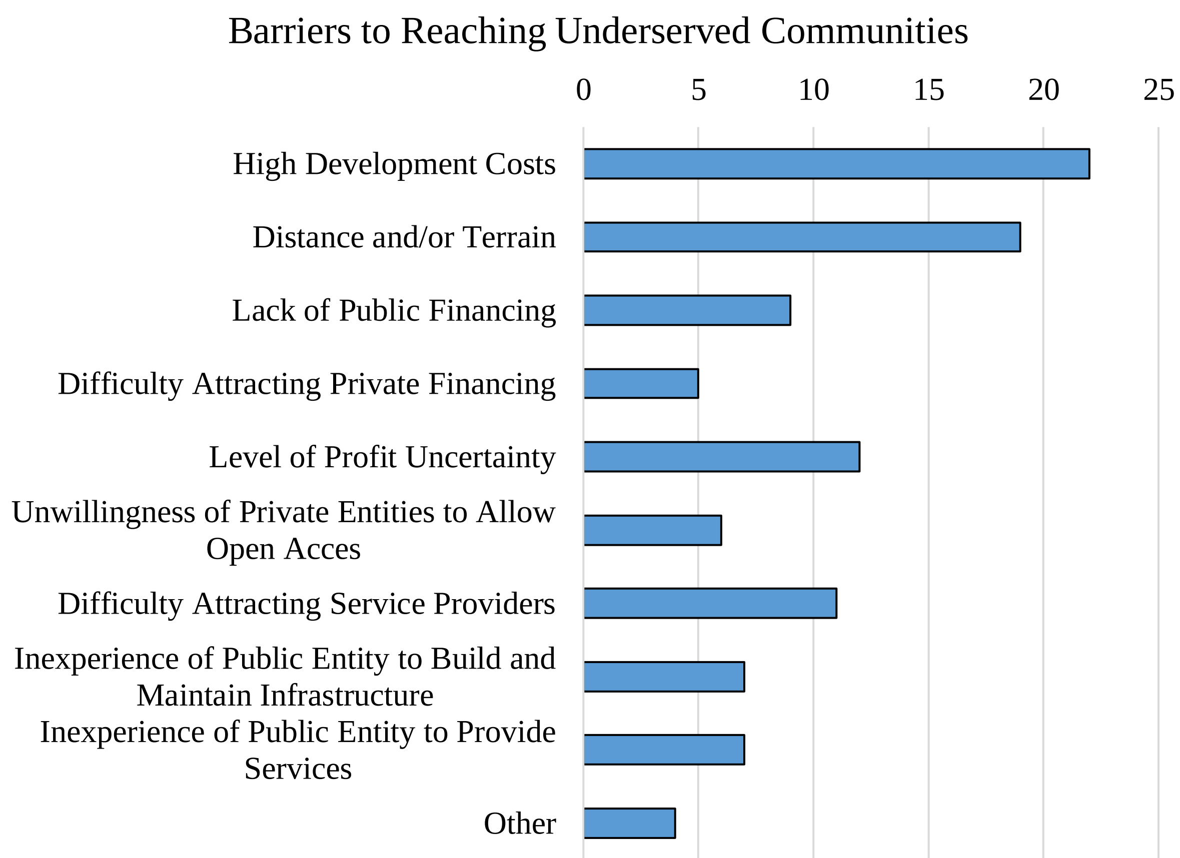


Other Responses:

- Federal government support.
- Not applicable: services provided by state network.
- Public funding of middle-mile to ensure lower cost dark fiber leasing rates.
- Transparency and months of community outreach and education.

Figure 11. Measures for market entry, improving competition, and lowering user cost

The survey captured the barriers and difficulties to reaching underserved and disadvantaged communities in the broadband projects. The findings of the survey, specifically pertaining to these challenges, are summarized in Figure 11. Twenty-two respondents identified high development costs as a significant obstacle, while nineteen respondents highlighted issues related to distance and/or terrain during the development phase. Additionally, twelve respondents expressed concerns about the uncertainty surrounding the level of profitability that development in these communities would yield. Moreover, eleven respondents encountered difficulties in attracting a sufficient number of service providers to establish a competitive market.

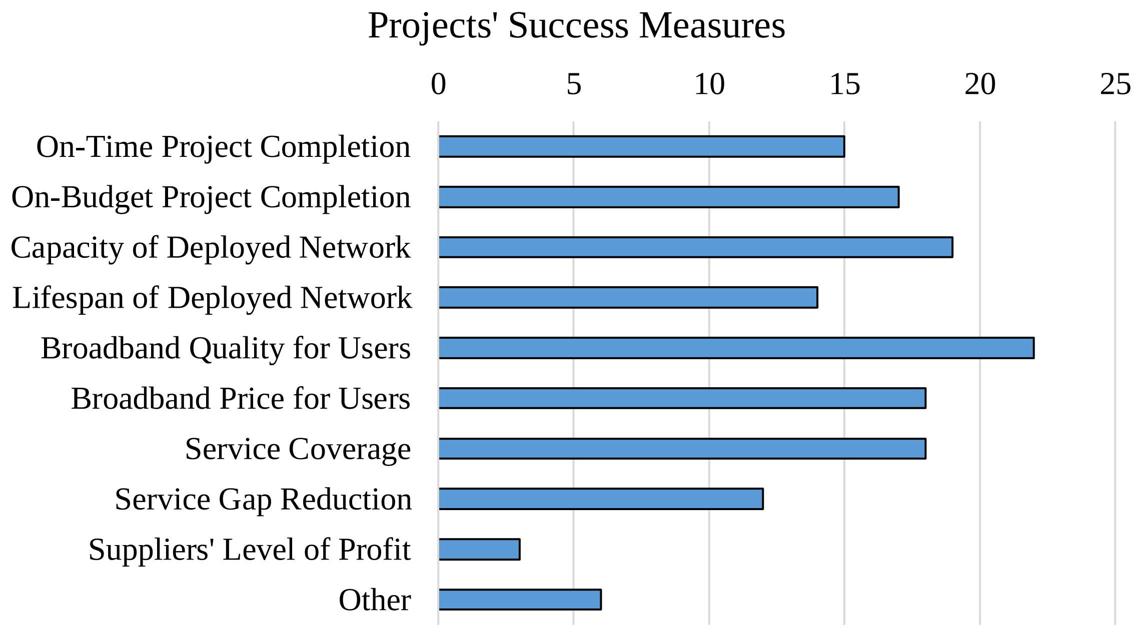


Other Responses:

- Construction delays limiting access.
- Lack of vision and political will.
- Project would not have been possible without ARPA and BEAD funds.
- Reaching the elderly population who did not have internet and therefore no emails.

Figure 12. Barriers to reaching underserved and disadvantaged communities

The final question of the survey focuses on various factors that contributed to the success of each project. Broadband quality was identified by twenty-two respondents as a crucial variable, while network capacity was highlighted by nineteen respondents. Additionally, eighteen respondents emphasized the significance of broadband price and service coverage. Furthermore, seventeen respondents indicated the importance of on-budget project completion, and fifteen respondents emphasized the value of on-time project completion.



<u>Other Responses:</u>

- Adoption and utilization.
- Analytics relative to outcomes, as well as alignment to budgetary pro-forma.
- Documented changes in community outcomes and mission advancements relative to anchor institutions.
- Helping non-users explore the possibilities that broadband offers.
- Publicly owned infrastructure to assure open access.
- Upfront payment to offset public subsidy.

Figure 13. Broadband development projects' measures of success

Chapter III: Dashboard Description

Dashboard: Exploring Opportunities for Equitable Broadband Access

Dashboard development platform: ArcGIS Experience Builder
Development date: April 2023
Dashboard size: 18.636 MB
Dashboard URL: Link
(https://experience.arcgis.com/experience/de54366d352746ed8e0b3d69250d49cd/)

Prepared by:
Subhrajit Guhathakurta, Ph.D.
Bon Woo Koo, Ph.D.
Lisa Stanovski, Graduate Student

Project Title:

Sustainable and Equitable Innovative Funding Strategies for Enhancing Broadband Initiative in Underserved and Disadvantaged Communities

Purpose of the dashboard

The purpose of this dashboard is to deliver key statistics and maps about conditions and prospects of broadband access in Georgia, USA, through an interactive portal. The dashboard has two main topics: (1) the current level of access to broadband services in different neighborhoods (i.e., Census Tracts) in Georgia, USA and (2) their eligibility for the Affordable Connectivity Program.
The key information about the two topics is provided through text and map formats. Examples of the key information provided in text format include the total number of households and the proportion of them without broadband access, both for the entire state as well as within a certain distance from interstates. The interactive map offers a visual representation of where households with (and without) broadband access are distributed within Georgia.
For both topics, special attention is given to those neighborhoods that are within 5 or 10 miles from the interstate highways because the majority of households without broadband access live near interstates. Interstates also make extending broadband infrastructure easier by providing accessible and linear tracts along the roads for burying cables.

Data and methods

Most data used for the dashboard is from 2021 American Community Survey. The total number of Census Tracts used in the dashboard is 2,791. The list of the variables used in the dashboard is shown in Table 1. Internet speed is the only variable from a different source: The Fixed Broadband Deployment Data from FCC Form 477 (link). The geometric information of the interstate highways is acquired from the Atlanta Regional Commission's open data portal (link).

Table 5. Variable names and table ID of Census data used in the dashboard.

Census Variable name	Census table ID
Total population	B01003
Total household	B28002
Presence and type of internet subscription	B28002
Median household income of the past 12 months	B19019
Ratio of income to poverty level in the past 12 months	C17002

The calculation of 5- and 10-mile specific statistics are conducted using sf package in R programming language. The statistics within certain distance from the interstate highways (e.g., the total population living within 5 miles from the interstate highways) are estimated by (1) drawing a 5-mile buffer polygon from the interstate polyline, (2) spatially intersecting the buffer and Census Tract polygons, (3) calculating the proportion of Census Tracts overlapping with the buffer, (4) multiplying the proportion of overlap with the original value of variables (e.g., total population) of Census Tracts, and (5) aggregating the results up to appropriate geographic units (e.g., the entire state of Georgia).

Dashboard design

Landing page

The landing page delivers to the users a few key information about the dashboard, including the title, institutions behind the dashboard, and the overall theme of the dashboard (Fig 1). This landing page can be modified to provide a brief description of the dashboard if necessary. Clicking the "Go to dashboard" button takes users to the main dashboard.

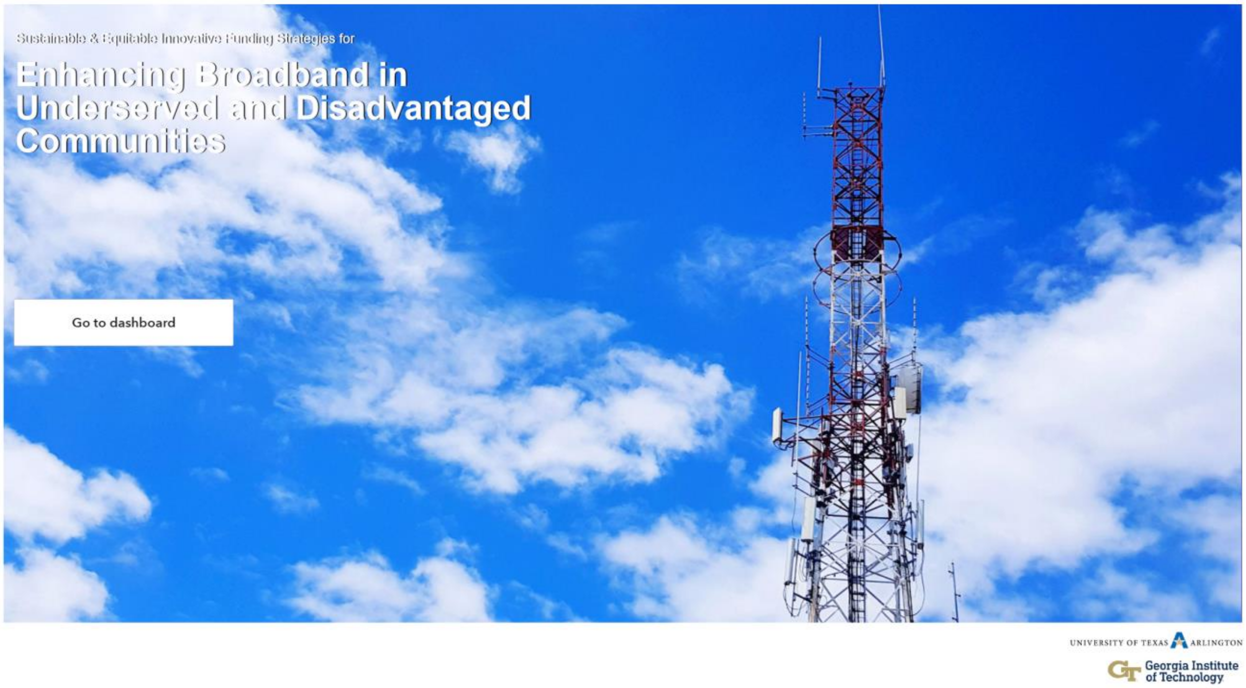


Figure 14. Landing Page of the dashboard.

Main dashboard page

The main dashboard page has a multi-panel design. Below the title of the dashboard "Exploring Opportunities for Equitable Broadband Access," there are five main panels (Fig 2).

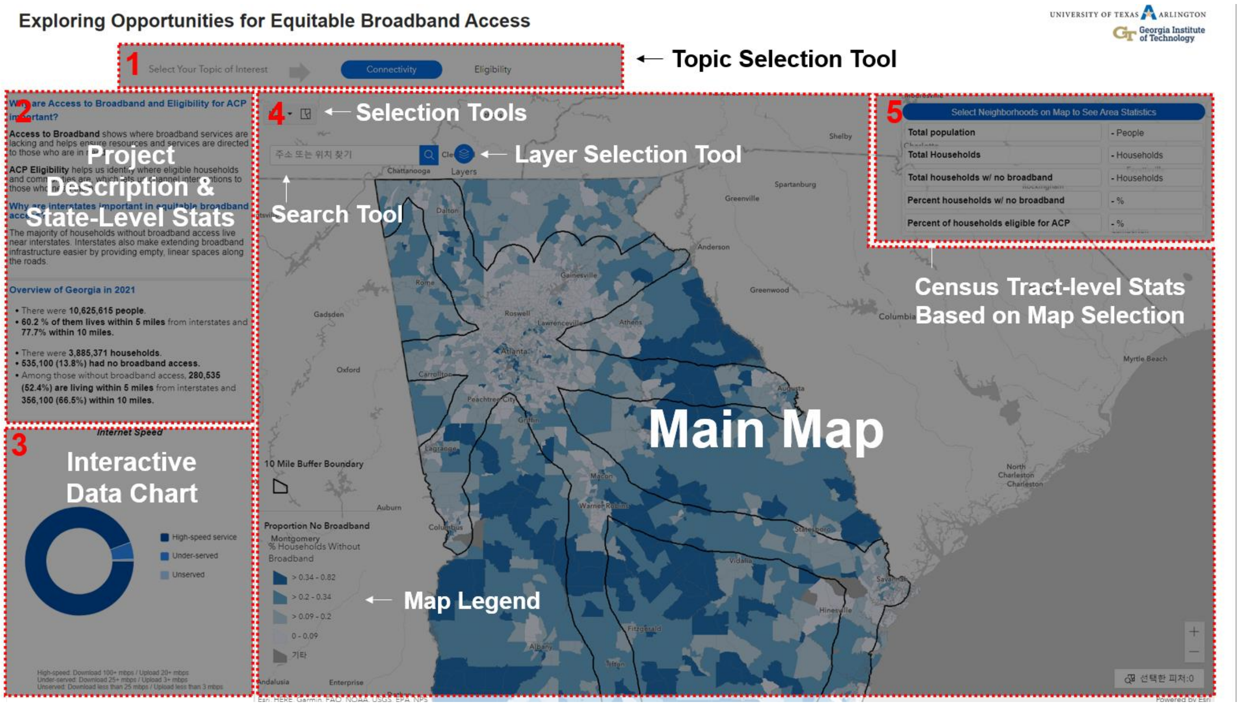


Figure 15. Main dashboard panel layout.

• Panel 1 is a topic selection tool that allows users to choose between Connectivity (to Broadband service) and Eligibility (for Affordable Connectivity Program (ACP); https://www.fcc.gov/acp). Clicking the Eligibility button will switch Panel 2 through 5 to display Eligibility-related information.

• Panel 2 provides a brief description of this project behind this dashboard, focusing on access to broadband and ACP eligibility. It also explains why interstates are important in achieving equitable broadband access. The bottom half of the panel provides basic descriptive information about the state of Georgia, including:
  - o Population and number of households.
  - o The proportion of the population living within 5 and 10 miles from the interstates.
  - o The number of households without broadband access and how many of them are living within 5 and 10 miles from the interstates.

• Panel 3 displays a pie chart of internet service speed grouped into three categories. The categories are:
  - o High-speed: Download speed 100+ mbps, Upload 20+ mbps
  - o Underserved: Download speed 25+ mbps, Upload 3+ mbps
  - o Download speed less than 100 mbps, Upload less than 20 mbps

• Panel 4 is the main map. This interactive map allows users to freely zoom using the mouse scroll wheel and pan by click-and-drag. The color of the polygons on the map is explained in the bottom-left corner in the Map Legend.

o Selecting polygon(s): One major function of the map is that the polygons can be selected using a mouse to view selection-specific statistics (Fig 3). Users can enable selection by clicking the button with a cursor icon (look for 'Selection Tools' in the image below), which will turn blue when clicked. Now clicking on the map will select polygons. By clicking the down arrow button next to the 'Selection Tools,' users can choose from five selection types, including rectangle, lasso, circle, line, and point. Clicking the button on the right deselects all selections made so far.

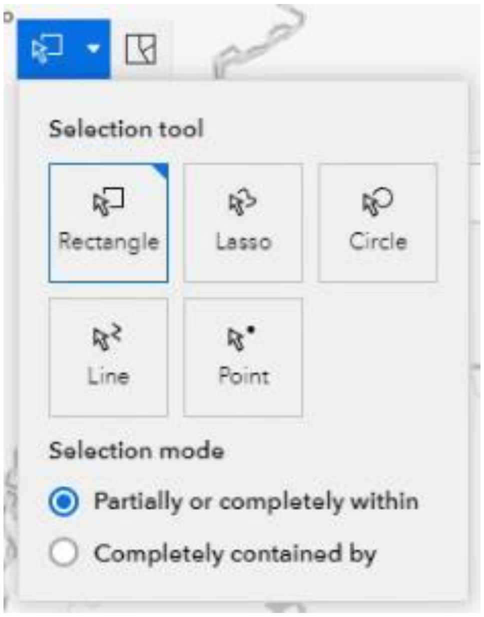


Figure 16. Selection Tools in Panel 4.

o Searching for county of your interest: Below the 'Selection Tools' is the 'Search Tool.' By typing in the name of a county and clicking the magnifier icon, users can display only the Census Tracts within the selected county. To view all Census Tracts, clear the search bar by either deleting them manually or by clicking the 'X' icon at the end of the search bar.

• Panel 5 is the neighborhood-level statistics panel that works in tandem with the 'Selection Tools' of Panel 4, the main map (Fig 4). Users can select Census Tract(s) in the map to view the total population and households, number of households without broadband access, and the proportion of eligible households for ACP of the selected Census Tracts.

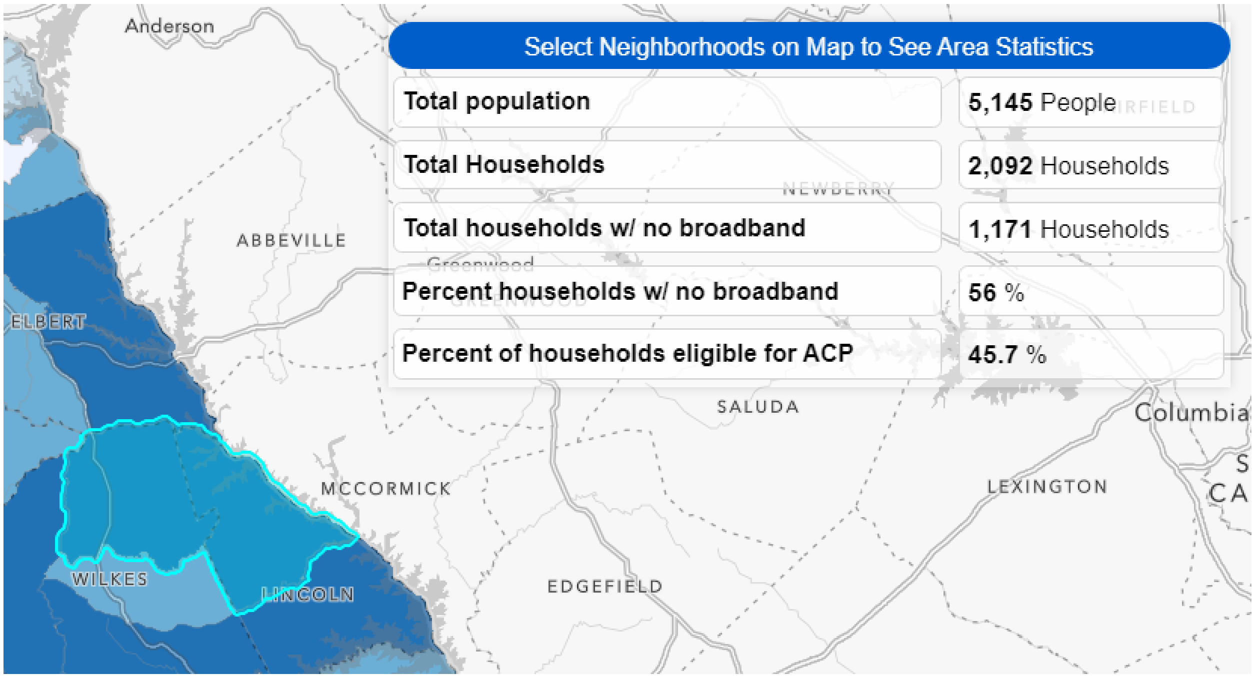


Figure 17. Census Tract-level statistics that are interactively updated based on the selected Census Tracts.

Using Panel 1, Users can switch to the 'Eligibility' section. The Eligibility section is visually different from the 'Connectivity' section, as 'Eligibility' section uses green as the overall theme. All functionalities are identical to 'Connectivity' section, except for Panel 3, the pie chart. The pie chart in 'Eligibility' section displays Census Tracts in five groups depending on the cost of providing broadband infrastructure, including (1) Dense urban, (2) More costly, (3) Significantly more costly, (4) Rural and complex deployments, and (5) Most expensive. These groups are created based on household density:

- Dense urban: 1,525 households per sqmi or more
- More costly: 767 households per sqmi or more
- Significantly more costly: 302 households per sqmi or more
- Rural and complex deployments: 63 households per sqmi or more
- Most expensive: NA

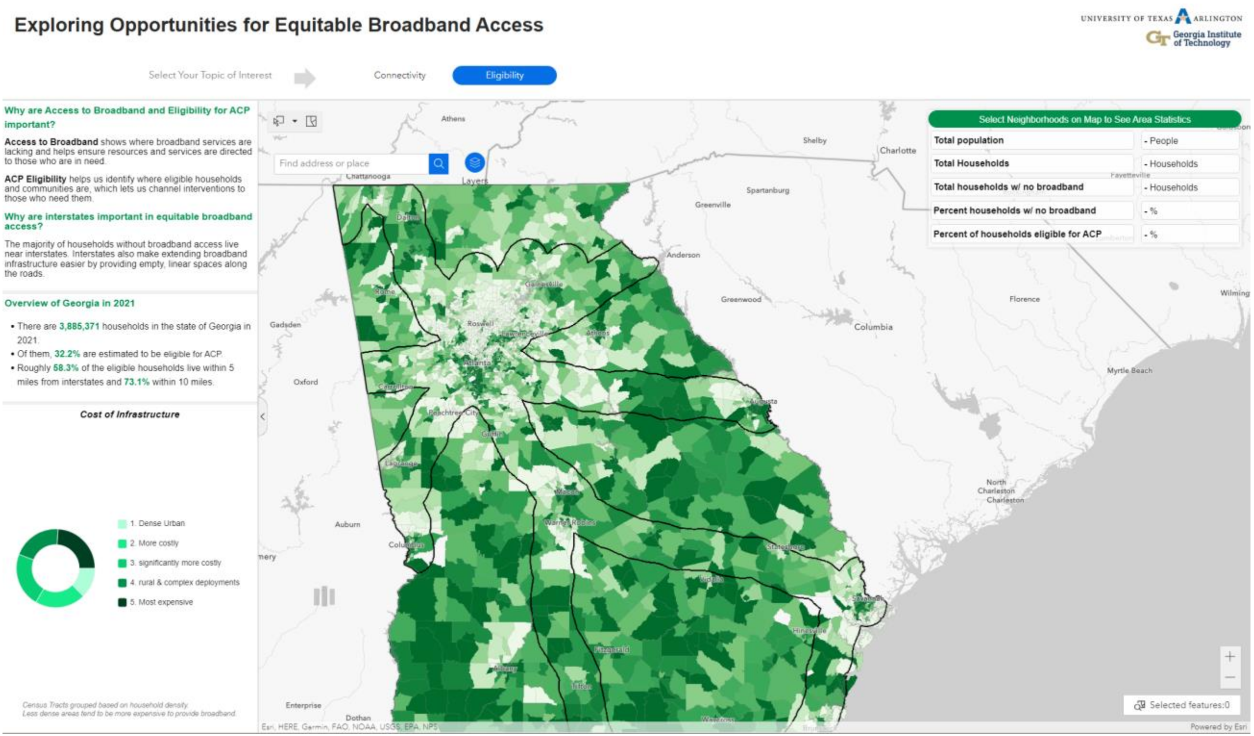


Figure 18. Eligibility section of the main dashboard.

Example use cases

To provide step-by-step instructions on how to use the dashboard, a hypothetical use case is discussed here: a city planner in the department of planning at DeKalb County government is tasked to research the current state of broadband access in their county as well as other counties around DeKalb and to find where households eligible for ACP are located. To accomplish this task, the planner can follow the steps below.

1. Select Connectivity button in Panel 1 to examine the current state of broadband access.
2. Read carefully the Overview of Georgia in 2021 for the state-wide statistics relevant to broadband access.
3. Examine the map to understand the landscape of broadband access of DeKalb County in comparison to other areas of Georgia. The mouse wheel can be used to zoom in for a closer look.
4. If there are a few Census Tracts that are of interest, they can be clicked using the Selection Tools to get Tract-specific information.
5. To narrow down the map to just DeKalb County, use the Search Tool within the main map and type DeKalb or DeKalb County. Either will hide all Census Tracts that are outside the DeKalb County from view.
6. Now Census Tracts in DeKalb County can be selected easily to view DeKalb County-specific information.
7. The Eligibility button in Panel 1 can be selected to switch to learn about the eligibility of Census Tracts. All functionalities shown above apply to the Eligibility section.

Appendix A: Survey Questionnaire

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Appendix A: Survey Questionnaire

CENTER FOR TRANSPORTATION
EQUITY, DECISIONS & DOLLARS

Sustainable & Equitable Innovative Funding Strategies for Enhancing Broadband Initiative in Underserved and Disadvantaged Communities

The Georgia Institute of Technology and The University of Texas at Arlington invite you to participate in a short survey pertaining to innovative funding strategies for enhancing broadband initiatives in underserved and disadvantaged communities. The survey is a part of the Center for Transportation Equity, Decisions, and Dollars (CTEDD) Project #022-05, titled: "Sustainable and Equitable Innovative Funding Strategies for Enhancing Broadband Initiative in Underserved and Disadvantaged Communities." This survey aims to capture the successes and challenges of different contribution models for broadband development and to acquire information about broadband development projects. The survey contains 16 questions and is expected to take approximately 5-10 minutes. CTEDD and our research team highly appreciate your contribution to this unique effort. If you have any questions about this research study, please contact Dr. Mohsen Shahandashti, P.E. at mohsen@uta.edu or directly at 817-271-0440.

Contact Information:

First Name

Last Name

Position

Email Address

Question 1: Do you have any experience or prior knowledge of implementing broadband initiatives?

- o Yes.
- o No (survey terminates).

Question 2: Select the state the project was in.

---Select State--- ▼

Question 3: Which cities and/or towns was the project in?

Cities/Towns

Question 4: What year was the project finished/is expected to finish?

Year

Question 5: What type of broadband technology was used in the broadband project? (Select all that apply).

- o Fiber to the Home (FTTH).
- o Cable internet (COAX).
- o Copper based internet (xDSL).
- o Wireless assets (e.g., fixed wireless).
- o Satellite.
- o Other (please specify).

Question 6: Who assumed ownership of the middle-mile broadband infrastructure in the project? (Select only one).

- State, city, or municipality owned, operated, and maintained.
- Private operator or service provider.
- Shared between public and private.
- Privately owned, then flipped to public.
- Other (please specify).

Question 7: Who assumed ownership of the last-mile broadband infrastructure in the project? (Select only one).

- State, city, or municipality owned, operated, and maintained.
- Private operator or service provider.
- Shared between public and private.
- Privately owned, then flipped to public.
- Other (please specify).

Question 8: Which development (or contribution) model best describes the broadband project? (Select only one).

- Private sector owner and operator, single ISP.
- Private sector owner and operator, open access.
- Dark fiber open access (hybrid).
- Municipal electrical utility owned and operated, single ISP.
- City owned and operated, single ISP.
- Manual open access, multiple ISPs (single entity manages the network infrastructure, and the process of adding new ISPs is done manually).
- Automated open access, multiple ISP (single entity manages the operator, the operator manages the network infrastructure and provides automated access to multiple ISPs using software and technological tools).
- Other (please specify).

Question 9: What types of financing models were used by the private sector to develop the broadband project? (Select all that apply).

- Project bonds.
- Direct loans.
- Syndicated loans.
- Corporate bonds.
- Subordinated bonds.
- Listed equity capital.
- Unlisted equity capital.
- Vendor financing.
- Strategic investors.
- Private funds from the operator.
- Private funds from two or more operator that share the infrastructure.
- Corporate social responsibility (e.g., environmental, social, and corporate governance [ESG] initiatives).
- Other (please specify).

Question 10: What types of financing models were used by the public sector to develop the broadband project? (Select all that apply).

- Equity capital market.
- Debt capital market.
- Subordinated loans.
- Minimum revenue guarantees.
- Government operation subsidies.
- Government loss guarantee scheme.
- Off-take agreements.
- Federal government loan.
- State government loan.
- Local government loan.
- Government equity participation.
- Government roll-out subsidies.
- Tax increment financing.
- Tax incentives.
- Infrastructure bonds, such as state-, county-, and municipality-backed bonds.
- Pooled fund by clustering several counties, cities, or states that benefit from the project.
- Public-Private-Partnership (P3 or PPP) project finance.
- Other (please specify).

Question 11: What types of financing models were used by the community to develop the broadband project? (Select all that apply).

- Infrastructure or asset transfer (rights of way).

- Community bonds.
- Community funding.
- Subscriber equity.
- Subscriber finance.
- Other (please specify).
- Community did not contribute financially.

Question 12: What types of revenue models were used in the broadband project? (Select all that apply).

- Pre-sales.
- Demand aggregation (i.e., aggregation of multiple users to sign up for a service).
- Anchor tenant contract (e.g., the government or a public entity).
- Dual service provision (i.e., another product sold on top of connectivity subsidizes the service).
- Demand side government subsidies at the user level (e.g., connectivity coupons).
- Other (please specify).

Question 13: Did the project's users receive any financing support? (Select all that apply).

- Microfinancing of devices.
- Reduction in taxes and import duties on devices and usage of services.
- Reduction or exemption of patent royalties.
- Demand aggregation for devices.
- Subsidies reducing the cost of devices.
- Facilitation of reuse of discarded devices.
- Other (please specify).
- No financing support received.

Question 14: What measures were taken to enable market entry of different providers, improve competition, and lower user cost? (Select all that apply).

- Deployment of open access network.
- Setting parameters, guidelines, or ranges for broadband rates, fees, and charges to prevent the rise of monopolies.
- Removing barriers and streamlining processes for local ISPs.
- Waving fees or offered promotional rates to increase market entry.
- Overbuilding the middle-mile.
- Bond financing for homeowners (i.e., homeowner acts as the private partner to prevent companies from purchasing the network).
- Other (please specify).

Question 15: What were the biggest barriers to reaching underserved and disadvantaged communities in your project? (Select all that apply).

- High development costs.
- Distance and/or terrain issues for development.
- Lack of public financing.
- Difficulty attracting private financing.
- Uncertainty over the level of profit development in these communities would yield.
- Private entity being unwilling to allow open access on infrastructure they develop.
- Difficulty attracting enough service providers to establish a competitive market.
- Lack of skills and/or expertise for public entity to build and maintain infrastructure.
- Lack of skills and/or expertise for public entity to provide services.
- Other (please specify).

Question 16: What were the most important measures of success for your project? (Select all that apply).

- On-time completion of the project.
- On-budget completion of the project.
- Technical capacity of network infrastructure deployed.
- Expected lifespan of network infrastructure deployed.
- Quality of broadband service for users.
- Price of broadband service for users.
- Service coverage (number of households connected to the new network).
- Service gap reduction (number of households in service area that still do not have access to broadband).
- Level of profit received by suppliers.
- Other (please specify).

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The **Center for Transportation, Equity, Decisions and Dollars (CTEDD)** is a USDOT University Transportation Center, leading **transportation policy research** that aids in **decision making** and **improves economic development** through **more efficient, and cost-effective use of existing transportation systems,** and offers **better access to jobs and opportunities.** We are leading a larger consortium of universities focused on **providing outreach** and **research to policy makers**, through **innovative methods** and **educating future leaders of the transportation field.**

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