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Community network as a solution to unequal internet access to education

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Abstract

The digital divide in internet access has posed a significant challenge to advancing education worldwide, particularly in 3T regions—remote, frontier, and underdeveloped areas—where internet connectivity is often limited or entirely unavailable. This paper examines the negative impact of unequal internet access on the education sector. To address this challenge, the concept of community networks has emerged as a promising solution. These networks actively involve local communities in the planning, implementation, and maintenance of network infrastructure. By doing so, community networks not only provide more equitable and affordable internet access but also promote digital inclusion by empowering communities to manage their resources. Additionally, this paper highlights successful examples of community network initiatives from around the world, including projects in developing nations and remote areas within developed countries. These case studies underscore the potential of community networks as a viable solution to bridge the internet access gap in education. By evaluating the benefits, challenges, and opportunities associated with these networks, this paper offers valuable insights into their effectiveness in enhancing educational access and quality. It also strengthens the argument for the importance of inclusive and equitable education globally in this digital era.

Keywords: Digital Divide; Community Networks; Internet Access; Inclusive Education; Digital Inclusion

1. Introduction

In Indonesia, internet access has become a critical factor in enhancing the quality of education and bridging gaps between urban and rural areas. However, the persistent digital divide, particularly in the 3T regions (Terdepan, Tertinggal, and Terluar), poses significant challenges to achieving equitable and high-quality education across the nation. Students in these areas struggle to access online learning materials, teachers face limitations in delivering remote education, and educational institutions encounter difficulties in integrating technology into their learning processes [1].

To address these challenges, the concept of Community Networks has emerged as a promising solution. By actively involving local communities in the construction, management, and maintenance of Internet infrastructure, Community Networks enable more equitable and affordable Internet access for all. These networks not only provide connectivity but also empower communities to improve education quality in 3T regions through local collaboration [2].

Several countries, such as South Africa, Argentina, and Malaysia [3], have successfully implemented Community Network models to address their internet access gaps. These examples illustrate the potential of Community Networks to overcome local challenges and bridge digital divides. In Indonesia, understanding the impacts of unequal internet access, exploring the possibility of Community Networks, and learning from international implementations can guide the development of effective strategies to enhance nationwide access to quality education. These findings align with broader systematic reviews, which underline the role of government and institutional support in bridging this gap.

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2. Material and methods

2.1. Internet

The Internet is a global network that connects various devices worldwide, enabling effective communication and information sharing. This network is supported by different physical infrastructures such as fiber optic cables, copper wires, satellites, and wireless connections, which transmit data through standardized communication protocols, primarily the Internet Protocol (IP) and Transmission Control Protocol (TCP) [4].

The Internet operates through a network of protocols that link computers and manage network traffic. These protocols handle data formats, error handling, message routing, and other communication standards. The fundamental protocols used on the internet are TCP/IP, which work across diverse computer systems without interference from hardware or operating system differences. A domain name and a unique IP address in numeric form identify each computer connected to the network. The internet also includes gateways to other networks that may use different protocols.

The most well-known part of the internet is the World Wide Web (WWW), which consists of billions of web pages accessed via web browsers. Additionally, the Internet provides services like email, file transfers, media streaming, and social media. The IP addressing system and Domain Name System (DNS) ensure efficient communication between devices. With advanced security mechanisms to protect data and privacy, the Internet has become integral to modern life, revolutionizing communication, work, education, and access to information.

The Internet offers several benefits, including fast and easy access to global information, instant communication through email, instant messaging, and video calls, and abundant resources for learning and research. It also supports e-commerce, enabling online shopping, digital banking, and other services that enhance efficiency and convenience. However, there are drawbacks, such as security and privacy risks, including hacking, identity theft, and malware. Additionally, the spread of misinformation or fake news can be misleading and harmful. Overreliance on the Internet may also reduce face-to-face social interactions and lead to health issues associated with sedentary lifestyles [5].

2.2. Education

Education is a process that involves the development of knowledge, skills, values, and attitudes through various methods such as teaching, training, research, and discussions. It is not limited to formal learning in schools or universities but also includes informal experiences gained through daily interactions and self-directed learning. The primary goal of education is to empower individuals to think critically, solve problems, and contribute positively to society. Furthermore, education plays a key role in shaping character, broadening perspectives, and preparing individuals for challenges in both the workforce and life in general. Thus, education serves as the foundation for personal and societal advancement.

The internet has significantly transformed the way education is delivered and received, enabling quick and efficient access to information and educational resources worldwide. Through e-learning platforms, online courses, and digital resources such as instructional videos, articles, and e-books, the Internet allows students and educators to access knowledge without geographical constraints. Moreover, the Internet supports collaboration and communication between students and teachers through email, discussion forums, and video conferencing applications, enriching the learning experience. In this way, the internet not only broadens the reach of education but also introduces more flexible and interactive learning methods, making education more inclusive and adaptable to the needs of modern times [6].

Thus, education is an effort to teach students to understand concepts and to shape them into individuals capable of critical thinking.

2.3. 3T (Frontier, Left Behind, and Outermost)

The 3T (Frontier, Left Behind, and Outermost) areas in Indonesia are regions that face significant limitations in accessing basic services such as healthcare, education, transportation, economy, and internet connectivity. These areas are characterized by economic and social backwardness, limited infrastructure, high poverty rates, and very limited healthcare and educational services.

These regions are also situated far from administrative centers or major urban areas, making them difficult to reach and develop. The challenging geographic conditions, along with isolation, especially in border areas between Indonesia and neighboring countries, further complicate efforts for development.

The 3T areas are identified based on criteria such as economy, society and human resources, infrastructure, and regional financial capacity. They encounter various issues like poor accessibility, low-quality education, and limited internet access. Therefore, efforts are needed to improve and enhance the quality of life for communities in these areas to foster well-being and regional progress. According to Presidential Regulation No. 63 of 2020 on the Designation of Underdeveloped Areas for 2020-2024, 62 districts fall into this category, including Nias (North Sumatra), Mentawai Islands (West Sumatra), North Musi Rawas (South Sumatra), North Lombok (West Nusa Tenggara), Central Sumba & Alor (East Nusa Tenggara), Donggala (Central Sulawesi), Talibau Island (North Maluku), Nabire & Asmat (Papua), and Teluk Wondama & Pegunungan Arfak (West Papua) [7].

According to data from the Central Bureau of Statistics (BPS), internet access in Indonesia was still uneven as of 2022. This data can be seen in the proportion of villages/urban areas with mobile phone signals and signal reception strength by island for 2020 and 2021. The data highlights that in Eastern Indonesia, particularly in Maluku and Papua, nearly 40% of the regions still lack signal reception.

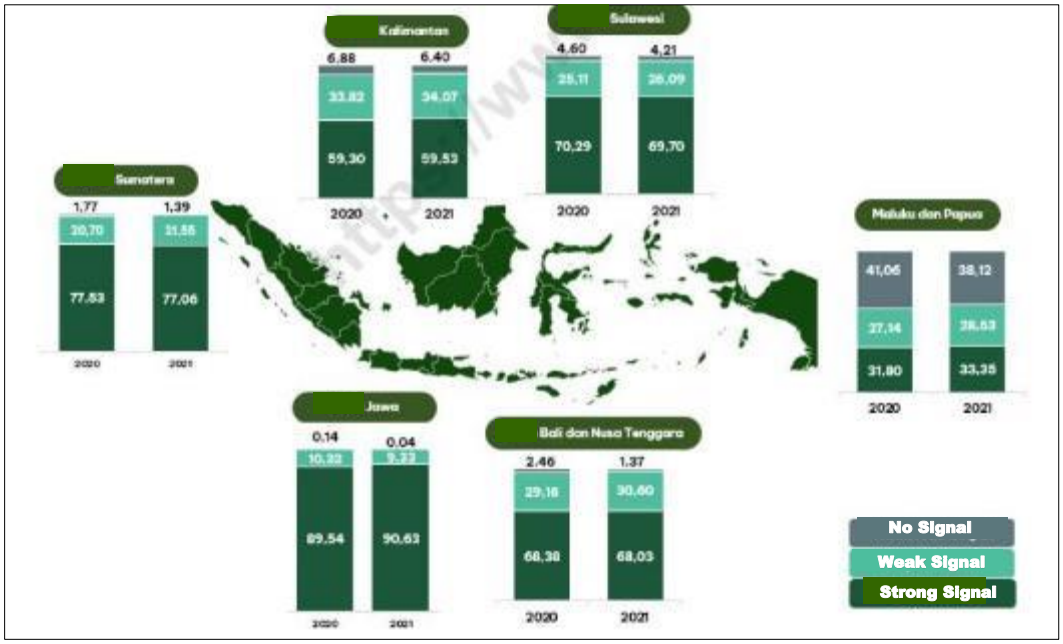

Figure 1 Mobile phone ownership data in 2022

This distribution then also affects internet access data in Indonesia. The following data shows the percentage of the population aged 5 years and over who have accessed the internet in 2022.

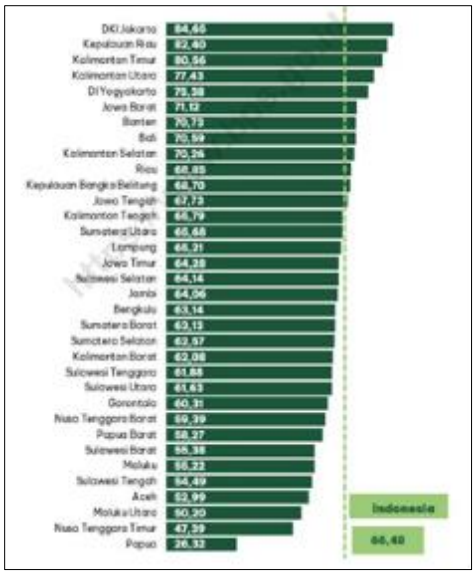

Figure 2 Internet access data for residents aged 5 years and over from BPS

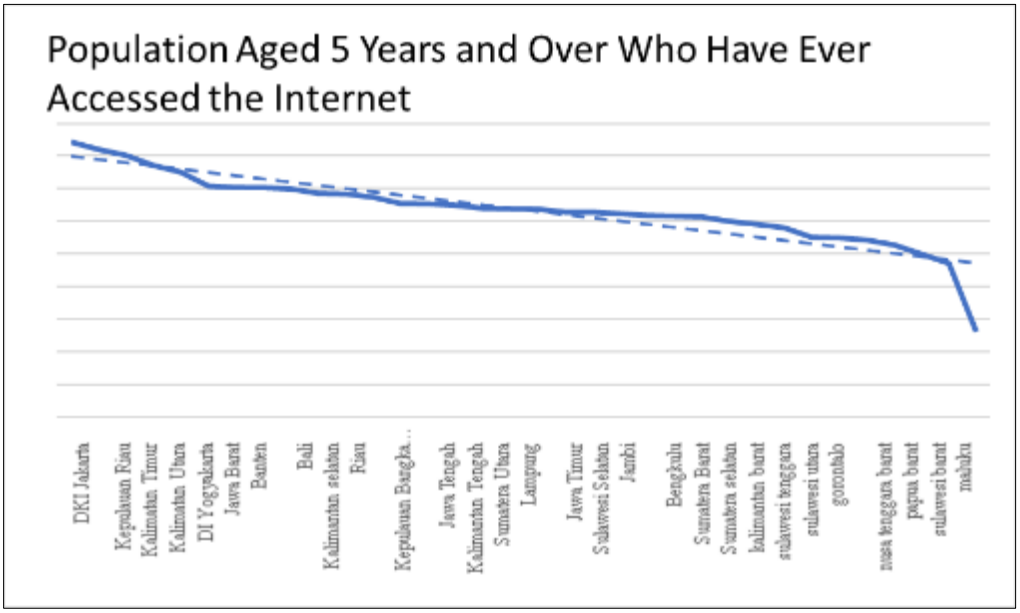

Figure 3 Population Distribution that Accessed the Internet

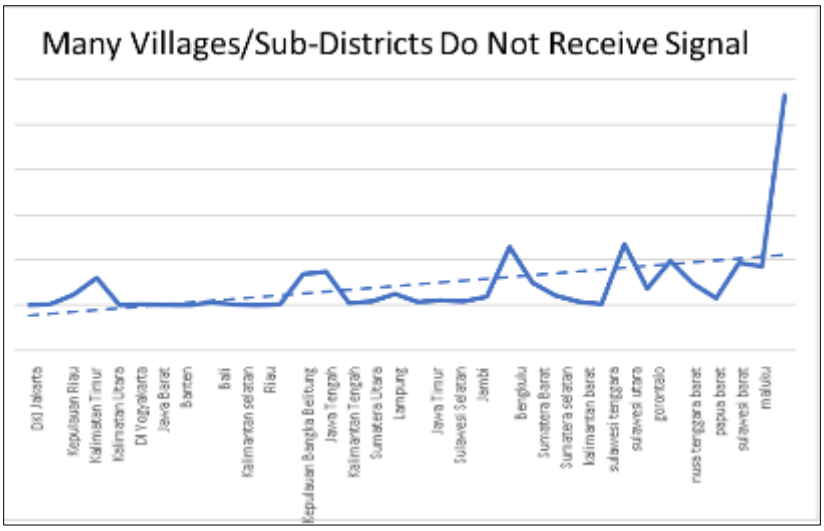

Figure 4 Village Distribution that has not Received Signal

The graph above proves the influence of the relationship between the percentage of the population aged 5 years and over who have accessed the Internet and the number of villages/sub-districts that do not receive a signal. The data above shows an inverse relationship, so it can be understood that the percentage of accessing the internet is still low because the area still has difficulty receiving a signal.

The regions experiencing significant challenges in receiving signals are primarily located in eastern Indonesia, particularly Papua, which includes many areas categorized as 3T (Outermost, Frontier, and Disadvantaged). Among all provinces and islands in Indonesia, Papua stands out as having the highest number of 3T areas, with 30 districts falling into this category [8].

According to the Central Statistics Agency's 2021 village potential data survey, only 39,062 out of 84,096 villages/sub-districts in Indonesia had BTS towers within their vicinity. This existing condition leaves 45,034 villages/sub-districts without such infrastructure.

This digital divide has a profound impact on education, creating disparities in learning outcomes between students in areas with reliable internet access and those in underserved regions. Socio-economic challenges, limited human resource development, and unequal access to educational facilities drive the poor quality of education in 3T areas. Students in regions with internet access benefit from enhanced learning opportunities through access to online materials and connectivity tools, which significantly aid their educational journey. Conversely, the lack of internet in many areas exacerbates educational inequality, with noticeable gaps in school attendance and progression. This disparity is evident in the comparison of 2021/2022 data showing the percentage of the population aged five and older who accessed the internet versus the percentage of elementary school graduates who advanced to junior high school [9].

3. Results and discussion

3.1. Community Network Example

As a student, one potential solution to address this issue is to establish a Community Network. A Community Network is an independent network built by a local community to provide internet access or other communication services managed by the community. These networks are designed, operated, and owned by non-governmental organizations and can collaborate with communities, governments, and other partners. The main advantage of Community Networks is their ability to provide more affordable internet access, helping to bridge the digital divide, especially in remote or marginalized areas that are challenging for commercial service providers to reach.

Community Networks have been successfully implemented in several countries, including Spain, Mexico, and South Africa. They have proven effective in reducing the digital divide, lowering communication costs, and creating job opportunities. One example of a successful Community Network is Guifi.net in Spain. It leverages fiber optic and wireless networks, supported by contributions from community members, to build and maintain the network. Over 15 years,

Guifi.net has developed more than 35,000 network nodes spanning thousands of kilometers of fiber optic and wireless networks, serving the needs of over 80,000 people.

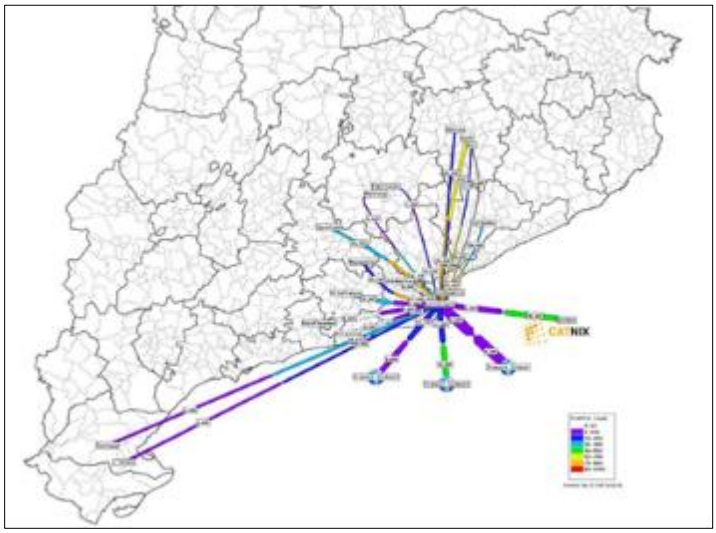

Figure 5 Network Map from Guifi.net

Guifi.net operates using an open, collaborative, and non-profit organizational model. Community members actively participate in building and maintaining parts of the network, embodying the network's core principles. This approach has enabled Guifi.net to deliver affordable and high-quality internet access to thousands of individuals in both rural and urban areas who face challenges in obtaining reliable internet connectivity. By 2021, Guifi.net had established over 35,000 network nodes, spanning thousands of kilometers of fiber optic and wireless infrastructure. Research conducted by the Institut Català de Recerca en Tecnologies de la Informació i les Comunicacions (i2CAT) highlights Guifi.net's significant impact in bridging the digital divide and boosting the local economy in Catalonia.

Figure 6 Community contributions to the development of the Rhizoamtica network

Another example is Rhizomatica in Mexico, which leverages low-cost GSM technology to deliver telecommunications services in rural areas. Rhizomatica enables the creation of community-managed cellular networks using affordable GSM technology. By 2020, the organization had supported the establishment of over 20 community networks in Mexico, serving more than 3,500 people. Rhizomatica collaborates with indigenous and rural communities, providing technical training and regulatory assistance to empower them to manage their networks.

In Oaxaca, Rhizomatica is helping communities develop micro-telecommunications networks that are both owned and operated locally. These networks use OpenBTS technology, significantly reducing installation costs to approximately $2,500. The system operates on the 850 MHz frequency spectrum to connect users within the network, with internet connectivity provided via Protocol, which also routes external calls through VoIP. According to the Alliance for Affordable Internet (A4AI), Rhizomatica's efforts have lowered communication costs in the communities it serves by up to 98%.

Figure 7 Zenzeleni Network Infrastructure

Zenzeleni Networks in South Africa employs a cooperative model to distribute internet access in rural villages, utilizing Wi-Fi and other wireless technologies. This approach ensures that the network is owned and operated by the community, following the principle of "by the community, for the community." Profits generated are reinvested into improving infrastructure and community services. Zenzeleni Networks has successfully connected over 13,000 people and ten institutions in several villages across the Eastern Cape province, offering internet services at significantly lower costs—around 20% of what major telecommunications operators charge. This affordability has expanded educational and economic opportunities for residents. According to an evaluation by the Internet Society, Zenzeleni Networks has not only increased internet access but also empowered local communities by providing training and creating job opportunities.

Reflecting on the success of Zenzeleni Networks, along with other Community Networks like Rhizomatica and Guifi.net, it becomes evident that such a system could be effectively implemented in Indonesia, particularly in 3T (Outermost, Frontier, and Disadvantaged) areas. These regions, often inaccessible to commercial service providers or government infrastructure, could benefit greatly from a Community Network model to address the inequality of internet access. The reasons Community Networks are suitable for Indonesia include:

1. Diverse Geography: Many remote areas in Indonesia are challenging to reach with conventional internet infrastructure.
2. Digital Divide: There is a significant gap in internet access between urban and rural regions.
3. Local Initiatives: Indonesian communities have a strong spirit of cooperation, making them ideal partners in network development.
4. Community Empowerment: Community Networks offer opportunities for local communities to gain skills in managing and maintaining their networks.

3.2. Implementation of Community Networks in Indonesia

To address the internet access gap impacting education, Community Networks can prioritize 3T areas. These networks require a primary source of internet (backhaul), which can be legally acquired by purchasing capacity from large ISPs or utilizing satellite internet connections. Collaboration with communities, governments, and partners is crucial for securing permits, funding, and technical support.

Once the internet source is established, the connection can be distributed throughout the community using wireless technologies, mesh networks, or fiber optics for greater stability. Access points should be strategically installed in locations such as schools, community centers, and public spaces to ensure widespread connectivity. Regular maintenance is essential to ensure the network remains functional, with a dedicated community team responsible for its upkeep.

Educating the local community about the installation, maintenance, and productive use of the Internet is vital for ensuring the network's sustainability and maximizing its benefits. This sustainability includes understanding how to utilize the internet for educational purposes, enabling the Community Network to improve the quality of education in 3T areas significantly.

3.3. Benefits of Internet Access for Education in 3T Areas

Access to Quality Resources: The internet provides diverse educational materials that might not be locally available. Students in 3T areas can benefit from e-learning platforms and resources comparable to those in urban areas, reducing educational disparities.

Teacher Development: Teachers in 3T areas can access online courses, webinars, and professional communities to enhance their skills and teaching quality.

Mentoring Programs: The internet facilitates remote mentoring and tutoring, connecting students in 3T areas with mentors and tutors for academic guidance and support.

Dissemination of Innovations: The internet enables rapid sharing of the latest educational tools and methods, ensuring schools in 3T areas remain updated with modern practices.

Government programs and non-profit initiatives can use internet connectivity to efficiently deliver innovative learning solutions to schools in 3T areas, helping bridge the educational gap and improving outcomes for students in these regions.

4. Conclusion

In Indonesia, the distribution of mobile phone ownership and internet access remains uneven. This disparity is largely due to population density, which is heavily concentrated on the island of Java, leading to infrastructure development being prioritized in that region. As a result, educational attainment is also unequal, as reflected in the lower rates of elementary school graduates progressing to junior high school in 3T (Outermost, Frontier, and Disadvantaged) areas compared to Java.

To address this issue, establishing a Community Network offers a viable solution. This system can help bridge the gap in internet access across Indonesia, contributing to improved educational opportunities nationwide. Implementing Community Networks in 3T areas with a well-planned approach and sufficient support can leverage local community initiatives and the strong spirit of cooperation. By doing so, these networks can reduce the digital divide and enhance the quality of education for people in remote regions.

Compliance with ethical standards

Disclosure of conflict of interest

The author(s) declares no conflict of interest.

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