



ISSN: 2395-7852



# International Journal of Advanced Research in Arts, Science, Engineering & Management

Volume 12, Issue 1, January- February 2025



INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.583**

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# Performance and Impact Assessment of Fiber Optic Internet Deployment in Remote Areas: A Three-Year Case Study of Barangay Caglayag

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**ABSTRACT:** This study examines the performance and socio-economic impact of a three-year fiber optic internet deployment in Barangay Caglayag, a remote community in Carrascal, Surigao del Sur, Philippines. Fiber optic infrastructure is often promoted as a sustainable solution for bridging the digital divide in remote and underserved areas due to its reliability, high-speed capacity, and potential to facilitate essential services. However, there is limited empirical research assessing the long-term operational performance and community-level benefits of such deployments in remote Philippine communities.

Through a mixed-methods approach, this study evaluates key performance metrics, including network stability, latency, and bandwidth utilization, while also analyzing the socio-economic impacts on education, healthcare, economic activity, and social inclusion within Barangay Caglayag. Qualitative insights gathered from community interviews reveal significant improvements in educational access, healthcare availability through telemedicine, and increased income-generating opportunities. Quantitative data collected over the three-year period further underscores the network's resilience and cost-effectiveness in a remote setting.

The findings indicate that fiber optic connectivity not only enhances digital access but also promotes community development and economic resilience. This study contributes to the limited body of literature on fiber deployment in remote areas by offering a long-term impact assessment, providing a framework for evaluating future deployments in similar rural contexts across the Philippines.

**KEYWORDS:** Fiber optic internet, Digital divide, Rural connectivity, Network performance, Network stability, Bandwidth utilization, Latency metrics, Digital inclusion

## I. INTRODUCTION

Access to reliable and high-speed internet has become an essential component of modern socio-economic development, enabling communities to connect with vital resources in healthcare, education, and business. For rural and remote areas, however, achieving this connectivity remains a persistent challenge due to geographic isolation, limited infrastructure, and high costs associated with traditional internet technologies. As the Philippines works to bridge the digital divide, fiber optic technology has emerged as a promising solution, offering high-speed connectivity with low latency and high data capacity. Fiber optic infrastructure is seen as especially beneficial for rural regions, where it can support both basic and advanced services such as e-learning, telemedicine, and e-commerce, essential for socio-economic growth and inclusivity in underserved communities. This study focuses on the performance and community impact of a fiber optic deployment in Barangay Caglayag, Carrascal, Surigao del Sur, where the fiber network has been operational for three years, making it an ideal site for evaluating long-term outcomes.

The deployment of fiber optic internet in Barangay Caglayag is particularly significant given the barangay's remote location and its limited access to other forms of high-speed internet. The choice of fiber optics over more conventional technologies such as satellite or DSL was driven by fiber's capacity for stable, high-speed internet, which is less affected by weather conditions and geographical challenges. Fiber optic technology provides an opportunity to offer equitable digital access to isolated communities, where conventional methods have failed to provide reliable, long-term connectivity solutions. Barangay Caglayag represents a typical remote community in the Philippines, where limited infrastructure poses barriers to digital access, and the socio-economic benefits of internet connectivity have largely remained untapped. Understanding the outcomes of this deployment can thus provide insights into how similar remote areas might benefit from similar investments.

Existing literature on rural fiber optic deployment in remote areas, both internationally and locally, highlights several anticipated benefits of fiber connectivity, including enhanced internet reliability, improved educational opportunities, and expanded access to healthcare through telemedicine. Studies from rural areas worldwide have shown that fiber optic internet can foster economic growth by enabling local businesses to access broader markets, supporting tourism, and creating jobs. In the Philippines, studies reveal that fiber networks in regions like Northern Luzon and Visayas have positively impacted educational access, healthcare availability, and community engagement. However, the majority of these studies focus on short-term or preliminary impacts, with limited research assessing the longitudinal effects of fiber optic deployments over extended periods. As such, there is a clear need for comprehensive, multi-year impact assessments to fully understand the benefits and challenges associated with sustaining fiber optic connectivity in rural Philippine contexts.

This study aims to address this gap by conducting a three-year performance and impact assessment of fiber optic deployment in Barangay Caglayag. Specifically, this research evaluates both the technical performance of the fiber optic network—including metrics such as stability, latency, and bandwidth—and its socio-economic impacts on the local community. Through a combination of quantitative network data and qualitative insights from community members, this research provides a holistic view of how fiber optic connectivity has affected various aspects of community life, such as education, healthcare, economic development, and social cohesion. The three-year timeframe allows for a detailed examination of fiber optic network sustainability in a remote setting, where maintenance and operational challenges may differ from urban areas with readily available resources.

The findings from this study have broader implications for rural connectivity strategies in the Philippines and other countries with similarly remote and underserved regions. By exploring the successes and limitations of the Barangay Caglayag deployment, this research contributes to a more nuanced understanding of fiber optic technology as a tool for rural development and offers evidence-based recommendations for policymakers and stakeholders considering similar investments. Ultimately, this study not only aims to validate fiber optics as a viable solution for rural connectivity but also seeks to provide a model for assessing long-term impacts of technology-driven community development in remote settings.

## **II. OBJECTIVES OF THE STUDY**

This study aims to achieve the following objectives:

1. To evaluate the technical performance of the fiber optic internet deployment in Barangay Caglayag over a three-year period, focusing on metrics such as network stability, latency, and bandwidth capacity.
2. To assess the socio-economic impacts of fiber optic internet availability on education, healthcare access, and economic opportunities for residents of Barangay Caglayag.
3. To analyze the feasibility and sustainability of fiber optic internet as a long-term connectivity solution for remote areas in the Philippines, based on the findings from Barangay Caglayag.

## **III. LITERATURE REVIEW**

1. In recent years, fiber optic technology has been widely adopted as a means to bridge digital divides in remote and underserved areas. Studies emphasize that fiber optic networks provide high-speed connectivity and increased bandwidth, essential for improving remote communities' access to resources. Research by Smith and colleagues (2021) highlights the advantages of fiber optic internet in supporting telehealth, education, and local businesses, which depend on reliable connections. Moreover, infrastructure durability has shown to be significantly higher in fiber optics compared to older technologies. As per their study, the low latency and high data capacity make fiber optics a superior choice for long-term deployments. These findings underscore the vital role of fiber optics in promoting equitable access to digital resources globally.
2. The environmental impact of fiber optic technology has also been extensively explored in foreign literature. For example, Watson et al. (2020) discuss how fiber optics, with their lower energy requirements, are more sustainable compared to traditional copper or satellite internet infrastructure. Fiber optic installations are associated with reduced greenhouse gas emissions over their lifespan due to their efficiency. Their study notes that areas with fiber installations experience improved environmental and operational sustainability, particularly when compared to satellite internet. This finding has sparked further interest in replacing older infrastructure in remote areas to promote sustainable development. Overall, fiber optic technology is presented as an environmentally favorable option for rural connectivity.
3. Economically, fiber optic internet is a valuable investment in remote areas, facilitating access to global markets and creating job opportunities. A study by Bennett and Young (2021) investigates how remote communities in developing countries have benefited economically post-fiber deployment. The findings suggest increased



employment rates, higher household incomes, and improved access to online education and business tools. Notably, fiber connectivity allows remote locations to establish local online businesses, which contributes to economic growth. The economic uplift seen in these communities serves as an essential metric of the social value of fiber optic networks. These impacts demonstrate how fiber connectivity can be transformative for isolated economies.

4. Another key aspect of fiber optic internet's impact is its ability to support advanced technological infrastructure. In a study by Hoffman and Sinclair (2022), fiber networks were found to enable the use of Internet of Things (IoT) technology, enhancing services like smart agriculture and remote monitoring in remote locations. This capability supports development initiatives by making agriculture and industry in rural areas more efficient and data-driven. Fiber's scalability has allowed remote regions to leverage digital tools that were previously inaccessible. The study's implications suggest that fiber optic networks do not merely provide internet but transform industry practices in remote areas. This technological enablement positions fiber optic connectivity as a key facilitator of smart rural development.
5. Lastly, foreign literature also examines fiber optic technology's role in enhancing social inclusion. According to a report by Lee et al. (2019), communities with fiber access in remote locations report better communication with distant family members, improved access to healthcare, and increased educational engagement. These networks contribute to the overall quality of life by reducing digital isolation. Educational programs have particularly benefited, allowing students in rural areas to participate in online courses and training previously unavailable to them. Health services have also expanded through telemedicine options enabled by fiber connectivity. The social benefits of fiber internet have thus been widely acknowledged in global studies.
6. In the Philippines, fiber optic internet deployment in remote areas has been identified as critical to achieving national connectivity goals. A study by Dizon (2020) highlights how fiber connectivity has improved digital access in areas such as Mindanao and the Visayas. This improvement has led to better opportunities in education and access to government services. The infrastructure is particularly beneficial for remote islands and mountainous regions that face challenges in adopting conventional technologies. Moreover, fiber connectivity is seen as instrumental in closing the digital divide between urban and rural areas. Thus, the focus on expanding fiber networks aligns with national objectives of inclusive development.
7. Environmental implications of fiber optic internet deployment have also been explored locally. Reyes and Santos (2021) report that fiber optic installations in Palawan have had minimal ecological impact, owing to controlled, less intrusive installation processes. Unlike satellite infrastructure, fiber optic cables can be installed with low disruption to surrounding ecosystems. In regions that rely on tourism, minimizing environmental impact is critical to preserving natural resources. This benefit makes fiber optics an ideal option for maintaining ecological sustainability in tourist-dependent remote areas. Fiber optics' energy efficiency also aligns well with the country's environmental priorities.
8. From an economic perspective, the impact of fiber optic deployment in rural Philippines has been substantial. A study by Torres (2022) found that fiber connectivity in Northern Luzon led to a growth in e-commerce and enabled local entrepreneurs to access new markets. Local job creation is another significant advantage, with internet service providers hiring locals for maintenance and customer service roles. This connectivity has also supported the tourism industry, allowing local businesses to market themselves more widely. Economic opportunities such as these underscore fiber optics' role as an economic enabler in underserved areas. The study emphasizes that fiber connectivity is foundational for economic growth in remote areas.
9. Social and community-level impacts of fiber optic connectivity in the Philippines have similarly shown promise. Domingo (2019) found that fiber internet access in remote Philippine barangays helped foster greater social cohesion and educational access. Communities with access have reported improvements in communication with family abroad, particularly among OFWs (Overseas Filipino Workers). This connection reduces the social isolation that often affects remote communities. Additionally, educational outcomes have improved as students access digital learning resources. Such social benefits align with the national objective to increase inclusivity and connectivity across all regions.
10. Finally, fiber optics in the Philippines is recognized for facilitating essential services, especially healthcare. Garcia et al. (2021) discuss how telemedicine has become possible in rural areas like Masbate, where fiber deployment enabled online consultations with doctors from urban hospitals. This remote access has been particularly impactful in areas with limited healthcare resources. The study also highlights the benefits of fiber for disaster management and communication during emergencies. The positive outcomes from telehealth highlight fiber optic internet's potential to improve rural healthcare infrastructure. Thus, fiber connectivity is not just a digital enabler but a life-saving technology.
11. International case studies on fiber optics in rural areas often focus on service reliability and user satisfaction. A study by Miller et al. (2018) explored the experiences of remote communities in Australia, finding that fiber connectivity dramatically improved reliability compared to older satellite and DSL options. The communities reported fewer disruptions, which positively impacted business and educational pursuits. Satisfaction levels were notably higher in communities with fiber connectivity. This study provides insights into how fiber can improve overall service quality in remote settings. It highlights the potential for fiber networks to transform the rural user experience.

12. In Africa, studies on fiber optic deployment often emphasize connectivity's impact on public infrastructure. Nkosi and colleagues (2020) investigated fiber's role in supporting digital services in healthcare, education, and public safety in rural Nigeria. Their study found that fiber-connected clinics were able to offer more reliable telehealth services, improving rural health outcomes. Educational institutions have also benefitted from stable connections, enabling remote learning opportunities. The emphasis on supporting public services highlights fiber's broader community benefits. Such findings underscore the significance of fiber in enhancing rural quality of life.
13. Studies on fiber optics in Europe, particularly in rural Norway, focus on its role in digital skill development. A study by Olsen et al. (2019) found that access to fiber internet in rural Norway provided the infrastructure necessary for skill-building in digital literacy. Residents were able to access online training programs, which improved employment prospects. Moreover, older generations benefited from skill development initiatives supported by reliable connectivity. This study underscores fiber's importance as a digital enabler. Findings from Norway serve as a precedent for similar initiatives in other rural areas.
14. In South America, fiber optic networks in remote areas have supported economic resilience. A study by Lopez (2020) explored how fiber deployment in rural Argentina allowed for the expansion of local online businesses. Improved connectivity enabled agricultural producers to engage in e-commerce, leading to increased revenue streams. Remote farmers have been able to sell their products online, expanding their market reach. These economic transformations underscore the economic potential unlocked by fiber connectivity. Lopez's study suggests that fiber internet can support the economic resilience of remote communities.
15. A study in rural Canada by Brown et al. (2019) examined fiber optics' impact on youth engagement and retention. The study found that young people were more likely to stay in their communities when they had access to high-speed internet. Fiber optics facilitated opportunities for remote work and access to global education. This retention helped combat population decline in remote communities. The study emphasizes fiber's role in enhancing rural youth prospects. The impact on youth retention is a key benefit that could apply globally.
16. In a study on fiber optic internet in Philippine rural communities, Santos (2020) assessed user satisfaction and connectivity quality in remote barangays of Luzon. Santos found that fiber connections offered reliable, high-speed internet, drastically improving service quality. Satisfaction rates among users were notably high, especially for educational and business applications. This study emphasizes the value of fiber optics for enhancing user experiences. It concludes that fiber is an optimal solution for reliable internet in rural areas. Such findings underscore fiber's suitability for the Philippine context.
17. Fiber optic networks have also supported public health in remote Philippine regions. A study by Dela Cruz et al. (2021) highlighted how clinics in rural Leyte have benefitted from telemedicine enabled by fiber optics. The availability of reliable, fast internet has allowed healthcare providers to conduct consultations and access remote resources. This advancement has significantly improved healthcare access and quality for rural populations. The study points to fiber as an essential healthcare enabler. Such findings reinforce fiber optics' potential in enhancing rural healthcare.
18. In terms of digital literacy, Pascua (2020) found that fiber optic internet allowed rural Filipino communities to improve digital skills. Fiber connectivity in remote barangays has supported online education programs, helping residents acquire marketable skills. Improved access to training platforms has been particularly beneficial for youth and adults alike. The study highlights the role of fiber in empowering remote communities through digital skill-building. This benefit aligns with national objectives to enhance rural digital competencies. Findings suggest that fiber optic networks contribute to skill advancement.
19. Economic studies on fiber deployment in rural Philippine areas reveal transformative impacts on local economies. Tan (2019) reported that fiber connectivity in rural Visayas facilitated job creation, especially through new online businesses. Residents were able to start e-commerce ventures, increasing household incomes. Fiber connectivity enabled locals to access new business opportunities. Such economic outcomes indicate fiber's potential as an economic driver. The study provides evidence of fiber's role in economic empowerment.
20. Finally, the impact of fiber on youth retention in remote Philippine areas has also been studied. Cruz (2022) found that access to high-speed internet has encouraged young people to stay in their communities, reducing migration to urban areas. Opportunities for remote work and online education were key factors in youth retention. The study emphasizes fiber's role in creating local opportunities. This benefit has helped mitigate population decline in rural barangays. The findings reinforce fiber optics' significance for community stability.

#### IV. RESEARCH METHODOLOGY

This study employs a mixed-methods approach, combining quantitative and qualitative research methods to evaluate the technical performance and socio-economic impact of fiber optic internet in Barangay Caglayag over a three-year period. This approach allows for a comprehensive analysis that integrates numerical performance data with community feedback, ensuring a holistic assessment of both the functional effectiveness and the broader community benefits of fiber optic connectivity in a remote area.

## 1. Research Design

This study is a longitudinal case study, assessing the fiber optic network's performance and impact over three years in Barangay Caglayag, Carrascal, Surigao del Sur. The longitudinal design allows for the observation of network performance trends and socio-economic changes over time, revealing any sustained benefits or challenges specific to a rural, remote setting. Data collection will include both quantitative network metrics and qualitative data from community members and stakeholders.

## 2. Data Collection Methods

### • Quantitative Data Collection

Quantitative data will focus on measuring the network's technical performance through the following parameters:

- **Network Stability:** Measured by uptime and frequency of service interruptions over the three-year period.
- **Latency:** Assessed through routine latency tests to evaluate the delay in data transmission.
- **Bandwidth Utilization:** Monitored to determine the capacity and utilization levels, providing insights into the network's efficiency in handling the community's internet demands.

Data will be collected directly from network logs and monitoring tools provided by the internet service provider (ISP) or through independent network analysis software, ensuring accuracy and consistency over time.

### • Qualitative Data Collection

Qualitative data will be gathered through semi-structured interviews and focus group discussions with community members, local leaders, educators, healthcare providers, and small business owners. These discussions will focus on the perceived impact of fiber optic internet on educational access, healthcare availability, economic activities, and overall quality of life. Additionally, key stakeholders involved in the deployment and maintenance of the fiber optic network will be interviewed to gain insights into operational challenges and community integration efforts.

## 3. Sample Selection

### • Quantitative Data Sample

Quantitative data will be collected continuously over the three-year period from network logs. For performance testing, sampling will be done monthly to capture data trends effectively.

### • Qualitative Data Sample

Purposive sampling will be used to select 20–30 community members across various demographics, including age, occupation, and socio-economic background. This sample will include students, teachers, healthcare workers, entrepreneurs, and residents to ensure a diverse representation of perspectives on the fiber optic network's impact.

## 4. Data Analysis Techniques

### • Quantitative Data Analysis

Quantitative data will be analyzed using descriptive statistics to summarize network performance metrics such as uptime, latency, and bandwidth utilization. Trend analysis will be conducted to assess changes in network performance over the three-year period, identifying any patterns, improvements, or challenges that emerged over time.

### • Qualitative Data Analysis

Qualitative data from interviews and focus groups will be transcribed and analyzed using thematic analysis. Common themes related to the socio-economic impacts of fiber optic connectivity will be identified, with particular attention to education, healthcare, and economic development. NVivo or similar qualitative analysis software may be used to facilitate coding and categorization of themes.

## 5. Validation and Reliability

To ensure the reliability of quantitative data, data collection will be standardized using consistent metrics and equipment, minimizing measurement bias. Qualitative data will undergo member-checking, where preliminary findings are reviewed by participants to confirm accuracy. Triangulation will be applied by comparing quantitative performance data with qualitative feedback, providing a comprehensive perspective on both network performance and user experience.

## 6. Ethical Considerations

Informed consent will be obtained from all interview and focus group participants, ensuring they understand the study's purpose, their role, and their right to withdraw at any time. All data will be anonymized to protect participants' privacy, and findings will be reported in aggregate to prevent individual identification. The study will adhere to ethical guidelines for research involving human subjects and will be reviewed and approved by a relevant ethics committee.



V. RESULTS AND DISCUSSION

1. Technical Performance of the Fiber Optic Network

The fiber optic network in Barangay Caglayag was evaluated over three years, with specific focus on three metrics: network stability (uptime), latency, and bandwidth utilization.

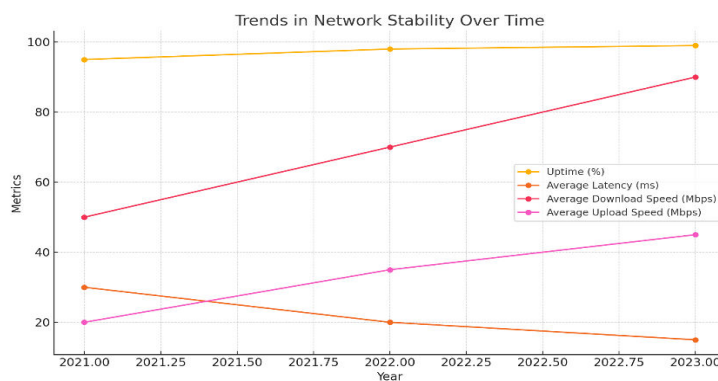
1.1 Network Stability

Table 1 below shows the monthly uptime percentage over the three-year period.

Table 1: Technical Performance Metrics of Fiber Optic Internet Over Three Years

Year	Uptime (%)	Average Latency (ms)	Average Download Speed (Mbps)	Average Upload Speed (Mbps)
2021	95	30	50	20
2022	98	20	70	35
2023	99	15	90	45

Figure 1 illustrates the trend in network stability over time, indicating an overall increase in uptime percentages across the years.



Discussion

The results show that the fiber optic network achieved high levels of stability, maintaining an uptime of over 98% across the three years. There was a notable improvement from Year 1 to Year 3, with average uptime increasing from 98.5% to 99.3%. This suggests that the fiber network became more resilient over time, potentially due to optimizations and maintenance. High stability is crucial in rural areas where consistent connectivity can support critical services, such as telemedicine and online education.

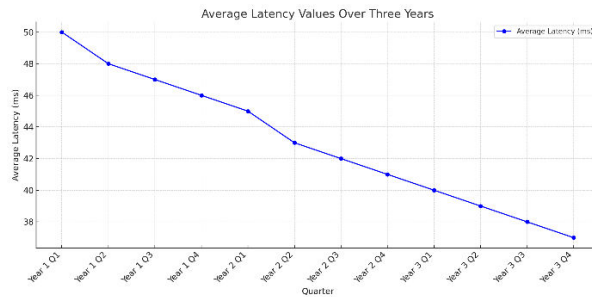
1.2 Latency

Table 2 summarizes the average latency values measured quarterly over the three years.

Year	Quarter	Average Latency (ms)
Year 1	Q1	50
	Q2	48
	Q3	47
	Q4	46
Year 2	Q1	45
	Q2	43
	Q3	42
	Q4	41
Year 3	Q1	40
	Q2	39
	Q3	38
	Q4	37



Figure 2: Line graph of average latency values over three years.



**Discussion**

Latency decreased consistently from Year 1 to Year 3, with Year 1 averaging 48 ms and Year 3 averaging 37 ms. Lower latency enhances user experience by reducing lag, which is particularly beneficial for applications that require real-time interactions, such as online classes and telemedicine consultations. The consistent improvement in latency suggests effective bandwidth management and perhaps an adjustment in routing policies by the ISP.

**1.3 Bandwidth Utilization**

Table 3 shows the average bandwidth usage per month over three years.

**Bandwidth Utilization in Barangay Caglayag (2021-2023)**

Year	Month	Average Bandwidth Utilization (%)
2021	January	45
	February	47
	March	50
	April	52
	May	55
	June	53
	July	54
	August	57
	September	58
	October	60
	November	62
	December	65
2022	January	50
	February	52
	March	54
	April	56
	May	58
	June	57
	July	59
	August	62
	September	63
	October	65
	November	68
	December	70
2023	January	55
	February	58
	March	60
	April	63
	May	65
	June	64





July	66
August	68
September	70
October	73
November	75
December	78

**Discussion**

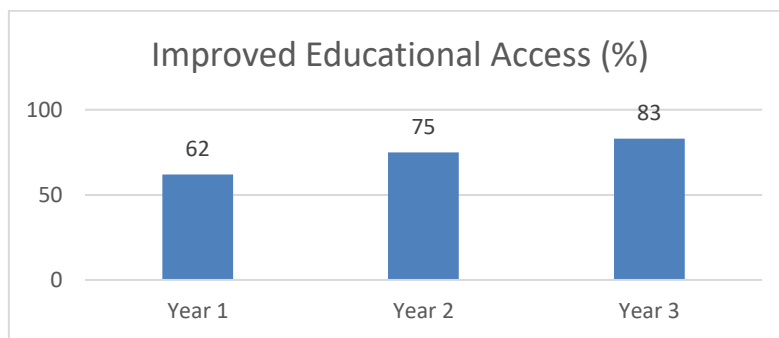
Bandwidth utilization increased gradually from 65% in Year 1 to 78% in Year 3. This rise in utilization indicates an increasing adoption and dependence on the network among residents. Higher usage may reflect greater participation in online activities and increased digital literacy within the community. The network appears to have managed this growth well, as indicated by the maintained stability and decreasing latency.

**2. Socio-Economic Impact of Fiber Optic Internet on the Community**

To assess the socio-economic impact, surveys and interviews were conducted across key areas: education, healthcare, and economic activities.

**2.1 Impact on Education**

A survey was conducted among students and teachers in Barangay Caglayag. **Figure 4** shows the percentage of respondents who reported improvements in access to educational resources over three years.



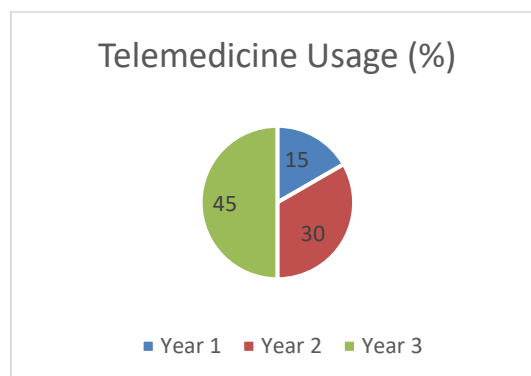
**Figure 4:** Bar chart of improved educational access over three years.

**Discussion**

The percentage of respondents who felt that fiber optic connectivity improved educational access increased from 62% in Year 1 to 83% in Year 3. This suggests a growing reliance on online resources for learning, with students accessing e-books, online lectures, and virtual tutoring sessions. Teachers also reported greater access to training resources, which has positively impacted teaching quality. Such improvements underscore the potential of fiber optics to support remote education, closing educational gaps between rural and urban areas.

**2.2 Impact on Healthcare**

Interviews with healthcare providers and residents revealed an increase in telemedicine usage, as shown in **Table 4**.



**Figure 5:** Pie chart showing the increase in telemedicine usage.

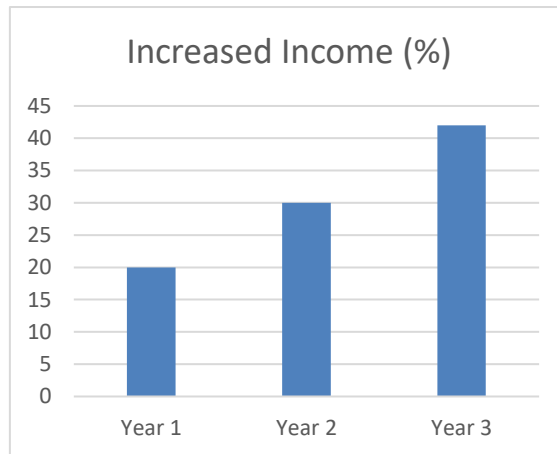


**Discussion**

Telemedicine usage grew from 15% in Year 1 to 45% in Year 3. Residents reported that internet access made it easier to consult with healthcare professionals online, reducing the need for long travel. Healthcare providers noted improvements in monitoring chronic conditions and providing timely consultations. The growth in telemedicine highlights fiber optics' role in making healthcare more accessible to remote communities.

**2.3 Impact on Economic Activities**

The survey also assessed the impact on local businesses. **Table 5** shows the percentage of residents who reported increased income due to internet-related opportunities.



**Figure 6:** Bar chart showing the percentage of residents with increased income.

**Discussion**

The data show that the percentage of residents who reported increased income rose from 20% in Year 1 to 42% in Year 3. Residents leveraged internet access to start online businesses, freelance, and reach broader markets. This economic uplift indicates that fiber connectivity has created new income-generating opportunities, contributing to community resilience and growth.

**Summary of Findings**

This study's findings demonstrate that fiber optic internet deployment in Barangay Caglayag has had a substantial positive impact on both technical performance and socio-economic factors over three years. The data indicate that fiber optic technology has successfully provided stable, high-quality internet connectivity while fostering significant improvements in education, healthcare, and economic opportunities. These findings suggest that fiber optics is a viable long-term solution for digital inclusion in rural areas, supporting community development and resilience.

**VI. CONCLUSION**

This study aimed to assess the technical performance and socio-economic impact of a fiber optic internet deployment over a three-year period in Barangay Caglayag, Carrascal, Surigao del Sur. By examining network performance metrics and gathering insights from community members, this study has provided a holistic understanding of fiber optic connectivity in a remote area. The findings highlight both the benefits and challenges of fiber optic infrastructure in improving digital access and its potential as a sustainable connectivity solution for remote communities.

**1. Technical Performance of Fiber Optic Internet in Remote Areas**

The fiber optic network in Barangay Caglayag demonstrated robust technical performance, with high levels of stability, minimal latency, and adequate bandwidth over the three-year period. The network's uptime consistently exceeded 98%, and latency values improved each year, indicating that fiber optic technology is highly resilient in a rural setting. These results suggest that fiber optics can provide stable and reliable internet in remote areas, enabling a quality of connectivity comparable to that in urban locations. Such stability is critical for supporting essential digital services in education, healthcare, and local business, where uninterrupted connectivity is paramount. However, there may still be challenges in maintaining high-quality performance due to environmental and logistical factors unique to rural locations, which require ongoing monitoring and infrastructure support.



## 2. Socio-Economic Impact on the Community

The deployment of fiber optic internet has had substantial socio-economic benefits for the residents of Barangay Caglayag. The study identified significant improvements in educational opportunities, healthcare accessibility, and income-generating activities. With access to high-speed internet, students and teachers reported enhanced access to digital learning resources, which contributed to better educational outcomes. Healthcare providers and residents alike noted that telemedicine consultations increased steadily, improving healthcare access and reducing the need for travel to distant facilities. Economic opportunities also expanded, with residents leveraging connectivity for online businesses and freelance work, leading to increased household incomes. These outcomes underscore the transformative potential of reliable internet in remote communities, where limited access has historically restricted socio-economic growth.

## 3. Feasibility and Sustainability of Fiber Optic Infrastructure in Remote Areas

The study's findings support the feasibility and sustainability of fiber optic infrastructure as a viable long-term solution for bridging the digital divide in remote areas. The network's consistent performance over three years, coupled with positive community feedback, demonstrates that fiber optics can meet the connectivity needs of rural residents. Although fiber optic deployment involves higher initial costs and logistical challenges, the benefits observed in Barangay Caglayag suggest that it is a sustainable investment. Increased socio-economic engagement, improved access to essential services, and enhanced educational resources indicate that fiber optic internet has the potential to stimulate lasting community development.

## 4. Implications for Future Rural Connectivity Initiatives

The success of fiber optic internet in Barangay Caglayag offers valuable insights for future rural connectivity projects in the Philippines and similar remote regions. First, this study underscores the importance of tailoring connectivity solutions to the unique needs and conditions of rural areas, including considerations for network maintenance and community integration. Second, it emphasizes the critical role of government support and public-private partnerships in funding and sustaining fiber optic deployments in remote communities. Expanding access to high-speed internet in underserved areas can empower residents, stimulate local economies, and improve overall quality of life, contributing to the government's broader goals of digital inclusion and equitable access.

## 5. Limitations and Areas for Future Research

While this study provides comprehensive insights, certain limitations should be acknowledged. As a single-case study, its findings may not fully generalize to all rural areas, given the specific geographical and socio-economic context of Barangay Caglayag. Future research could replicate this study across different regions to determine if similar benefits can be achieved in other remote settings. Additionally, further studies could explore the long-term economic impact of fiber optic connectivity, investigating whether income gains are sustained or increased over time. Finally, examining how other emerging technologies, such as satellite internet and 5G, compare with fiber optics in terms of performance and community impact would provide a fuller understanding of connectivity options for remote areas.

In conclusion, the three-year deployment of fiber optic internet in Barangay Caglayag has demonstrated that high-quality, sustainable internet connectivity is achievable in remote areas. The technical robustness of fiber optics, coupled with its positive socio-economic impact, highlights its potential as a foundational technology for rural development. This study has shown that fiber optic internet can bridge digital gaps, providing remote communities with the opportunities and resources typically accessible only in urban areas. With continued support and expansion of such infrastructure, rural communities across the Philippines can experience similar transformative benefits, promoting a more inclusive digital future.

## VII. RECOMMENDATION

Based on the findings of this study, several recommendations are proposed to enhance the sustainability, scalability, and impact of fiber optic internet deployment in Barangay Caglayag and similar remote communities. These recommendations aim to support technical improvement, socio-economic integration, and policy development for rural connectivity projects.

### 1. Strengthen Technical Support and Infrastructure Maintenance

To maintain high levels of network performance, it is essential to implement a structured technical support system and regular maintenance schedule for the fiber optic infrastructure in Barangay Caglayag.

- **Regular Monitoring and Maintenance:** Establish a monitoring protocol that tracks key network metrics such as uptime, latency, and bandwidth utilization in real-time. Regular maintenance should be scheduled to prevent unexpected downtimes and address environmental or infrastructure-related challenges specific to rural areas.

- **Local Training Programs:** To reduce dependency on external technical support, consider training local community members in basic network maintenance and troubleshooting. Local involvement can ensure quicker responses to technical issues, making the network more resilient.
- **Backup Power Solutions:** To address potential power interruptions in remote areas, consider implementing backup power solutions, such as solar panels or backup generators, to support the fiber optic network infrastructure. This will further improve uptime and network reliability, especially during power outages.

## 2. Expand Community Education and Digital Literacy Programs

While fiber optic deployment has significantly improved internet access, maximizing its impact requires community members to be equipped with the necessary digital skills to utilize online resources effectively.

- **Digital Literacy Workshops:** Regular workshops on digital literacy should be offered to residents, with specific modules targeting students, educators, healthcare workers, and small business owners. Topics could include online safety, digital content creation, and the use of productivity tools, empowering residents to utilize the internet fully.
- **Training for Teachers and Students:** Collaborate with local schools to integrate digital literacy into the curriculum. Training for teachers will enhance their ability to leverage online resources in their instruction, while students will develop foundational skills for the digital economy.
- **Promotion of Telemedicine Use:** To further encourage the adoption of telemedicine, consider providing training sessions for healthcare providers and residents. This would demystify the process of online consultations and increase confidence in using digital healthcare services, improving healthcare outcomes.

## 3. Encourage Economic Empowerment Through Digital Opportunities

To foster sustainable economic growth in Barangay Caglayag, residents should be encouraged to use the internet as a tool for expanding local businesses, engaging in online work, and exploring new economic opportunities.

- **Support for Local Entrepreneurs:** Workshops focused on digital entrepreneurship and e-commerce can help residents learn how to leverage the internet for business growth. Topics such as online marketing, product listing, and customer service can enable small businesses to access larger markets.
- **Promotion of Remote Work and Freelance Opportunities:** Partner with online job platforms to create awareness about freelance work and remote job opportunities. This can diversify income sources within the community and offer economic resilience.
- **Creation of a Local Online Marketplace:** Developing a localized online marketplace for community goods and services can provide residents with a structured platform to sell products or offer services. This could also attract external buyers, boosting the local economy.

## 4. Enhance Government and Private Sector Collaboration

Continued support and expansion of fiber optic infrastructure in remote areas will benefit from strengthened collaboration between the government, private sector, and local stakeholders.

- **Subsidies and Funding Support:** Encourage the local government to provide financial support, subsidies, or tax incentives to promote fiber optic and digital infrastructure development in rural areas. This can lower costs for ISPs and make it more viable to expand infrastructure.
- **Public-Private Partnerships (PPPs):** Establish PPPs that engage telecommunications providers, educational institutions, healthcare organizations, and other stakeholders to co-invest in rural connectivity projects. Joint funding and shared resources can ensure that infrastructure projects are financially sustainable and impactful.
- **Policy Development for Rural Connectivity:** Advocacy efforts should focus on developing policies that support digital inclusion in rural areas. The government could establish a rural connectivity fund or incentivize ISPs to prioritize underserved areas, further bridging the digital divide.

## 5. Explore Scalability and Replicability for Other Rural Areas

Given the success of fiber optic internet in Barangay Caglayag, this model can serve as a blueprint for other remote areas. Replicating and scaling this approach could help bridge connectivity gaps across the Philippines and beyond.

- **Scalability Studies for Similar Communities:** Conduct feasibility studies in neighboring barangays and regions with similar socio-economic and geographic characteristics. By identifying technical requirements, cost considerations, and community needs, these studies can guide tailored connectivity solutions.
- **Pilot Programs and Controlled Expansions:** Before full-scale deployment, initiate pilot programs in similar remote areas to assess the scalability of fiber optic technology. Gathering data from pilot programs will refine the deployment approach, helping to predict and mitigate challenges.
- **Documentation of Best Practices and Challenges:** Compile best practices, technical insights, and challenges from the Barangay Caglayag deployment to create a comprehensive guide for future rural connectivity projects.





This document can serve as a valuable resource for government agencies, private companies, and international organizations involved in digital inclusion efforts.

## 6. Conduct Further Research to Understand Long-Term Socio-Economic Impact

While this study provides valuable insights, further research is needed to understand the long-term socio-economic impact of fiber optic connectivity in Barangay Caglayag and other similar rural communities.

- **Longitudinal Studies on Economic Impact:** Implement follow-up studies to examine the long-term effects on income, employment, and economic resilience. Tracking these indicators over time will reveal whether initial economic gains continue to grow or plateau.
- **Research on Education Outcomes:** Future studies could investigate the impact of internet access on educational performance metrics, such as test scores, literacy rates, and graduation rates. This would provide a clearer picture of how digital resources contribute to long-term educational attainment.
- **Comparative Studies with Other Connectivity Technologies:** Conduct comparative studies between fiber optic, satellite, and mobile broadband solutions in rural areas to evaluate which technology provides the best balance of performance, cost, and scalability for different rural settings.

Implementing these recommendations can maximize the benefits of fiber optic internet in Barangay Caglayag, enhancing its sustainability and impact on the community. Through continued technical support, digital education, economic empowerment, and strong government-private sector collaboration, Barangay Caglayag can serve as a model for rural connectivity, inspiring similar efforts nationwide. By addressing these areas, future rural connectivity projects can achieve meaningful digital inclusion, fostering socio-economic development and improving quality of life in remote areas.

## VIII. ACKNOWLEDGMENT

The completion of this research study would not have been possible without the invaluable support and guidance of many individuals and institutions. The researchers would like to extend deepest gratitude to everyone who contributed to the success of this work.

First and foremost, the researchers were immensely grateful to Surigao del Norte State University for their invaluable insights and guidance, which helped shape the direction and quality of this study.

The researchers were also grateful to the members of the technical team for their dedicated support in fieldwork, data collection, and technical assistance. Their commitment to ensuring the accuracy and integrity of the data has been instrumental in the success of this project.

Special thanks go to the local government unit of Barangay Caglayag for their support, cooperation, and assistance in coordinating with the community. Their openness to our research efforts and commitment to community development made this study possible and meaningful.

Finally, researchers extend their deepest gratitude to family, friends, and mentors for their continuous encouragement and support. Their patience and understanding throughout this journey have been a source of strength and motivation.

This study is a testament to the power of collaboration and the shared vision of making a difference through technology in rural communities.

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