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From Telecentres, Community Networks To Sustainable Smart Villages and Smart Islands

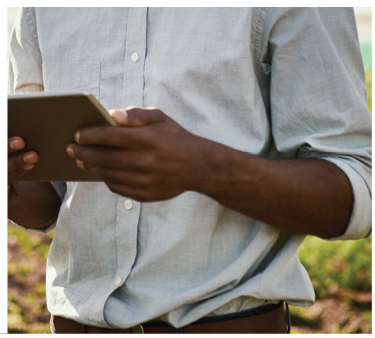
Case Studies









Internet Society

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Foreword

Digital transformation is key to achieving socio-economic development.

Efforts made by the ITU Telecommunication Development Bureau (BDT) to connect the unconnected with voice, data, and access to digital services have been ongoing for decades through pioneering efforts around telecentres and community networks. While they have continued to play a significant role in benefiting rural and remote communities, sustainability has remained a key challenge.

As we now move towards an integrated whole-of-government, whole-of-society approach through initiatives such as smart villages and smart islands, experiences from telecentres and community networks provide valuable insights to learn from and adopt.

This report undertakes a review of telecentre and community networks and examines sustainability across the six dimensions of financial sustainability, sociocultural sustainability, organisational sustainability, operational sustainability, policy sustainability and environmental sustainability. Ten telecentre and community network case studies from India, Indonesia, Kiribati, Malaysia, Papua New Guinea, Thailand, and Vanuatu have been analysed, and the sustainability dimensions applied to provide practical insights.

The learnings and recommendations in the report are designed to guide governments, industry, development agencies, civil society, and other stakeholders in embedding good practices in their digital programmes and projects and enhancing their sustainability.

Cosmas Luckyson Zavazava
Director of Telecommunication Development Bureau
International Telecommunication Union

Foreword

Bringing people online has always been a cornerstone of the Internet Society's work. Today, connecting people who are still offline demands greater creativity, commitment, and collaboration – because they live beyond the geographic or business reach of traditional last-mile connectivity models.

Connectivity gaps persist not only due to disparities in infrastructure and technology, but also because of socioeconomic barriers such as affordability, digital literacy, and local challenges. As a result, those most impacted by the digital divide are often people who are already more likely to be marginalized, including women, Indigenous peoples, and the forcibly displaced.

The 10 case studies in this report highlight the important role that the Internet plays in advancing all 17 of the United Nations Sustainable Development Goals (SDGs), particularly in improving access to the global economy and education. They also offer essential, practical advice for communities living in remote villages and islands that goes beyond basic connectivity, including how to enhance affordability and digital skills, so that the newly connected can reap the full benefits of the Internet.

Crucially, the report finds that successful telecentres, community networks, and smart villages all share one key characteristic: strong community participation and ownership. This community-centered approach is critical for delivering last-mile connectivity and ensuring long-term success. Participation helps tailor the solution to a community's unique needs, while ownership ensures that the network is maintained long after it is first deployed.

The Internet Society applauds the ITU's whole-of-government, whole-of-society approach to providing sustainable connectivity in remote islands and village communities. It is the exact kind of creativity, commitment, and collaboration that will help us bring the hardest-to-reach communities online, at last.

Sally Wentworth
President and CEO of the Internet Society
and the Internet Society Foundation

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Executive summary

Expanding broadband connectivity and digital services supports the achievement of all 17 Sustainable Development Goals (SDGs). However, significant disparities in broadband coverage and the use of digital services persist within and between nations, amplifying inequalities, undermining sustainable development, and potentially leading to many being left behind as economies experience digital transformation. According to the ITU Facts and Figures 2025, there are 2.2 billion people offline[1]. Outside of the Africa region, most of these people live in the Asia and the Pacific region. While there has been a notable increase in mobile broadband accessibility in this region with active mobile broadband subscriptions reaching 101 per cent by 2025, there are still many countries where the population connectivity rates remain at under 50 per cent. There are also gender and rural-urban digital divides that need to be addressed to ensure that "no one is left behind". As digital transformation progresses in the public and private sectors, those without connectivity will be increasingly marginalized and left behind and so will miss out on the benefits of digital services.

To close these digital connectivity gaps and build more digitally inclusive economies where everyone can benefit from access to digital services, International Telecommunication Union (ITU) has developed the Smart Villages and Smart Islands initiative. This initiative is designed to address the obstacles preventing communities in remote islands and villages from reaping the benefits of digital connectivity. The initiative aims to transform rural and remote communities and improve the livelihoods and well-being of their citizens by connecting them to a range of digitally enabled services. Following a whole-of-government approach, the initiative is demand-driven, user-centric, flexible, and focused on sustainability, scalability, and multi-sector collaboration.

The Smart Villages and Smart Islands initiative comprises four pillars:

- to make broadband connectivity accessible to remote islands and villages;
- to enhance affordability;
- to enhance digital skills;
- to widen the range of digital services delivered.

A holistic and inclusive approach to rural digital transformation is employed to achieve the SDGs in remote and underserved communities. The initiative recognizes that providing connectivity alone is insufficient to ensure that local communities benefit from the Internet. The initiative emphasises a whole-of-government approach, multistakeholder engagement, including the participation of local communities, and citizen-centred digital services as critical ingredients to ensure that digital network infrastructure can deliver a sustainable development of inclusive and equitable services.

The Smart Villages and Smart Islands initiative recognizes that low levels of access and coverage are due to various factors, including limited access to broadband connectivity, affordability issues, and insufficient digital skills. It also recognizes that the infrastructure of broadband Internet is crucial for delivering vital digital services. Broadband connectivity needs to be resilient and sustainable. The Smart Villages and Smart Islands initiative also addresses human capacity challenges such as the awareness, confidence, and skills needed to harness the benefits of connectivity successfully as well as means to enhance community access to digital services.

[1] ITU, Facts and Figures 2025, 2025. https://www.itu.int/itu-d/reports/statistics/facts-figures-2025/.

The Smart Villages and Smart Islands approach is preceded by other initiatives to bridge the digital divide and it is important to learn from these previous initiatives to build sustainable Smart Villages and Smart Islands. Telecentres are one of the first attempts to bridge the digital divide. Telecentres are centres within communities that typically provide Internet access, some ICT equipment such as computers, printers and cameras, as well as access to the Internet, and in some cases, ICT and non-ICT-related services relevant to the community. Government agencies have often spearheaded these initiatives. However, telecentres have faced challenges related to a lack of community engagement, awareness, and relevance to the communities. To address these challenges, community networks were developed as an alternative to enhance community engagements while bringing connectivity to remote and rural areas. Often organized from the bottom-up, community networks provide Internet while engaging the community and fostering a sense of community ownership. However, this approach does not fully embrace a whole-of-government approach and also faces regulatory challenges that limit its potential and available technological options. The Smart Villages and Smart Islands initiative seeks to remedy the shortfalls of telecentres and community networks and build on learnings from them to create sustainable solutions to close the digital divide and connect the unconnected in remote island and village communities.

This report aims to provide an overview of key learnings from telecentres and community networks for initiatives such as Smart Villages and Smart Islands and develop a framework for assessing its sustainability.

Sustainability dimensions

This study analyses cases of telecentres and community networks to gather key lessons on implementing sustainable connectivity initiatives. The study first reviews the literature on telecentres and community networks to define the key sustainability dimensions of connectivity initiatives. Through the analyses, six key sustainability dimensions emerge: financial, socio-cultural, organizational, operational, policy, and environmental. Financial sustainability refers to the ability of the initiative to generate enough revenue to ensure its continued existence. Socio-cultural sustainability refers to the initiative's ability to foster social cohesion and a common identity, or at least a spirit of sharing common resources to ensure the continued participation of key actors and stakeholders. Organizational sustainability refers to the initiative's organizational capacity to deliver services reliably and the extent to which organizational structures empower the participants. Operational sustainability refers to the capacity of the initiative to offer high-quality and relevant services to the community continually. Policy sustainability refers to the broader political and policy frameworks and whether they enable or undermine the initiative. This dimension considers issues of legality, licensing, and government support. Environmental sustainability refers to the initiative's impact on its environment and to what extent it disrupts local ecosystems.

Case studies

The study showcases ten case studies of telecentres and community networks throughout the Asia and the Pacific region to provide an overview of the challenges and good practices across all the sustainability dimensions. The selection of case studies aims to demonstrate the diverse range of initiatives across the Asia and the Pacific region, accounting for differences in geographical, cultural, and political conditions. The report presents four case studies of community networks: TakNet in Thailand, Wireless for Communities (W4C) in India, Ungu

Community-based LTE Network in Indonesia, and the Common Room Community Network Initiative in Indonesia. These cases illustrate the diversity of community networks in the region. In Thailand, TakNet demonstrates how adaptability and flexibility in organizational models can enhance the sustainability of community networks. Wireless for Communities in India highlights the significant socioeconomic impact such initiatives can have on local communities. The Ungu Community-based LTE Network demonstrates how the creative use of technology can help community networks navigate various regulatory challenges. The Common Room initiative in Indonesia showcases the potentially positive impact such initiatives can have on indigenous communities.

The study further showcases six case studies of telecentres: the Telecentre Programme for Orang Asli (TPOA) in Malaysia, Gram Marg in India, the Computer Laboratory and Internet Community Centre in Vanuatu, the Kinect Network Telecentre in Papua New Guinea, and Community Telecentres in Kiribati and Vanuatu. The TPOA programme demonstrates the importance of the appropriate technical solutions for local conditions and the importance of integrating local community stakeholders. The Telecentre programmes in Kiribati, Vanuatu, and Papua New Guinea highlight the benefits and challenges of government-initiated initiatives in remote areas. As an experimental initiative that sits between community networks and telecentres, Gram Marg in India demonstrates that there are various models to provide sustainable connectivity in rural communities successfully. Finally, the Kinect Telecentre in Papua New Guinea reflects the importance of political commitment and community involvement.

Conclusion

The analysis of case studies produced several key learnings, which can be synthesized into three success factors for sustainable connectivity initiatives. The first and most fundamental factor for success is a reliable infrastructure that provides Internet connectivity at sufficient speeds to the community. Reliability of infrastructure comprises the resilience of the infrastructure to adverse weather conditions and the ease of maintenance and operation. This success factor can be enabled by the appropriate choice of technology depending on the local context. The second success factor is utilization of sustainable financial and organizational models. One of the main challenges to connectivity initiatives is sustaining operations beyond the initial funding and deployment period. Financial and organizational models that plan for the long-term operation of the initiative are crucial to address this challenge. These models need to be flexible to adapt to changing circumstances. Additionally, organizational, and financial models that incorporate and leverage the assets of multiple stakeholders are more resilient and can enable long-term sustainability. The third success factor is meaningful Internet connectivity. For Internet connectivity to have a positive impact, it must be relevant to the community. Hence, the development and provision of relevant and community-centric e-health, e-education, e-agriculture, or e-government services are crucial to the success and impact of connectivity initiatives. It is also important to engage local communities in the operation and maintenance of the network to foster a sense of ownership in the initiatives. The engagement of community members should be supported by opportunities for training to ensure they have the skills necessary to benefit from increased connectivity. Finally, it is critical that a concerted effort is made to ensure that all community members benefit from the initiative. Thus, it is vital that connectivity initiatives are implemented with consideration of the needs and challenges of marginalized groups such as women, people with disabilities, or ethnic minorities and that pathways for their participation are created.

Recommendations

Based on these insights, the report makes the following recommendations for policy-makers and organizations implementing connectivity initiatives.

- **Leverage appropriate technology** that provides reliable and affordable services to the community and cooperate with government and private sector partners to support the implementation of relevant technology solutions.
- **Employ a multistakeholder approach**, including partnerships with local and national governments, private sector actors, civil society organizations, and Academia.
- **Ensure local community participation and ownership** by involving the community members in all stages of the project through community needs assessment, community member training, community member involvement in operation and maintenance, and by offering relevant digital services that support long-term sustainability of the community networks.
- **Consider the local context** by employing sustainable operational and organizational models and technologies that fit the community's geographical, social, cultural, and political context.
- **Increase data availability** through rigorous impact reporting and sharing of lessons learned to grow the pool of knowledge further and thus enable communities to drive similar connectivity initiatives.

Section 1: Introduction

Digital divide

Broadband connectivity and information and communication technologies (ICTs) can significantly improve progress towards all 17 Sustainable Development Goals (SDGs). Mobile and fixed-line broadband contributes to gross domestic product (GDP) growth[2]. ITU research reveals that a one per cent increase in fixed- and mobile broadband penetration leads to a growth in GDP of 0.08 per cent and 0.15 per cent, respectively. However, the benefits of increased connectivity go beyond economic growth. A close relationship exists between connectivity and the human development index[3]. Mobile and fixed-line broadband connectivity contribute to ending poverty and improving food security, education, healthcare, and more.

According to ITU, there has been significant growth in access to mobile broadband in the Asia and the Pacific region, from 61.3 to 101 active mobile broadband subscriptions per 100 inhabitants between 2017 and 2025[4]. However, in some economies rates below 50 per 100 inhabitants persist. There are also ongoing disparities in access to fixed-line broadband in the Asia and the Pacific region. Fixed-broadband subscriptions stood at 21.4 per 100 inhabitants in 2025, which is slightly above the world average of 20.1 per cent. However, the average is skewed by some countries in the region with exceptionally high proportions of fixed-line broadband subscriptions, such as Australia with 36.5 per 100 inhabitants, People's Republic of China with 47.2 per 100 inhabitants, and the Republic of Korea with 47.8 per 100 inhabitants. Many economies have less than five subscriptions per 100 inhabitants[5]. Thus, while there has been some progress in closing the digital divide, it still persists[6].

Inequalities in digital connectivity between and within countries were aggravated by the COVID-19 pandemic as some countries and communities were more resilient and better able to cope with shocks due to greater access to digital services[7]. These inequalities are most pronounced in landlocked developing countries and small island developing States where 37.6 per cent and 64.1 per cent of the population use the Internet, respectively[8]. In small island developing states, around 10 per cent of inhabitants do not even have coverage[9]. Therefore, it is crucial to extend coverage to all inhabitants in the Asia and the Pacific region so as to leave no one behind.

Building the infrastructure to support broadband and access to ICTs can be challenging in certain areas, mainly due to vast geographical distances, rugged terrain, and dispersed island communities. Rural and remote communities often lack Internet coverage due to the high cost and low return on investment in network deployment in sparsely populated areas.

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2 ITU, Economic Impact of Broadband in LDCs, LLDCs, and SIDS: An Empirical Study, 2019. https://www.itu.int/en/ITU-D/LDCs/Documents/2019/Economic-impact-of-broadband-in-LDCs,-LLDCs-and-SIDS.pdf.

3 ITU, Global Connectivity Report 2022. https://www.itu.int/hub/publication/d-ind-global-01-2022/.

4 ITU, Facts and Figures: https://www.itu.int/itu-d/reports/statistics/facts-figures-2023/, https://www.itu.int/itu-d/reports/statistics/facts-figures-2025/, and Active mobile-broadband subscriptions - ITU DataHub.

5 ITU, Global Connectivity Report 2022. https://www.itu.int/hub/publication/d-ind-global-01-2022/.

6 ITU, Facts and Figures 2023. https://www.itu.int/itu-d/reports/statistics/facts-figures-2023/.

7 Liu and Fan, 'The Digital Divide and COVID-19'; Jun, Park, and Kim, 'Digital Transformation Landscape in Asia and the Pacific'. Bangkok: UNESCAP, 2022. https://www.unescap.org/kp/2022/digital-divide-and-covid-19-impact-socioeconomic-development-asia-and-pacific.

8 ITU, Global Connectivity Report 2022. https://www.itu.int/hub/publication/d-ind-global-01-2022/, Facts and Figures 2023, 2023. https://www.itu.int/itu-d/reports/statistics/facts-figures-2023/.

9 ITU, Global Connectivity Report 2022. https://www.itu.int/hub/publication/d-ind-global-01-2022/, Facts and Figures 2023, https://www.itu.int/itu-d/reports/statistics/facts-figures-2023/'.

Consequently, the combining of private and public resources is crucial to bridging the digital divide and bringing Internet access to underserved areas[10].

However, extending network coverage is not enough to ensure the benefits of increased broadband penetration. In addition to the coverage gap, a significant affordability gap remains that leaves many individuals, especially in the least developed countries (LDCs), landlocked developing countries (LLDCs), and small island developing states (SIDS) unconnected despite living within broadband coverage. In many LDCs, LLDCs, and SIDS, the average cost of mobile packages as a percentage of GNI per capita is significantly higher than the 2 per cent affordability target[11]. The high cost of the Internet in these countries highlights the importance of holistic connectivity initiatives that provide affordable connectivity opportunities to unconnected individuals and communities.

Challenges for remote islands and villages

Limited access to broadband and digital services inhibits communities from experiencing connectivity benefits in remote islands and regions. Low levels of access and coverage are due to various factors, including limited access to broadband connectivity, affordability issues, and poor digital skills. There are several dimensions to consider regarding restricted access to broadband connectivity. These include a lack of infrastructure for the delivery of digital services, limited resilience in broadband connectivity, and a need for sustainability in broadband connectivity. Further challenges include the lack of awareness, confidence and skills needed to harness the benefits of connectivity successfully.

Affordability is another critical factor limiting access to digital services in remote islands and villages. A lack of affordable devices, Internet services, and Wi-Fi in public places such as schools, hospitals, libraries, and offices highlights the need for increased affordability. Insufficient digital skills also play a role in limiting access to digital services. A lack of training programmes, education opportunities for digital literacy and skills, and community engagement for youth and women contribute to a gulf in digital skills. Finally, the limited availability of digital services undermines the extent communities can benefit from digital connectivity. There is a need for more service delivery platforms, digital applications, and services that support e-commerce, e-education, e-health, e-finance, e-agriculture, e-fishing, and e-tourism.

ITU Smart Villages and Smart Islands initiative

ITU has launched the Smart Villages and Smart Islands initiative to address the obstacles preventing communities in remote islands and villages from reaping the benefits of digital connectivity. The initiative aims to transform rural and remote communities, and improve livelihoods and well-being through connection to a range of digitally enabled services. The initiative is designed with a whole-of-government approach and is demand-driven, user-centric, flexible, and focused on sustainability, scalability, and multi-sector collaboration. The initiative comprises four pillars: to make broadband connectivity accessible to remote islands and villages, to enhance affordability, to enhance digital skills, and to widen the range of digital services delivered.

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[10] ITU, Connecting Humanity Assessing Investment Needs of Connecting Humanity to the Internet by 2030, 2020. https://www.itu.int/dms_pub/itu-d/opb/gen/D-GEN-INVEST.CON-2020-PDF-E.pdf.

[11] ITU, Global Connectivity Report 2022. https://www.itu.int/hub/publication/d-ind-global-01-2022/.

Crucial to the success of Smart Villages and Smart Islands is making broadband accessible and affordable to all and delivering relevant digital services. Enhancing affordability involves expanding shared broadband connectivity and the availability of devices, a shared or common digital infrastructure, government support for universal service obligations (USOs), public-private partnership models, and public Wi-Fi in schools, hospitals, public offices, and libraries.

Enhancing digital skills is also crucial to the Smart Villages and Smart Islands initiative. Enhancing digital skills can involve conducting training and digital literacy programmes to raise awareness within target communities, collaborating with partners to implement cross-sectoral initiatives, fostering community experts' ownership, and empowering youth, women, and persons with disabilities through targeted activities. These efforts aim to improve digital literacy and skills within rural and remote islands and villages, ultimately allowing residents to fully utilize and benefit from digital connectivity.

The Smart Villages and Smart Islands initiative follows a holistic and inclusive approach for rural digital transformation towards achieving the SDGs in remote and underserved communities. This approach seeks to enable communities to leverage digital connectivity, solutions and resources for development and transformation towards attaining the SDGs. This approach recognizes that providing connectivity alone is insufficient to ensure local communities benefit from the Internet. It is also crucial to widen the range of digital services available and increase demand for digital connectivity. A lack of relevant services undermines the benefits of connectivity. Therefore, Smart Village and Smart Island initiatives seek to understand the needs of communities and provide digital applications and services that will support their socio-economic development. Through adopting a whole-of-government approach, multistakeholder engagement, including the participation of local communities, Smart Village and Smart Island initiatives seek to build digital skills, and provide citizen-centred digital services that will ensure that the digital network infrastructure can deliver sustainable development. Smart Village and Smart Islands initiative adopts a whole-of-government approach as a single agency or ministry would be unable solve all of the complex challenges of digital connectivity, enhancing skills and making digital services accessible meaningfully. Each section of government can contribute their unique talents, skills, and resources while reducing duplication of expenditure, and operational costs. Furthermore, governments must demonstrate the political will to extend meaningful connectivity to rural areas. Such commitment should be reflected in the development of a broad range of digital services for local communities, including health, banking, education, job search, entrepreneurship agriculture, crime prevention, and e-government services. Finally, multistakeholder collaboration, including the participation of local communities in the design and implementation of Smart Villages and Smart Islands initiatives, is crucial. Smart Villages and Smart Islands initiative need to consider the varying needs and concerns of different sections of local communities while building strong partnerships with both private and tertiary sector actors to address these needs and concerns.

The Smart Villages and Smart Islands approach to connectivity promises a wide range of benefits over traditional methods. Individuals and organizations can conveniently utilize comprehensive services whenever and wherever necessary. These services are flexible and can be tailored to the specific requirements of citizens, groups, or institutions. The collection of these combined services is consistently enhanced to match evolving local demands. The network of collaborating organizations responsible for establishing and overseeing the intelligent community is consistently acquiring knowledge and adjusting and personalizing their provisions. Moreover,

governmental leadership embraces a holistic strategy that spans ministries and sectors to ensure integration across the board[12].

Learning from telecentres

The ITU Smart Village and Smart Island initiative is not the first approach implemented to address the digital divide and provide the benefits of digital connectivity to rural and remote communities. One of the earliest approaches to combatting the digital divide was the creation of telecentres, and this approach provides valuable insights that can help to ensure the success of the Smart Villages and Smart Islands initiative.

While telecentres vary in size, facilities, and services according to the local context, they can be roughly defined as "strategically located facilities providing public access to ICT-based services and applications"[13]. This means that they typically provide Internet access, some ICT equipment such as computers, printers, and cameras and a variety of ICT and non-ICT-related services relevant to the community[14]. Usually located within the convenient reach of community members, they provide these services at low or no cost[15]. Depending on the range of services they provide, telecentres can be categorized into four different categories: 1. micro or standalone telecentres such as phone shops or ICT centres providing some basic services; 2. mini telecentres; 3. basic telecentres; and 4. full-service centres. As technology advances, telecentres are progressing toward becoming fully equipped, versatile community hubs[16].

Telecentres originated in Sweden in the mid-1980s and experienced reasonably rapid growth in countries of the 'Global North', providing rural and isolated areas with telecommunications services and information technology facilities[17]. In more recent times, they have become much more common in countries of the 'Global South[18]'. Although the prominence of telecentres has shifted to the Global South, their primary purpose has remained the same. They continue to provide access to ICT tools and services for rural and isolated communities to empower them to meet their economic and communication needs[19]. Due to their focus on developmental goals, telecentres go beyond mere access to ICT tools. They also aim to extend the reach of public services such as education, health, and social services, provide information of general interest to the local community, and develop human capacity, thus supporting social and economic development and helping to empower marginalized communities[20]. Their value

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12 ITU, Building Smart Villages: A Blueprint as Piloted in Niger, 2020. https://www.itu.int/pub/D-STR-SMART_VILLAGE.NIGER.

13 Latchem and Walker, *Telecentres: Case Studies and Key Issues*, 3, 2001. http://hdl.handle.net/11599/116.

14 Latchem and Walker, *Telecentres: Case Studies,* 2001. http://hdl.handle.net/11599/116 *and Key Issues*; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars', 2021, https://doi.org/10.5539/jsd.v14n6p42.

15 Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars', 2021, https://doi.org/10.5539/jsd.v14n6p42.

16 Faroqi, Md. Gofran, Noore Alam Siddiquee, and Shahid Ullah. 'Sustainability of Telecentres in Developing Countries: Lessons from Union Digital Centre in Bangladesh'. Telematics and Informatics 37 (1 April 2019): 113–27. https://doi.org/10.1016/j.tele.2018.05.006.

17 Latchem and Walker, *Telecentres: Case Studies and Key Issues,* 2001. http://hdl.handle.net/11599/116; Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'. Telecommunications Policy 46, no. 3 (1 April 2022): 102265. https://doi.org/10.1016/j.telpol.2021.102265.

18 Faroqi, Md. Gofran, Noore Alam Siddiquee, and Shahid Ullah. 'Sustainability of Telecentres in Developing Countries: Lessons from Union Digital Centre in Bangladesh'. Telematics and Informatics 37 (1 April 2019): 113–27. https://doi.org/10.1016/j.tele.2018.05.006.

19 Sumbwanyambe, Nel, and Clarke, 'Challenges and Proposed Solutions towards Telecentre Sustainability: A Southern Africa Case Study'; Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries', 114, 1–8. IEEE, 2011.

20 Commonwealth of Learning (COL), 2001. http://hdl.handle.net/11599/116.

as development instruments has led them to become prominent features of developmental policies and programmes of governments and other development actors[21].

Despite their prominence, the success of telecentres has been mixed. While some have been highly successful, particularly if they could access sufficient financial support, many telecentres in developing countries shut down after a brief period[22]. Difficulties in generating the necessary funds to sustain themselves contribute to their short life-spans. A lack of funding is compounded by other issues such as a deficiencies in relevant services, weak community ownership, poor pricing structures, a lack of well-trained business managers, insufficient clear tariff structures, ambiguity concerning the role of overseeing agencies, and the theft of equipment[23].

Learning from community networks

Like telecentres, community networks also emerged as an element of strategies to address the digital divide[24]. Although there is no standard definition of community networks, their main feature is the participation of the local community in the deployment, operation, and governance of the network[25]. Community networks first emerged in the late 1990s, and they built on a long history of cooperation by local communities to meet their needs for communication and media infrastructure[26]. Community networks have evolved into various technological and institutional models depending on local circumstances. Networks range from a single shared Wi-Fi hotspot to a federation of local networks as large as a small country and can potentially host a wide range of services such as locally hosted offline resources, local-only voice calls, and high-speed broadband connectivity[27].

Community networks represent an alternative to large private or state networks and Internet service providers (ISPs)[28]. As such, they address two gaps in the traditional telecommunications

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21 Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'; Sumbwanyambe, Nel, and Clarke, 'Challenges and Proposed Solutions towards Telecentre Sustainability: A Southern Africa Case Study'; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'; Latchem and Walker, *Telecentres: Case Studies and Key Issues*.

22 Thai, Do Manh, Dang Duong, Morten Falch, Chung Bui Xuan, and Tran Thi Anh Thu. 'Factors Affecting the Sustainability of Telecentres in Developing Countries'. Telecommunications Policy 46, no. 3 (1 April 2022): 102265. https://doi.org/10.1016/j.telpol.2021.102265.

23 Sumbwanyambe, Nel, and Clarke, 'Challenges and Proposed Solutions towards Telecentre Sustainability: A Southern Africa Case Study'; Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries', 2, 1–8. IEEE, 2011..

24 Gwaka, Leon, Müge Haseki, and Christopher S. Yoo. 'Community Networks as Models to Address Connectivity Gaps in Underserved Communities'. Information Development, 29 March 2022, 026666692210896. https://doi.org/10.1177/02666669221089658.Internet Society, 'Community Network Readiness Assessment Handbook'.

25 Gwaka, Leon, Müge Haseki, and Christopher S. Yoo. 'Community Networks as Models to Address Connectivity Gaps in Underserved Communities'. Information Development, 29 March 2022, 026666692210896. https://doi.org/10.1177/02666669221089658; 'Community Network Readiness Assessment Handbook', 2022. https://www.internetsociety.org/resources/doc/2022/community-network-readiness-assessment-handbook/ ; Micholia, Panagiota, Merkouris Karaliopoulos, Iordanis Koutsopoulos, Leandro Navarro, Roger Baig Vias, Dimitris Boucas, Maria Michalis, and Panayotis Antoniadis. 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'. IEEE Communications Surveys & Tutorials 20, no. 4 (2018): 3581–3606. https://doi.org/10.1109/COMST.2018.2817686.

26 Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'; Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'.

27 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; Internet Society, 'Community Network Readiness Assessment Handbook'.

28 Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities', 2020. https://www.internetsociety.org/wp-content/uploads/2021/04/Telecommunications-Reclaimed-HandsOn-Guide-to-Networking-Communities_EN.pdf.

market, namely "the failure of commercial telecommunication operators to provide decent access to communication to people at the 'lower end of the market,' and of the governments to create suitable regulatory and other conditions"[29]. Community networks have become increasingly viable due to technological developments that make last-mile connectivity technologies cheaper and easier to operate[30]. Therefore, community networks have the potential to address the lack of last-mile connectivity and the "needs of billions of people in developing countries who have ineffective communication services"[31].

Due to the participatory nature of community networks, they promise various benefits beyond what other forms of connectivity provide. According to Bidwell and Jensen's analysis of 16 community networks worldwide, they can foster a sense of agency, empowerment, personal connections, and inclusion in local communities[32]. Through participation, women can benefit from community networks[33]. Community networks also bring economic benefits to local communities through the increased affordability of communications and a local circulation of money by facilitating local income-generating activities[34].

Developing and sustaining community networks is not without challenges. One main issue that community networks face is regulatory environments that do not foster their growth and replication[35]. In most countries, obtaining a spectrum licence is associated with lengthy, costly, and complicated procedures with multiple government agencies, which can be difficult for community networks to complete. Additionally, some countries have implemented application requirements such as minimum capital or collateral, which most community networks cannot provide. Most community networks are limited to using unlicensed spectrum such as Wi-Fi technology. However, while cheap and easy to deploy, these technologies have the drawback that they require a line-of-sight connection. This technological limitation means that towers must be closer together without obstructions such as hills or vegetation, making the connection of very remote areas in rugged terrain difficult. Additionally, technology that is suitable for extreme weather conditions often needs to be imported and is subject to high taxes, duties and custom fees, which increases the cost of development. The impact of high development costs is compounded by a scarcity of sources of funding[36].

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29 Internet Society, 'Community Network Readiness Assessment Handbook', 5, 2022. https://www.internetsociety.org/resources/doc/2022/community-network-readiness-assessment-handbook/.

30 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; Internet Society, 'Community Network Readiness Assessment Handbook'.

31 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 9, 2019.

32 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

33 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019; Digital Empowerment Foundation, 'Wireless for Communities: A Case Book'; Digital Empowerment Foundation, 'Connecting Remote Communities', 2014.

34 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

35 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

36 Bidwell and Jensen; Internet Society, 'Unleashing Community Networks: Innovative Licensing Approaches'; Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019'; Srivastava, 'Community Networks: Regulatory Issues and Gaps–Experiences from India'.

Sustainability challenges

There are many examples of impactful and sustainable telecentres and community networks, but there are also cases of them failing to deliver on their potential. A range of sustainability issues contributes to these failures. Research shows that the main challenge for telecentres and community networks is their underutilization in rural and remote areas. A lack of awareness of local inhabitants contributes to underutilization. Telecentres' services have tended to be too basic and so have failed to generate sufficient socio-economic benefits[37]. Other issues around their organization include a lack of financing and trained personnel[38]. Their success also depends on the existence of an enabling environment that includes meaningful digital services for public uptake[39].

A major hurdle for community network sustainability is challenging regulatory environments. Geared towards commercial ISPs, regulatory regimes often severely restrict the choices available for community networks regarding infrastructure, technology, organizational, and financial models. In particular, the technological constraint to unlicensed spectrum and licencing of networks leads to increased cost and decreased reliability of Internet connectivity[40].

Community networks also experience difficulties in achieving financial sustainability. One challenge to achieving financial sustainability is the high price of backhaul connectivity relative to disposable incomes in local communities due to the often rural and remote location of most community networks, especially considering that the target groups of community networks are often very price-sensitive to connectivity[41].

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37 Brown and Hoque, 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres'; Sumbwanyambe, Nel, and Clarke, 'Challenges and Proposed Solutions towards Telecentre Sustainability: A Southern Africa Case Study'.

38 Sumbwanyambe, Mbuyu, Andrè Nel, and Willem Clarke. 'Challenges and Proposed Solutions towards Telecentre Sustainability: A Southern Africa Case Study', 1–8. IEEE, 2011.

39 Brown, Jeremy, and Shah Md Hoque. 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres', 5–7, 2016.

40 Bidwell and Jensen; Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019'; Srivastava, 'Community Networks: Regulatory Issues and Gaps–Experiences from India'.

41 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019; Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019', 2019. https://www.unescap.org/sites/default/files/APAC_CN_Summit_2019_Report.pdf; Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities', 2021. https://wforc.in/wp-content/uploads/2022/02/2021-Barefoot-Wireless-Case-Study-EN.pdf.

Report objective

Figure 1: Community level connectivity approaches

Source: ITU

Telecentres and community networks provide valuable insights into the development of sustainable national Smart Villages and Smart Islands programmes. Therefore, ITU and the Internet Society commissioned this study to understand lessons learned and success factors emanating from the experiences of current and past initiatives. To fulfil this objective, the study examines the factors that contribute to sustainability of community networks and telecentres through analysis of various case studies. Based on this analysis, the study provides recommendations for enhancing the sustainable delivery of the Smart Villages and Smart Islands initiative in countries of the Asia and the Pacific region, considering connectivity, affordability, digital skills, governance, awareness, and service needs.

The following section outlines a methodology used to develop the study. Section 3 of the study consists of a literature review of sustainability challenges and lessons learned from community networks and telecentres. Based on the literature review, the report presents the sustainability dimensions of digital connectivity initiatives and the framework for developing case studies of community networks and telecentres. Section 4 presents the case studies of connectivity initiatives in the region. Each case study is structured according to the sustainability assessment framework developed based on the literature review and concludes with critical lessons learned. Section 5 concludes this report with an overview of key lessons learned and recommendations for future connectivity initiatives.

Section 2: Methodology

This report aims to provide an overview of key learnings from telecentres and community networks for future connectivity initiatives and develop a framework for assessing connectivity initiatives' sustainability. To achieve this goal, the research followed several steps. First, the research team conducted a comprehensive review of the literature on community networks and telecentres. Second, based on the insights of this review, the research team developed a sustainability framework and a questionnaire for assessing the sustainability of connectivity initiatives. Third, the research team identified ten case studies of telecentres and community networks in the region and applied the sustainability framework to examine the sustainability of each project and key learnings for enhancing sustainability of Smart Islands and Smart Villages. Each case study also served as means to examine the validity of the sustainability and framework and identify areas for future research. Based on the key learnings, the research team developed recommendations for future connectivity initiatives, particularly Smart Islands and Smart Villages in the Asia and the Pacific region.

Literature review

The research team conducted desk research of telecentre and community network initiatives, specifically targeting sustainability concerns. They primarily examined academic articles, international organization reports, and NGO documents. To guarantee data reliability regardless of context, they included literature covering global initiatives with a focus on developing countries.

The review encompassed case studies discussing challenges and learnings from various initiatives, as well as conceptual studies that synthesized crucial factors and dimensions of connectivity initiative sustainability. To offer a more practitioner-focused perspective, they supplemented these academic studies with reports from governments and national and international development stakeholders.

Drawing on the literature, the researchers then devised a framework to assess the sustainability of connectivity initiatives. The research team compiled and synthesized the most cited sustainability dimensions from the literature and identified factors contributing to each dimension based on available resources.

Selection of case studies

To showcase the effectiveness of the developed framework and offer recommendations for future connectivity initiatives, the research team collected data and created various case studies. The selection of case studies aims to demonstrate the diverse range of initiatives across the Asia and the Pacific region, accounting for geographical differences and highlighting strengths and weaknesses in sustainability dimensions. The research team reviewed various connectivity initiatives in the region, ultimately selecting ten case studies from South and Southeast Asia, and the Pacific region. These case studies represent the variety of the region's geography and cultures. The final selected case studies include telecentres and community networks from Vanuatu, Kiribati, India, Indonesia, Malaysia, Papua New Guinea, and Thailand.

The researchers sought to provide a balanced representation of telecentres and community networks, featuring four community network case studies: TakNet in Thailand, Wireless for Communities (W4C) in India, Ungu Community-based long term evolution (LTE) network in Indonesia, and the Common Room Community Network Initiative in Indonesia. The report also includes six telecentres case studies: the Telecentre Programme for Orang Asli (TPOA) in Malaysia, Gram Marg in India, the Computer Laboratory and Internet Community Centre in Vanuatu, the Kinect Network Telecentre in Papua New Guinea, and Community Telecentres in Kiribati and Vanuatu.

Data collection and analysis

The research team formulated a set of questions to apply the sustainability framework to an assessment of the selected case studies (see Annex 1). The questions are based on the sustainability framework and developed using existing questions found in the handbooks created by the Internet Society[42] and Micholia[43] for evaluating and constructing sustainable community networks. The existing questions were adapted, and additional questions were developed to fit the sustainability framework outlined above. The researchers employed these questions to guide the data collection, develop case studies and perform analysis.

Data collection combined desk review and primary data collection. For all the initiatives, the research team examined publicly accessible available data, including academic studies, reports from development organizations, and the initiatives' online materials. The researchers categorized and coded the obtained data based on the framework outlined in the next section. However, due to data limitations, not all dimensions presented in the framework appear in some cases. Specifically, the environmental sustainability and policy sustainability dimensions were difficult to develop based on available data. The authors acknowledge this limitation and recommend further research to address these areas.

In certain some cases, namely the Community Telecentres in Kiribati and Vanuatu and the Kinect initiatives in Papua New Guinea, primary data collection was in the form of stakeholder interviews. The developed questions and framework (refer to Annex 1) served as interview guidelines in these instances. Using the developed framework, they analysed the collected data to assess the overall sustainability of the initiatives. From these insights, they gathered key learnings and synthesized them into recommendations for future connectivity initiatives.

[42] 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'; 'Community Network Readiness Assessment Handbook'.
[43] 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'.

Section 3: Literature review and connectivity initiative sustainability framework

Sustainability dimensions

The literature on the sustainability of telecentres and on the sustainability of community networks overlap considerably. The sustainability of a telecentre is defined as the "capacity to generate enough revenue from ICT-enabled services to ensure continued existence in the community, fulfilling the socio-economic well-being of the society"[44]. However, "both financial and social outcomes, […] are dependent on other dimensions of the ecosystem involving policy, organization, and operational matters"[45]. The literature on community networks also highlights the importance of factors beyond the financial dimension of sustainability, especially considering the participatory nature of community networks[46].

The literature[47] on Telecentres thus considers the following six areas of sustainability:

- financial sustainability;
- social and cultural sustainability;
- operational/technological sustainability;
- organization sustainability;
- policy and political sustainability; and
- environmental sustainability.

The Internet Society[48] distinguishes between five types of sustainability for community networks including:

- economic sustainability;
- socio and cultural sustainability;
- political and organizational sustainability;
- legal sustainability; and
- environmental sustainability.

Social and cultural factors are crucial for ensuring the sustainability of connectivity initiatives and equal access to services and benefits within the community. The dimensions utilized in community networks and telecentres exhibit significant overlap. Both strands of literature

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44 Noor, Marhaini Mohd. 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'. Journal of Sustainable Development 14, 44, no. 6, 2021. https://doi.org/10.5539/jsd.v14n6p42.

45 Faroqi, Md. Gofran, Noore Alam Siddiquee, and Shahid Ullah. 'Sustainability of Telecentres in Developing Countries: Lessons from Union Digital Centre in Bangladesh'. Telematics and Informatics 37, 115, 1 April 2019. https://doi.org/10.1016/j.tele.2018.05.006.

46 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

47 Sarker, 'Policy Framework towards Sustainability of Union Digital Centres in Bangladesh', 2017; Tan et al, Innovative Use of TPOA Telecentres for Covid-19 Awareness among the Orang Asli Communities'. In 2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC), 1–6. Kuching, Malaysia: IEEE, 2020. https://doi.org/10.1109/R10-HTC49770.2020.9357028, 'The TPOA Telecentre'; Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'; Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries', 1 April 2019, 113–27. https://doi.org/10.1016/j.tele.2018.05.006.

48 Internet Society. Telecommunications Reclaimed: Hands-on Guide to Networking Communities', 2020. https://www.internetsociety.org/wp-content/uploads/2021/04/Telecommunications-Reclaimed-HandsOn-Guide-to-Networking-Communities_EN.pdf.

cover the same factors in the dimensions of social or cultural sustainability and environmental sustainability. Therefore, the dimension of socio-cultural sustainability has been adapted by merging the two.

The dimensions of policy and legal sustainability within telecentres and community network literature overlap closely. The policy sustainability dimension is adopted as it incorporates legal and political support factors. The latter is clustered within the organizational dimension in community network literature. Including policy sustainability in the evaluation of sustainability of community networks is essential as the literature consistently highlights the significant impact policy and regulations have on the sustainability of such initiatives.

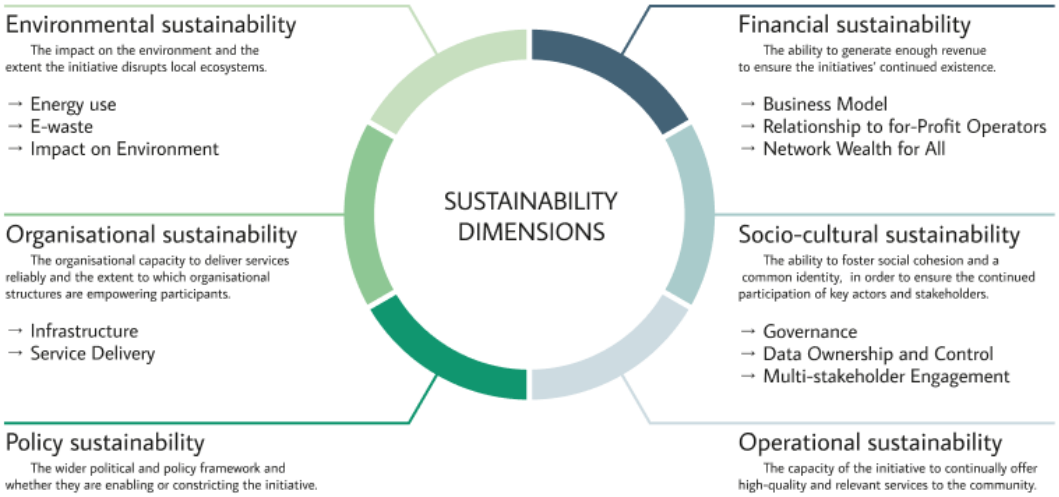
The organizational sustainability dimension is adopted with a focus on governance of the initiative, excluding external political factors. The split of internal organizational factors from the external policy environment in the organization and policy sustainability dimensions allows for a more nuanced evaluation of the sustainability of the initiative.

In the literature on community networks, economic sustainability encompasses financial aspects such as financial viability and business models, as well as operational aspects such as personnel, skills, service delivery, and economic outcomes for the community. However, the literature on telecentres distributes these factors between financial and operational sustainability, with the latter including technological aspects. For this study, the latter approach was chosen to enable the framework to evaluate both dimensions separately, considering the diverse nature of the initiatives in question. This approach allows for a more thorough evaluation of technological factors in isolation, as well as other sustainability dimensions. Additionally, it highlights the importance of relevant and high-quality services for the overall adoption and sustainability of the initiative, enabling the evaluation of the ability of the initiative to continue delivering such services to the community.

We have thus arrived at the following areas of sustainability:

- **Financial sustainability:** the ability of the initiative to generate enough revenue to ensure its continued existence.
- **Socio-cultural sustainability:** the ability of the initiative to foster social cohesion and a common identity, or at least a spirit of sharing common resources to ensure the continued participation of key actors and stakeholders.
- **Organizational sustainability:** the organizational capacity of the initiative to deliver services reliably and the extent to which organizational structures are empowering the participants.
- **Operational sustainability:** the capacity of the initiative to continually offer high-quality and relevant services to the community.
- **Policy sustainability:** the broader political and policy framework and whether they enable or constrict the initiative and issues of legality, licensing, and government support.
- **Environmental sustainability:** the impact of the initiative on its environment and to what extent it disrupts local ecosystems.

Figure 2: Six key sustainability dimensions



Source: ITU

Financial sustainability

Financial sustainability is a significant challenge for telecentres and community networks[49]. Generally, financing models can be differentiated between support from public agencies or institutions such as government agencies or development organizations, donations from other sources such as crowdfunding or one-time grants, member subscriptions, in-kind support or offering of other services[50]. The literature on community networks and telecentres highlights the importance of multiple forms of income streams, particularly the importance of self-generated income through local entrepreneurial activities[51].

For community networks, it is challenging to gather the resources first to set up the network and establish backhaul connectivity[52]. Operating community networks is relatively low-cost, but backhaul connectivity is often more expensive than with commercial operators due to the sparse population and conditions in which community networks operate[53]. These factors make backhaul connectivity one of the leading financial constraints for community networks, especially considering that their target population is often particularly price-sensitive[54]. Consequently, the financial sustainability of community networks is impacted by the density of users and their

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49 Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'; Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'; Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

50 Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries'.

51 Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries'; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'; Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'.

52 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

53 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

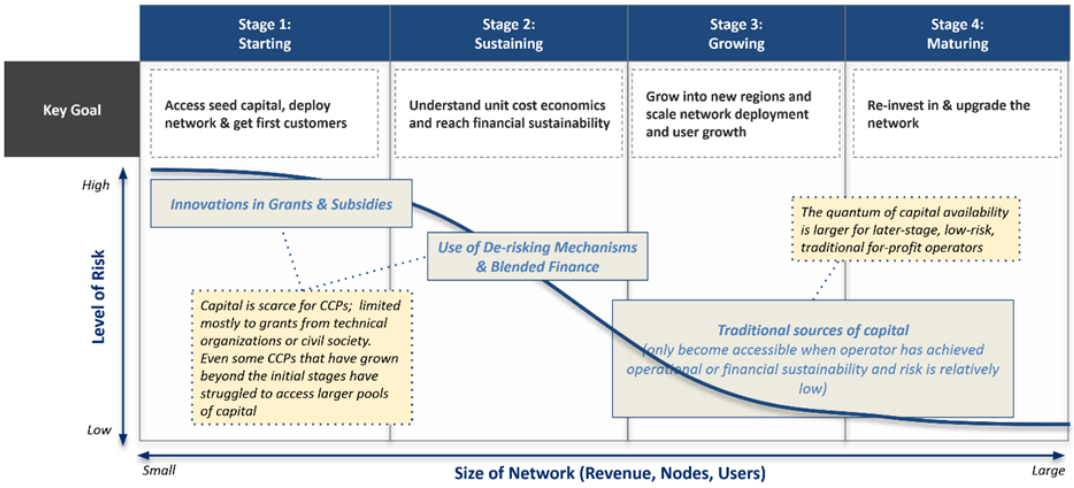
54 Bidwell and Jensen, 2019; Digital Empowerment Foundation, 'Connecting Remote Communities', 2014.

income levels, usage-dependent costs (primarily upstream connectivity and, to some extent, energy), and fixed operating costs[55]. Considering these factors, community networks must gain a critical mass of users to sustain themselves in the long-term[56].

Community networks and other sustainability initiatives change over time as they mature and potentially adapt to changes in their context. A report by the Internet Society[57] differentiates between four key phases of community networks: starting, sustaining, growing, and maturing. During the starting phase, the key goals are to plan, obtain equipment, find initial customers, and seek funding. In the sustaining phase, the goal is to reach an operational break-even point and gain an understanding of their economic situation and opportunities. In the growing phase, the goal is to expand the network and reach a total break-even point. Finally, in the maturing phase, community networks need to move beyond the break-even point to reinvest profits into capital expenditure (CAPEX) upgrades. Depending on the stage a community network is in, different sources of finance are appropriate. While in the beginning, the initiative may rely on the government and other external funding, it should look for innovative solutions to move towards traditional sources of capital and move from partial cost recovery to total cost recovery[58].

Organizational sustainability

Figure 3: Financing mechanisms for locally owned Internet infrastructure



Source: Forster, J., Matranga, B., & Nagendra, A. (2022).

https://www.internetsociety.org/wp-content/uploads/2022/10/Financing-Mechanisms-for-Locally-Own

[55] Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South, 2019'.

[56] Micholia, Panagiota, Merkouris Karaliopoulos, Iordanis Koutsopoulos, Leandro Navarro, Roger Baig Vias, Dimitris Boucas, Maria Michalis, and Panayotis Antoniadis. 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'. IEEE Communications Surveys & Tutorials 20, no. 4 (2018): 3581–3606. https://doi.org/10.1109/COMST.2018.2817686.

[57] Forster, Jim, Ben Matranga, and Anoop Nagendra. 'Financing Mechanisms for Locally Owned Internet Infrastructure'. Internet Society, 2022. https://www.internetsociety.org/wp-content/uploads/2022/10/Financing-Mechanisms-for-Locally-Owned-Internet-Infrastructure.pdf.

[58] Forster, Jim, Ben Matranga, and Anoop Nagendra. 'Financing Mechanisms for Locally Owned Internet Infrastructure'. Internet Society, 2022. https://www.internetsociety.org/wp-content/uploads/2022/10/Financing-Mechanisms-for-Locally-Owned-Internet-Infrastructure.pdf.

The literature on telecentres and community networks stresses the importance of organizational factors for the sustainability of these initiatives[59]. Factors contributing to the organizational sustainability of telecentres supported by local government agencies include effective management, monitoring and evaluation, and well-trained personnel[60]. Some authors highlight the benefits of cross-sectoral cooperation in the form of public-private partnerships (PPPs). A comparison of telecentres in the People's Republic of Bangladesh and the Republic of the Philippines shows that private sector employees are more skilled and motivated than government officials as their income was directly dependent on the telecentre's performance[61].

The literature on community networks also stresses the importance of governance and organizational structures, given the open and participatory nature of the community network models[62]. Significantly, community networks rely directly on the participation of the community and thus need to facilitate and allow for conflict resolution and participation of stakeholders, including issues such as "empowerment, active ownership of resources and data, control of one's own communication needs, […] and the rights of the network's users"[63].

One more concern that merits attention is the possible risk of free riders and of misuse due to the open nature of community networks. This issue can be tackled through technological solutions such as blockchain or community currencies, or by implementing organizational strategies such as incentive and punishment structures[64]. Certain challenges, such as managing backhaul connectivity and administrative matters such as licensing and networking with development partners, can be particularly difficult for local communities to handle[65]. Bidwell and Jensen discovered that more established and successful community networks frequently belonged to a regional or umbrella organization that assumed such responsibilities, thereby enhancing their organizational sustainability[66].

The findings indicate that a comprehensive multistakeholder approach is crucial for the sustainability of connectivity initiatives. Involving government and private sector actors in these initiatives creates opportunities to provide a broader range of services, thereby enhancing the relevance of Internet connectivity for local communities. Local connectivity initiatives can also draw upon the expertise and resources of public and private sector participants. Simultaneously, active engagement of the local community in the initiative fosters organizational sustainability by ensuring that the initiatives can continue even after the support from other stakeholders has ended.

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59 Tan et al., 'The TPOA Telecentre'; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'; Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries'; Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'.

60 Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries', 2019.

61 Brown and Hoque, 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres', 2016.

62 Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities, 2021'.

63 Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities', 94, 2021.

64 Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions', 2018.

65 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

66 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

Operational sustainability

For the operational sustainability of telecentres and community networks, it is crucial that the underlying technology is robust and allows for the reliable offering of services. One main issue both types of initiatives face, particularly in very remote areas, is the reliability of electricity[67]. Another issue is the reliability of Internet connection for community centres, and particularly the backhaul connection[68]. In the Asia and the Pacific region especially, Internet connection might be vulnerable to weather and climate events such as thunderstorms, making it difficult and dangerous to maintain infrastructure such as towers[69]. Offering offline and local network services can thus be very beneficial to overall sustainability, as demonstrated in the case of telecentres in Malaysia[70].

The literature on community networks highlights that government regulations are one of the main factors that limit the technological robustness of community network backhaul connections[71]. Although there are many new technologies available that should make it easy to establish connectivity for community networks, regulatory issues, import duties, and delivery charges tend to limit community networks to using only Wi-Fi spectrum[72]. Government regulations that require active and passive infrastructure sharing and reducing barriers to utilizing more sustainable and robust technologies are therefore crucial for improving the operational sustainability of community networks.

Research shows that the quality and relevance of digital services offered through telecentres is an essential factor that contributes to their success[73]. Case studies in the Socialist Republic of Viet Nam, the Kingdom of Bhutan and the Peoples Republic of Bangladesh show that the integration of digital government services, including e-government, significantly improves the utilization of telecentres by local communities while also increasing government commitment[74].

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67 Tan et al, 2020., 'The TPOA Telecentre'; Brown and Hoque, 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres', 2016; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

68 Tan et al, 2020., 'The TPOA Telecentre'; Srivastava, 'Community Networks: Regulatory Issues and Gaps-Experiences from India'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019.

69 Tan et al, 2020., 'The TPOA Telecentre'; Srivastava, 'Community Networks: Regulatory Issues and Gaps-Experiences from India', 2019.

70 Tan et al, 2020., 'The TPOA Telecentre'.

71 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 2019; Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019', 2019; Srivastava, 'Mapping the Regulatory Environment of Community Networks in India, Myanmar & Philippines', 2019.

72 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019'; Srivastava, 'Mapping the Regulatory Environment of Community Networks in India, Myanmar & Philippines'.

73 1World Connected, 'EMPOWERING RURAL COMMUNITIES: REACHING THE UNREACHED'; Brown and Hoque, 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres'; Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries'; Tan et al., 'The TPOA Telecentre'; Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'.

74 Brown and Hoque, 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres'; 1World Connected, 'EMPOWERING RURAL COMMUNITIES: REACHING THE UNREACHED'; Kamarudin et al., 'Factors Predicting the Adoption of E-Government Services in Telecentres in Rural Areas'.

Furthermore, barriers for community members to use digital services must be reduced. In particular, the importance of trained staff is highlighted throughout the literature[75]. The potentially steep learning curve related to technology could inhibit local community members from using and benefiting from the services offered, thus necessitating the presence of trained staff[76]. Another factor is the reliance of some centres on volunteer staff for the operation of the centre who need to be adequately trained as the professional staff might not be always available, as seen in the case of telecentres in Malaysia[77].

These findings demonstrate the importance of going beyond providing connectivity to ensure the community benefits from the Internet. This approach is reflected within the ITU Smart Villages and Smart Islands initiative which advocates for introducing digital services in different sectors such as banking, health, education, agriculture, job search, and e-government services that can enhance the community's well-being. Digital services have the advantage that they are accessible anytime and anywhere, are adaptable to local circumstances and needs and can ensure local communities have meaningful connectivity. By offering a wide range of digital services, connectivity initiatives further empower community members to become digital citizens and contribute to achieving the SDGs[78].

Policy sustainability

Political support is one of the main factors of telecentres' success, including a supportive regulatory and policy regime, a commitment to provide telecentres to rural and remote areas, and adequate staffing and financial resources[79]. Government support can and should integrate e-government services to increase the digital services available at telecentres[80]. A case study of telecentres in operation in the form of public-private partnerships (PPPs). A comparison of telecentres in the People's Republic of Bangladesh highlights the importance of political support, especially in the early years of the initiative. Initial support can take the forms of capacity building, digital and entrepreneurial skills development, and the building of strong organizational ties with local government administrators. Continued support over long periods is also essential, as it can take years for telecentres to be financially self-sustaining[81].

Community networks struggle with the fact that they are often not given sufficient recognition by national governments or the same support as for-profit operators in connecting rural and remote areas[82]. Nevertheless, the success of any community network depends directly or indirectly on public policies on local, national, and international levels[83]. Operating networks and providing

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75 Tan et al., 'The TPOA Telecentre'; Brown and Hoque, 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres'; Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries'.

76 Tan et al., 'The TPOA Telecentre'; Kamarudin et al., 'Factors Predicting the Adoption of E-Government Services in Telecentres in Rural Areas'.

77 Tan et al., 'The TPOA Telecentre'.

78 ITU, 'Building Smart Villages: A Blueprint as Piloted in Niger', 2020. https://www.itu.int/pub/D-STR-SMART_VILLAGE.NIGER.

79 Whyte, *Assessing Community Telecentres: Guidelines for Researchers*; Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'.

80 1World Connected, 'EMPOWERING RURAL COMMUNITIES: REACHING THE UNREACHED'; Brown and Hoque, 'Community Based Information Services: A Comparative Study between Bangladesh and Philippine Telecentres'; Kamarudin et al., 'Factors Predicting the Adoption of E-Government Services in Telecentres in Rural Areas'; Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'.

81 Faroqi, Siddiquee, and Ullah, 'Sustainability of Telecentres in Developing Countries'.

82 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

83 Srivastava, 'Mapping the Regulatory Environment of Community Networks in India, Myanmar & Philippines'.

network services often comes with certain legal obligations. Depending on the context, this can create difficulties as many telecommunications legislations do not consider community networks. Legal ambiguity might hurt the community network as people will be reluctant to participate, and funds will be harder to access[84]. Moreover, competition and legal conflicts with telecommunication companies can put an entire community network project at risk. Rather, community networks should focus on fostering synergies with various stakeholders, including private sector companies[85].

Possibly the largest constraint community networks face is adverse regulatory regimes[86]. Complicated and expensive licensing regimes, limitations of bandwidth, a lack of recognition of not-for-profit network operators, illegality to compete with telecommunication operators, the high import tax of technology, and limitations on sharing public Wi-Fi hotspots all contribute to a constraining regulatory environment[87]. Furthermore, existing regulatory structures of governments are not geared towards community networks but towards telecommunication companies. Community networks generally do not benefit from government support such as universal service funds (USFs) for extending network coverage[88]. Nonetheless, this challenge can be tackled by adopting innovative regulatory tools and securing essential political support from the government, as demonstrated in Papua New Guinea, which aims to enhance the environment in which community networks operate[89]. In general, this underscores the importance of a multistakeholder approach for local connectivity initiatives[90].

These findings highlight the need for a holistic approach to government involvement in connectivity initiatives. A whole-of-government approach to connectivity initiatives, as piloted in the Smart Village project in the Republic of the Niger and Smart Island in Vanuatu, can help to overcome these challenges. Through various governmental agencies and departments working together, it is possible to streamline policy and regulations to effectively implement connectivity initiatives that ensure community benefits[91].

Socio-cultural sustainability

Telecentres and community networks rely on the successful integration within, and the participation of the local community for their sustainable operation and to provide benefits to the community[92]. As they rely on the participation of the community, telecentres and community

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84 Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'; Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'.

85 Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'.

86 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

87 Srivastava, 'Community Networks: Regulatory Issues and Gaps–Experiences from India'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019', 2019.

88 Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019', 2019.

89 Internet Society, Internet Society, 'Report on the Asia-Pacific Regional Community Networks Summit 2019', 2019.

90 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

91 ITU, 'Building Smart Villages: A Blueprint as Piloted in Niger' https://www.itu.int/pub/D-STR-SMART_VILLAGE.NIGER.

92 Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'; Tan et al., 'The TPOA Telecentre'; Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'; Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'.

networks must foster a sense of belonging, social cohesion, and trust, which should include socialization activities as well as measures that ensure equality and equity in access to the services offered[93]. Furthermore, initiatives need to foster the social capital necessary to allow the community's continued participation[94].

In aiming to foster a community spirit, it is crucial to consider geographically specific cultural and governmental frameworks[95]. Case studies of telecentres in India found that the socioeconomic status of community members impacted how often people accessed the telecentres, with people of lower economic status accessing the telecentre less. However, since the telecentres were run as commercial enterprises, nobody was excluded per se. Occupation also played a role in predicting access to the telecentres if there was an overlap between services offered and certain occupations (i.e., agricultural services). Gender dynamics were also important depending on the context such as for example whether the operator was female, or if the telecentre was located inside a home, which influenced whether more men or women would be accessing the centre. Thus, it is crucial to consider the local cultural context[96].

Community networks also face challenges concerning the exclusion of certain groups due to socio-economic factors, pricing and out-of-reach locations. However, it is essential to note that this exclusion is often due to a lack of recognition within national policies and the consequences of challenging regulatory regimes, which may result in the negative effects of enforced reliance on Wi-Fi technology[97]. Furthermore, the research found that gender issues can also lead to exclusion in community networks. Gender should therefore be a vital consideration in designing and operating community networks[98]. In addition, it is important that these services are also accessible to persons with disabilities.

To ensure the socio-cultural sustainability of connectivity initiatives, there should be a concerted effort to follow the key digital principles laid out in the blueprint for the Smart Villages initiative, including developing solutions that are locally appropriate, equitable, and inclusive while placing local community members at the centre of the network and solution planning process[99].

Environmental sustainability

"Environmental sustainability refers to the control and appropriate level of exploitation and use of scarce natural resources"[100]. While environmental sustainability has received less attention within the telecentre literature[101], it is crucial to consider ensuring that connectivity initiatives

93 Tan et al., 'The TPOA Telecentre'; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'; Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'; Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'.

94 Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'; Micholia et al., 'Community Networks and Sustainability: A Survey of Perceptions, Practices, and Proposed Solutions'; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'.

95 1World Connected, 'EMPOWERING RURAL COMMUNITIES: REACHING THE UNREACHED'; Mukerji, *ICTs and Development: A Study of Telecentres in Rural India*.

96 Mukerji, *ICTs and Development: A Study of Telecentres in Rural India*.

97 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

98 Srivastava, 'Barefoot Women Wireless Engineers Creating Socially Viable Community Networks in India'.

99 ITU, 'Building Smart Villages: A Blueprint as Piloted in Niger' https://www.itu.int/pub/D-STR-SMART_VILLAGE.NIGER.

100 Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'.

101 Thai et al., 'Factors Affecting the Sustainability of Telecentres in Developing Countries'.

can be a driver towards achieving the SDGs and overall sustainable rural development[102]. For telecentres and community networks, this primarily concerns how location and geography influence the choice of technology for connectivity and the potential detrimental effects resulting from infrastructure construction[103].

[102] ITU, 'Building Smart Villages: A Blueprint as Piloted in Niger' https://www.itu.int/pub/D-STR-SMART_VILLAGE.NIGER.

[103] Internet Society, 'Telecommunications Reclaimed: Hands-on Guide to Networking Communities'; Noor, 'A Sustainable Rural Telecentre Concept on Sustainability Pillars'.

Section 4: Case studies

The following case studies aim to give an overview of challenges and good practices in community networks and telecentres initiatives throughout the Asia and the Pacific region. The report presents four case studies of community networks: TakNet in Thailand, Wireless for Communities (W4C) in India, Ungu Community LTE Network in Indonesia, and the Common Room Community Network Initiative in Indonesia. These cases were selected because they showcase the diversity of community networks in the area. TakNet in Thailand shows how adaptability and flexibility in organizational models can enhance community network sustainability. At the same time, W4C exemplifies the tremendous socioeconomic impact such initiatives can have on local communities. In contrast, Ungu Community-based LTE Network demonstrates how creative use of technology can help community networks navigate various challenges. The Common Room initiative demonstrates the potentially positive impact on indigenous communities and the spaces they inhabit.

The report further showcases six case studies of telecentres: the Telecentre Programme for Orang Asli (TPOA) in Malaysia, Gram Marg in India, the Computer Laboratory and Internet Community Centre in Vanuatu, the Kinect Network Telecentre in Papua New Guinea, and Community Telecentres in Kiribati and Vanuatu. The TPOA demonstrates the importance of selecting the right technical solutions for the context and of integrating local communities. The Telecentre programmes in Kiribati, Vanuatu, and Papua New Guinea highlight the benefits and challenges of government-initiated telecentre programmes in remote areas. Concerning an experimental initiative that sits between community networks and telecentres, the Gram Marg programme in India demonstrates that various models can be used to provide sustainable connectivity in rural communities successfully. Finally, the Kinect Telecentre in Papua New Guinea reflects the importance of political commitment and community involvement.

Overview of case studies

Initiative	Initiative type	Country	Year	Business model	Technology
TakNet	Community network	Thailand	2013	Subscription model Donations for initial CAPEX	Wi-Fi mesh
Wireless for Communities (W4C)	Community network	India	2010	Donor Funded	Wi-Fi network
Ungu Community LTE Network	Community LTE network	Indonesia	2016	Operated by a local missionary school that sells sim cards and data subscriptions through further sellers	Data-only LTE network Wi-Fi backhaul connection. Local server
Common Room	Community network	Indonesia	2018	APC Community Networks Learning Grant (CNLG) Sale of Internet vouchers	Sectoral antennas and MikroTik routers are used to cast Wi-Fi connections to the backhaul Internet infrastructure.

(continued)

Initiative	Initiative type	Country	Year	Business model	Technology
The Telecentre Programme for Orang Asli (TPOA	Telecentre	Malaysia	2013-2018	Government funded	Each centre is equipped with Wi-Fi and various devices Utilization of virtual remote management system (VRMS)
Gram Marg	Community Network/ Telecentres	India	2012	Coupons sold by the local government. Coupons sold by local village entrepreneurs	Wi-Fi network Initially tested TVWS technology but discontinued due to regulatory issues
Computer Laboratory and Internet Community Centre (CLICC),	Telecentre	Vanuatu	2016	Levies for students and coupons for community members Initially funded by the government (2-year period)	Data subscription from local ISP
Kinect	Telecentre	Papua New Guinea	2021	CAPEX funded by Kacific Operation funded through the sale of Internet vouchers.	VSAT
Community Telecentres	Telecentre	Kiribati		Initially funded under Kiribati's Universal Access Programme (1 year) Further funding through the sale of vouchers	VSAT systems
Telecentres under the Community Telecommunications Grants	Telecentre	Vanuatu	2018	Initially funded under the Community Telecommunications Grant (3 months) Further funding through the sale of vouchers and fees for other services	VSAT

Community networks

TakNet – Thailand

Country	Thailand
Implementing partners	Internet Education and Research Laboratory (intERLab) at the Asia Institute of Technology (AIT) Net2Home (social enterprise) Thai Network Information Centre Foundation Local College Local technicians and bill collectors
Year initiated	2013
Type of initiative	Community network
Business model	Subscription model Donations for initial CAPEX
Technology model	Wi-Fi mesh network

Overview

TakNet in the northwest of Thailand is a prominent community network in Thailand, significantly improving the lives of local people. It employs a model which combines external support with an entrepreneurial franchise model to bring affordable wireless Internet access to a rural area around the city of Mae Sot in Tak province[104]. The Internet Education and Research Laboratory (intERLab) at the Asia Institute of Technology (AIT) in Bangkok initiated the project in 2013.

Financial sustainability

When the network was initially deployed, it functioned mainly as a mechanism to share the digital subscriber line (DSL) Internet connection installed in multiple households. Households with an installation then shared their connection using Wi-Fi to other neighbouring households for a small fee of about USD 2.50 per month. These fees aimed to cover the Internet subscription and electricity charges. The network relied on local volunteers for installation and maintenance with support from inTERlab technical staff. Additionally, some of the initial hardware was donated by various outside partners. However, this was insufficient to cover new services, expansion, or repairs[105].

In response to financial sustainability challenges, the project adopted a new business model, including subscription and organizational changes. The subscription amount was increased to about USD 8 for each participant, which is still about two to three times lower than a broadband subscription of commercial operators. Furthermore, households with a router installed were

[104] APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

[105] Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'.

required to sign a contract committing not to switch off the router to maintain the network and refrain from reselling the service or using it for business purposes. A social enterprise called Net2Home was established to manage the services and network deployment of TakNet. The management of the community network service through the Net2Home social enterprise includes training local technicians and bill collectors who are paid about USD 50 and USD 30 per month, respectively[106].

Organizational sustainability

For the project's first three years, the local communities largely governed the network and relied on volunteers for deployment and maintenance. Community members decided where to locate the new gateway and who would collect the subscription fees. However, after the model change, some of the responsibilities were shifted to the new social enterprise. Nevertheless, the network still relies strongly on local people to provide technical services. The strong involvement of local entrepreneur technicians, along with their gradual assumption of responsibility for managing the network, is seen as a vital strength of the project and as a crucial factor in expanding the network to nearby areas[107].

Incorporating various stakeholders has been seen as a key success factor of the project[108]. The initiative relies on a solid partnership between the research and development team led by the Internet Education and Research Laboratory (intERLab) of the Asian Institute of Technology, the corporate social responsibility (CSR) programme of the Thai Network Information Centre Foundation (THNICF), and the participation of the local community. Furthermore, the local community college in Mae Sot has also played an important role in providing outreach and coordination support.

Operational sustainability

The technical infrastructure of TakNet, which is a component of its operational sustainability, takes the form of a mesh network in which a number of local routers installed in local households form a network connected to the Internet through a central backhaul connection. Mesh networks are more resilient to infrastructure disturbances as one node breaking down will not impact the whole network[109]. The project is also piloting TV white space (TVWS) technology, which could provide the community with a more efficient and affordable form of backhaul connectivity[110].

The operational resilience of the network is bolstered by the deep integration of local technicians who can troubleshoot and perform maintenance services. Additionally, the network provides various other services to increase its relevance to the local community. IntERLab has installed an affordable local weather station and air pollution remote sensing device, both of which are connected to the mesh network. A rural school wireless mesh network featuring an educational

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106 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'.

107 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'.

108 APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

109 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

110 Adisorn Lertsinsrubtavee, 'TakNet – A Community White Space Wireless Network'.

video-on-demand system was also deployed at Ban Mae Kued Luang School[111]. TakNet also seeks to implement incentive applications such as distributed ledger and chat applications, along with Internet of things (IoT), which can expand the community network to encompass agricultural services, local village manufacturing activities, and community-based waste or pollution management solutions[112].

Policy sustainability

The Net2Home local social enterprise acts as the Internet service provider (ISP) licensee for the services. Unfortunately, local regulations only allow for the use of unlicensed 2.4 and 5 GHz bands, which have limited transmission ranges. However, with a grant from the National Broadcasting and Telecommunication Commission, the intERLab research group tested the use of Carlson TVWS and LTE equipment for connecting rural and remote areas, having obtained special approval for research purposes from the regulator[113].

Socio-cultural sustainability

TakNet aims to empower marginalized groups and employs gender-sensitive policies. As a result, almost 50 per cent of inTERLab and NEt2Home team members are women, while at the community level, most of the community leaders working with the initiative are also women[114].

Key learnings

The TakNet project in northwest Thailand demonstrates the strength of a multistakeholder approach in bringing affordable wireless Internet access to a rural area. The engagement of government, local community, and academia has been crucial for the network's success. The project has also shown adaptability and resilience in changing its organizational model to fit circumstances, particularly in response to financial sustainability challenges. In addition, the project is committed to upskilling locals and aims for the integration of women in its efforts. The case study demonstrates strengths within the financial, organizational, and socio-cultural sustainability dimensions. Financial sustainability is achieved through changes to the subscriptions and the establishment of a social enterprise, Net2Home, to manage the services and network deployment. Organizational sustainability is achieved through the strong involvement of local entrepreneur technicians who gradually assume responsibility for running the network. Socio-cultural sustainability is achieved through community members deciding where to locate the new gateway. Furthermore, the engagement of and training for local technicians and bill collectors is a crucial aspect of socio-cultural sustainability. The strong multistakeholder engagement that includes academia and community involvement are key strengths supporting the expansion of the network to nearby areas.

111 intERlab, 'Net2Home – IntERLab'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
112 APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'.
113 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'.
114 APC and IDRC, 'BUILDING LAST-METRE COMMUNITY NETWORKS IN THAILAND'.

Wireless for communities (Chanderi) - India

Country	India
Stakeholders/Partners:	Internet Society Digital empowerment Foundation Barefoot engineers (local technicians)
Year initiated:	2010
Type of initiative	Community network and digital resource centre
Business model	Donor funded
Technology model	Wi-Fi network

Overview

Wireless for Communities (W4C) is a community network initiative from the Digital Empowerment Foundation with support from the Internet Society that was first piloted in Chanderi, a small municipality in India[115]. The pilot study was a great success, and subsequently, W4C successfully used this model to deploy over 250 community networks in 68 districts in 20 states[116].

In Chanderi, average household incomes have more than doubled, mainly because of various ICT interventions. There is at least one digitally literate person in each weaver household, which, combined with other ICT-enabled programmes, has allowed community members to establish their own enterprises. Additionally, all 13 local schools have been equipped with computer labs connected to the Internet. Moreover, a telemedicine facility links its Wi-Fi-enabled healthcare centre with the next district hospital, enabling patients to consult with doctors at specific times[117].

Financial sustainability

W4C is mainly funded by the Internet Society and receives further support from various other national and international agencies, including the national government, Cap Gemini, the Ford Foundation, the European Commission, Ericsson, Intel, Microsoft, and the Tata Trust[118].

Organizational sustainability

One major strength of the W4C model is its "train-the-trainers" approach which enables communities to sustain and grow their own community network and helps people in other communities establish new networks. Subsequently, there were about 350 local technicians or "barefoot engineers" who help villages establish their own networks or provide training to grow networks in India and other countries[119].

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115 Digital Empowerment Foundation, 'Connecting Remote Communities'.
116 Internet Society, 'Barefoot Wireless Engineers: Using Human Networks to Grow the Internet An Idea Expands from a Single Community to a Web of Engineers, Connecting Thousands to Opportunities', 6.
117 Digital Empowerment Foundation, 'Connecting Remote Communities'.
118 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
119 Internet Society, 'Barefoot Wireless Engineers: Using Human Networks to Grow the Internet An Idea Expands from a Single Community to a Web of Engineers, Connecting Thousands to Opportunities'.

Operational sustainability

In 2014, W4C set up a digital design resource centre called 'Chanderiyaan' in Chanderi to demonstrate the benefits of connectivity and convince the local community to participate in the project. In the following years, this was extended to computer-training centres and to ordinary households installing computers and Internet connections[120]. The network relies mainly on unlicensed 2.4 GHz and 5.8 GHz Wi-Fi spectrum. In Chanderi, the network covers an area of five square kilometres with 360-degree wireless signals provided by an 80-foot high antenna[121].

Beyond establishing connectivity in Chanderi, W4C also introduced telehealth services and support for entrepreneurship. The latter has been particularly impactful in Chanderi, a traditional hand-weaving community. Through their programmes and the introduction of digital tools, W4C was able to empower weavers to digitally preserve traditional sari designs, conduct research and create new designs, enhance production efficiency, and increase income by enabling direct communication with buyers instead of relying on intermediaries[122].

W4C relies on training local technicians or "barefoot engineers" to deploy and maintain their community networks. Thus, training was a key component of setting up the network in Chanderi, which started with ten enthusiastic local young people who were trained to install and maintain the wireless network. The initiative further developed a training course with simple, easy-to-understand guidelines and video tutorials on installing and maintaining community networks[123].

Policy sustainability

The regulatory environment represents one of the main challenges for community networks such as W4C. The Indian regulatory regime limits the choice of technology to unlicensed spectrum and imposes other responsibilities on community networks, such as logging users' information that complicates their operation[124].

Socio-cultural sustainability

W4C emphasizes engaging women to empower them to participate in their communities and improve their livelihoods. For example, "barefoot engineer" training focuses on engaging women, contributing to their empowerment and to a cultural shift in communities' perception of women's role in society. The "Barefoot Women Wireless Engineers" have become role models for women and girls in their communities[125]. Furthermore, the Digital Empowerment Foundation has started two programmes targeting women. The Wireless Women for Entrepreneurship and Empowerment (W2E2) programme was created to support women's micro-level social enterprise-based ICTs and women entrepreneurs in using Wi-Fi. While the Solar Women Wireless Engineers for Entrepreneurship and Empowerment (SW2E3) programme was developed to provide solar and wireless training to women[126].

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120 Digital Empowerment Foundation, 'Wireless for Communities: A Case Book'.
121 Digital Empowerment Foundation, 'Wireless for Communities: A Case Book'.
122 Internet Society, 'Barefoot Wireless Engineers: Using Human Networks to Grow the Internet An Idea Expands from a Single Community to a Web of Engineers, Connecting Thousands to Opportunities'.
123 Internet Society, 'Barefoot Wireless Engineers: Using Human Networks to Grow the Internet An Idea Expands from a Single Community to a Web of Engineers, Connecting Thousands to Opportunities'.
124 Srivastava, 'Community Networks: Regulatory Issues and Gaps–Experiences from India'.
125 Internet Society, 'Barefoot Wireless Engineers: Using Human Networks to Grow the Internet An Idea Expands from a Single Community to a Web of Engineers, Connecting Thousands to Opportunities'.
126 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

Key learnings

The Wireless for Communities (W4C) initiative has demonstrated the importance of implementing services that are relevant to the community, as seen in the success of the weaving programme in Chanderi, India. This approach allowed the community to understand the benefits of connectivity and build buy-in before establishing the network infrastructure.

In addition to being relevant to the community, the "train-the-trainers" or "Barefoot Engineers" approach employed by the W4C initiative is crucial for organizational sustainability. This approach enables communities to sustain and grow their own community network and helps people in other communities establish new networks. By training local technicians, or "barefoot engineers", W4C has been able to build a network of skilled individuals who can deploy and maintain community networks, reducing the reliance on external support. This approach has effectively empowered the local communities to take ownership of the networks and ensure their sustainability.

The W4C initiative has strongly emphasised women's empowerment, which has contributed to its success and sociocultural sustainability. By empowering women through training, education, and access to information and resources, W4C has created a more inclusive and equitable environment for the communities it serves. For example, in the traditional hand-weaving community of Chanderi, W4C has been able to empower weavers, many of whom are women, to preserve traditional sari designs digitally, research and create new designs, enhance production efficiency, and increase income by enabling direct communication with buyers, hence improving the livelihoods of many women in the community, and preserving and promoting the traditional hand-weaving industry. Additionally, the initiative has provided women with access to telehealth services and support for entrepreneurship, which have contributed to the overall socio-economic development of the communities. By providing women with access to information and resources, W4C has been able to break down traditional gender barriers and promote gender equality, leading to more sustainable and inclusive communities.

Ungu Community LTE Network - Indonesia

Country	Indonesia
Stakeholders/Partners	Local Missionary School ICT Watch University of Washington Airwave (local social enterprise)
Year initiated:	2016
Type of initiative	Community LTE network
Business model	Operated by a local missionary school that sells SIM cards and data subscriptions through further sellers
Technology model	Data-only LTE network Wi-Fi backhaul connection Local server

Overview

The establishment of the Ungu Community-based LTE Network (CoLTE) resulted from a long-term collaboration with the University of Washington to provide a data-only LTE network to Bokondi, a remote community in the highlands of Papua in Indonesia. Although the community already had an Internet link before the project, the coverage was limited to the local elementary school and a few additional households. In 2016, the Indonesian NGO ICT Watch was able to convince the Ministry of Communications and Digital Affairs (KOMDIGI) to provide experimental licences in the mobile cellular bands to explore alternative technologies and business models[127].

Financial sustainability

The initial capital expenditure of the project was provided by a grant of USD 12 000 from APNIC/ISIF. Local operational support, and upstream Internet connectivity come from a nearby social enterprise Airwaves Mission which operates as a wireless Internet provider. The operating costs of the project, including upstream connectivity and operating costs, are financed through the sale of prepaid accounts and data packages. The packages are sold to local agents who resell them to the local communities at a markup of about 20 per cent. A SIM card and initial setup, including 10 MB credit, costs USD 7, and data bundles are available at 10 MB for USD 5, 100 MB for USD 15, and 1 GB for USD 25[128]. Along with official resellers, a robust "secondary" hotspot market also emerged[129].

[127] Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
[128] Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South', 99.
[129] Sevilla et al., 'Experiences: Design, Implementation, and Deployment of CoLTE, a Community LTE Solution'.

This financial model has proven to be sustainable, generating enough revenue to cover the equipment cost in about two years, prompting community discussion about what should be done with the excess revenue[130]. However, it was also observed that the use of the network is unequal, and the network is supported by only a handful of relatively heavy users[131].

Organizational sustainability

The network is owned and operated by a missionary group that runs the local elementary school. They manage the day-to-day operations, including maintenance, credit sales to resellers, power management, and repairs[132]. However, the initiative is also supported by a nearby social enterprise wireless Internet provider, Airwaves Mission, which supported the earlier 2G project and provided the school with connectivity[133].

Operational sustainability

The network is a pure 4G LTE network which makes the setup and operation far more straightforward than if it had included voice and SMS services. This is especially so given the prevalence of text and voice call services, such as for example WhatsApp, that run over the Internet, and makes it a viable solution for the local community. The network's base station is connected to the Internet via a 50-kilometre long-distance (double-hop) Wi-Fi link to Mission Airwaves' very small aperture terminal (VSAT) installation in a nearby town[134].

This kind of data-only LTE networks setup is called Community LTE and includes a local server or "network in a box", which reduces the cost of bandwidth needed by about 50 per cent and improves reliability (local activity continues even when the upstream link goes down). In addition, to improve performance and save on expensive and limited satellite capacity, a local web cache and domain name system (DNS) server are also installed[135]. Local-only services facilitated through the model's local server include free local-to-local traffic and local copies of educational content such as Wikipedia and OpenStreetMap[136].

The power source for the network is provided through the local microgrid, which relies on diesel generators scattered throughout the community, solar panels, and a micro-hydroelectric generator connected to a battery bank for the large local private school. Choosing to rely on the local power grid over a dedicated diesel generator means that the network depended on a good relationship with the community and was only possible due to community discussion around power usage. However, this also instils a sense of ownership and an understanding of power outages, as the network will only be down if the whole community's power is out[137].

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130 Sevilla et al., 'Experiences: Design, Implementation, and Deployment of CoLTE, a Community LTE Solution'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
131 Johnson et al., 'Whale Watching in Inland Indonesia'.
132 Johnson et al., 'Whale Watching in Inland Indonesia'.
133 Sevilla et al., 'Experiences: Design, Implementation, and Deployment of CoLTE, a Community LTE Solution'.
134 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
135 Bidwell and Jensen, Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
136 Bidwell and Jensen, Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
137 ISIF ASIA, 'Technical Report: Community LTE in Papua'.

Policy sustainability

The community already had an Internet connection, but it needed to be more reliable. In 2016, the Indonesian NGO ICT Watch convinced the national telecommunication ministry (KOMINFO) to provide experimental licences in the mobile cellular bands to explore alternative technologies and business models. Permission was granted only on the condition that the initiative would not compete with existing commercial operators. Thus, when the incumbent operator Telkomsel established a mobile base station covering that area, the local 2G community network was decommissioned. However, Telkomsel's service did not support Internet connectivity, so the initiative moved to deploy the Community LTE network[138].

Socio-cultural sustainability

When implementing the project, local circumstances and culture were taken into consideration. For instance, upon the advice of all interested groups, small groups were implemented for discussions, information gathering, training and feedback to remove the troublesome issues of powerful local men dominating the public meetings. The small group approach was readily accepted, as traditional family talks are conducted similarly. Furthermore, to garner community interest and support, the local school was chosen to install the infrastructure due to its geographical and social centrality in the community and despite its sub-optimal location from a technical standpoint[139].

Key learnings

The Ungu Community-based LTE Network in Indonesia showcases the potential for innovative solutions to address connectivity challenges in remote areas. The local mobile network technology offers operational sustainability, with a simpler setup and operation than traditional networks that include voice and SMS services. Additionally, an offline server has been implemented, allowing for data storage and access without Internet connectivity, addressing the issue of unreliable Internet in the region. The data-only LTE network also did not compete with the local telecommunication company, enabling the initiative to operate in the area while navigating regulatory challenges.

The project's financial sustainability is noteworthy, as the initiative generated enough revenue through prepaid accounts and data packages to cover equipment costs within two years. This model supports the local communities by providing a source of income for resellers and allowing excess revenue to be used for community development.

The organizational sustainability of the initiative is achieved through partnerships and local ownership. The nearby social enterprise wireless Internet provider, Airwaves Mission, provided external support and upstream Internet connectivity. Meanwhile, a local missionary group owns and operates the network, managing day-to-day operations, maintenance, credit sales, power management, and repairs. This blend of external support and local ownership ensures the network's long-term sustainability, as the community is invested in its success and has the necessary skills and resources to maintain it. The Ungu Community-based LTE Network

[138] Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
[139] ISIF ASIA, 'Technical Report: Community LTE in Papua'.

demonstrates how innovative solutions and partnerships can provide sustainable connectivity in remote communities.

Common Room – Indonesia

Country	Indonesia
Stakeholders/Partners:	Common Room Networks Foundation Association for Progressive Communication (APC) Kasepuhan Ciptagelar indigenous community
Year initiated:	2018
Type of initiative	Community network
Business model	APC Community Networks Learning Grant (CNLG) Sale of Internet vouchers
Technology model	Sectoral antennas and MikroTik routers are used to cast Wi-Fi connections to the backhaul Internet infrastructure.

Overview

Yayasan Mitra Ruang Kolektif or Common Room Networks Foundation, is a non-profit organization founded in 2006 and is an open platform for creativity and innovation. It has collaborated with the Association for Progressive Communication (APC) since 2018 and has been actively engaged with the *Kasepuhan Ciptagelar* indigenous community since 2013. The Kasepuhan Ciptagelar region comprises an indigenous community of about 25 000 to 30 000 people living in the surrounding deep forest area of the Halimun-Salak Mountain National Reserve (TNGHS), and is facing increasing challenges and vulnerabilities due to rapid development. In 2018, the Common Room Networks Foundation started to develop a community network that nurtures creativity, innovation, and social entrepreneurship in the community[140].

Financial sustainability

The APC Community Networks Learning Grant (CNLG) initially supported the project. Continuing operation of the network was funded through the sale of Internet vouchers and was managed by the local community. In addition to financing the network development, some profit from the voucher sale is being re-invested into the maintenance and development of Internet networks and infrastructure in areas that still have no Internet access[141].

The project complements commercial Internet service providers with a more affordable and reliable option. Some commercial ISPs provide Internet access to the *Kasepuhan Ciptagelar* region through 3G/4G mobile Internet, but this remains unaffordable for many community members. Furthermore, the connection can be unstable when there is a power outage[142].

[140] CommonRoom, 'Connecting the Unconnected'.
[141] CommonRoom, Connecting the Unconnected'.
[142] CommonRoom, Connecting the Unconnected'.

Organizational sustainability

The community's residents developed and deployed the initiative with the assistance of Awinet, a local Internet service provider (ISP) based in Bayah, Banten Province. Awinet was initially established as a community network actively developing local Internet infrastructure. The Awinet community deployed and shared affordable Internet access utilising simple network infrastructure. In 2014, the Awinet community gradually began restructuring itself into an ISP company. The initiative further builds on the cooperation of the Common Room Networks Foundation itself, the local community, and the Association for Progressive Communication (APC), an international network of civil society organizations founded in 1990, dedicated to empowering and supporting people working for peace, human rights, development, and protection of the environment, through the strategic use of information and communication technologies[143].

Operational sustainability

In the Kasepuhan Ciptagelar region, Internet access has been provided by some telecommunication companies, but it is expensive and sometimes unstable. In 2018, a local ISP Awinet started to develop a wireless broadband connection using sectoral antennas and MikroTik routers to cast Wi-Fi to the core network in the region. This infrastructure provided Internet connectivity to 13 villages with an average of about 500 users daily, with increasing demand for Internet access from local community members. The local indigenous community is working together to construct the backhaul towers and establish wireless connection, with assistance from Awinet and the Common Room Networks Foundation team[144].

The project aims to support the economic, social and cultural empowerment of the Kasepuhan Ciptagelar indigenous community. Priority access to Internet connectivity is given to schools, subsidiary health clinics, and village administration offices. Furthermore, a "mini data centre" was set up to manage local knowledge used in a participatory mapping project to identify protected forest areas. Additionally, the local community members have been trained to build and manage local Internet infrastructure and can now maintain and expand the Internet networks independently[145].

Sociocultural sustainability

The development of local Internet infrastructure in the region is expected to support official State recognition of rights of the Kasepuhan Ciptagelar indigenous community, facilitate participatory mapping activities, and support efforts to preserve and protect the tropical forest area. Before launching the project, Awinet and Ciptagelar residents conducted studies for around three months to ensure that the local community would benefit from Internet access. Abah Ugi, an indigenous community leader, expressed a desire for media literacy programmes for the youth, women and adults in villages and hamlets that already have access to the local Internet infrastructure[146].

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143 CommonRoom, Connecting the Unconnected'.
144 CommonRoom, Connecting the Unconnected'.
145 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; CommonRoom, 'Connecting the Unconnected'.
146 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; CommonRoom, 'Connecting the Unconnected'.

Environmental sustainability

The project is expected to support participatory mapping activities facilitating the protection and conservation of the tropical forest area maintained by the Kasepuhan Ciptagelar indigenous community[147].

Key learnings

In the Kasepuhan Ciptagelar region, the Common Room Networks Foundation initiative, with support from APC and in partnership with a local ISP, provided Internet connectivity to 13 villages with an average of about 500 users every day. The initiative highlights the importance of properly understanding the local context. Through intensive research and engagement with the local community prior to developing the infrastructure, the initiative was able to create a network that fits the community's needs. Priority access to Internet connectivity is given to schools, subsidiary healthcare clinics, and village administration offices. A "mini data centre" was set up to manage local knowledge used in a participatory mapping project to identify protected forest areas. The initiative is thus able to support economic, social, and cultural empowerment, as well as support the protection and conservation of the tropical forest area maintained by the *Kasepuhan Ciptagelar* indigenous community. The development of local Internet infrastructure in the region is also expected to support official State recognition of the rights of the Kasepuhan Ciptagelar indigenous community.

Partnering with an ISP that started as a community network demonstrates that the right approach to community connectivity can lead to growth in opportunities. Furthermore, through engagement with the indigenous community, the initiative was able to garner support and leverage local community members for the deployment and operation of the infrastructure. The local indigenous community members have been trained to build and manage local Internet infrastructure and are now able to maintain and expand the Internet networks independently.

[147] CommonRoom, 'Connecting the Unconnected'.

Telecentres

The Telecentre Programme for Orang Asli (TPOA) - Malaysia

Country	Malaysia
Stakeholders/Partners:	Department for Development of Orang Asli (JAKOA Net2Home (social enterprise) Ministry of Rural Development (KKLW) Economic Planning Unit, Prime Minister's Department (EPU) Local community steering committee
Project period:	2013-2018
Type of initiative	Telecentres
Business model	Government funded
Technology model	Each centre is equipped with Wi-Fi and various devices Utilization of VRMS

Overview

Through the Telecentre Programme for Orang Asli (TPOA), the Department for Development of Orang Asli (JAKOA), collaborated with the Ministry of Rural Development (KKLW), and the Economic Planning Unit (EPU), of the Prime Minister's Department, to establish four telecentres in remote rural sites in the states of Pahang and Kelantan, Malaysia. The communities of Pos Balar, Pos Gob, Pos Lenjang, and Pos Sinderut[148], where the telecentres were established are populated mainly by indigenous people and are in very remote and hard to access areas due to challenging terrain[149]. The initiative was implemented to broadly facilitate the socio-economic development of these communities. The aim of the telecentre programme is to facilitate communication and to act as resource centres for new 'knowledge' and skills while providing education through ICT and training for local capacity building. Another aim of the telecentre programme is to provide health-related information to the villagers[150].

Organizational sustainability

The telecentres were designed to be fully managed and operated by the local communities. Therefore, a community advisory board was formed, and local coordinators, telecentre managers, community educators, and technicians were appointed. The TPOA initiative successfully overcame some of the constraints due to its remote location by implementing a virtual remote management system (VRMS). The VRMS was designed to support process-based management by strengthening local telecentre caretakers' managerial skills and problem-solving capacities without on-site support from the team in UNIMAS. Furthermore, the VRMS was successful in building an interactive ecosystem between the four communities with telecentres, other indigenous communities, telecentre managers, and university researchers[151].

148 Tan et al., 'Innovative Use of TPOA Telecentres for Covid-19 Awareness among the Orang Asli Communities'.
149 Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.
150 Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.
151 Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.

Operational sustainability

The telecentres are outfitted with solar panels for electricity generation, but some telecentres still face unreliable power issues. Each centre offers Wi-Fi access and is equipped with various devices tailored to different use cases. Tablet computers serve as the primary computing platform for most users, while telecentre administrators and advanced users utilize mini low-power desktop computers. For training purposes, LED TVs and ceiling-mounted projectors have been installed to display multimedia content. Moreover, a local app database portal has been redesigned to balance service usage duration and power consumption. To address challenges arising from the remote locations of the telecentres, they rely on a self-automated virtual remote management system (VRMS). Local server contents are virtually synchronized, and telecentre caretakers experiencing any issues can receive remote assistance to resolve them[152].

The establishment of the telecentres was accompanied by six socioeconomic community development programmes. These programmes included community training in areas such as leadership, ICT applications and usage, telecentre management, and entrepreneurship. An educational programme was developed to harmonize indigenous culture with contemporary forms of knowledge. Support was provided for agro-businesses, aiming to build the capacity of smallholder farmers to understand, analyse, and effectively link to markets while developing agro-enterprises. The initiatives also focused on documenting indigenous knowledge, supporting rural and Indigenous tourism as an alternative to mainstream tourism, and implementing a healthcare programme designed to develop respectful and sensitive protocols for understanding the realities of remote community life and for supporting e-health in Orang Asli communities through education[153].

The establishment of the telecentres together with the development programmes has led to some success stories where local communities were able to pursue business opportunities or other projects that would have been much less accessible and far costlier and difficult to achieve in the absence of the telecentres. For example, the community in Pos Sinderut was able to begin selling their own agricultural products directly without having to go through a middleman. Another example is the community in Pos Balar which was able to attain legal recognition of ownership over part of their ancestral land, which they deemed have been encroached upon by outside agencies[154].

However, the initiative had some issues retaining trained caretakers and administrators as some of the trained locals took the opportunity to move out of their villages, leveraging their new skills to pursue other opportunities[155].

Socio-cultural sustainability

The initiative aims to foster community support and a sense of ownership of the telecentres. Therefore, the centres were culture-specific, designed and built using locally available products (sand, stones, and wood) and skills through a joint effort known as *gotong royong* between the local communities and researchers from UNIMAS. Since the communities prefer open space over individual desks and chairs for training and learning, the internal space of the telecentres was designed accordingly. The 'open space' aligns with their community-based knowledge sharing,

152 Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.
153 Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.
154 Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.
155 Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.

which allows for the friendly exchange of ideas. The participatory nature of the governance of the telecentres further increases a sense of belonging and ownership among community members. Additionally, the linkages between the communities and outside stakeholders that were built through the VRMS further strengthen local networks and capacities[156].

Key learnings

The Telecentre Programme for Orang Asli (TPOA) in Malaysia has demonstrated the importance of appropriate technology in supporting various sustainability dimensions. The virtual remote management system (VRMS) has been crucial in overcoming problems and supporting operational and organizational sustainability. VRMS has effectively enabled process-based management, strengthened local telecentre caretakers' managerial skills, and synchronised local server contents virtually. It has further helped build an interactive ecosystem between the four communities with telecentres, other indigenous communities, telecentre managers, and university researchers.

The Telecentre Programme for Orang Asli (TPOA) has successfully achieved socio-cultural sustainability by involving local communities and providing relevant services. The telecentres are managed and operated by local communities with the help of a community advisory board, local coordinators, telecentre managers, community educators, and technicians. This approach has effectively empowered the communities to take ownership of the telecentres and ensure their sustainability. The provision of services such as health-related information, training for local capacity building, and education through ICT has been tailored to the specific needs of the indigenous communities, making the initiative relevant and beneficial to them. The TPOA initiative has also helped in creating awareness and understanding of the local culture and customs and addressing the needs and concerns of the communities.

Based on the services provided and their impact on communities, the initiative has had several success stories, including agribusiness development, which helped to diversify income sources and improve livelihoods, and obtaining recognition of ancestral lands, which had a significant impact on livelihoods and cultural identity. These success stories illustrate the importance of considering the local context and providing relevant services.

[156] Bala and Tan, 'Digital Inclusion of the Orang Asli of Peninsular Malaysia'.

Gram Marg – India

Country	India
Stakeholders / Partners	Local ISP Department of Electrical Engineering at the Indian Institute of Technology (IIT) Bombay *Panchayat* (local government administration) Village level entrepreneurs
Year initiated	2012
Type of initiative	Community network
Business model	1. Coupons sold by the local government administration 2. Coupons sold by local village entrepreneurs
Technology model	Wi-Fi network Initially tested TVWS technology but discontinued due to regulatory issues

Overview

Gram Marg is a community network in the Palghar district of Maharashtra, which was initiated by the Department of Electrical Engineering at the Indian Institute of Technology (IIT) Bombay in 2012, as a test bed for various technical and institutional solutions. Utilising two different organizational models the initiative was successful in providing Internet connectivity to 25 villages. The first model relied on close cooperation with the local government while the second emphasised local integration through village entrepreneurs. While emphasising different actors both models employed a broad multistakeholder approach and made efforts to integrate local communities. The Gram Marg community network thus demonstrates how different approaches can lead to sustainable connectivity initiatives[157].

Financial sustainability

The Gram Marg project is testing two different financial models for sustainability. The area was divided into two clusters. In both clusters, the public sector was crucial in technology innovation, deploying the network and providing the capital expenditure (CAPEX) funding for setting up the network infrastructure in the villages. The first cluster of 15 villages applies a revenue model that leverages the local Internet service provider (ISP) and the *Gram Panchayat* office. In this model, the local ISP sells 2 Mbps bandwidth to the *Gram Panchayat* (i.e. the local administration) office, directly paying the provider. The *Gram Panchayat* office also pays and is responsible for the operation and maintenance of the Internet service. However, as the office does not use all of the bandwidth, it sells unused bandwidth to villagers in the form of "pay as you use" daily coupons at INR 10 (USD 0.14) per hour. On average, 5 to 10 people use the Internet at the office daily,

[157] Belur, 'Addressing Sustainability in Rural Connectivity: A Case Study of Gram Marg Community-Led Networks'; Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.

contributing to the monthly revenue of *Gram Panchayat*, which plans to use the accumulated amount for development activities within the village[158].

In the second cluster of 10 villages, a Village Entrepreneur model is being employed. The Common Service Centre (CSC) government programme Wi-Fi Choupal, purchases bandwidth from a local ISP, which it distributes to the different villages depending on the number of users in each village. In these villages, the network is maintained and operated by local village entrepreneurs (VLE) who sell bandwidth to villagers through coupons based on a fixed pricing plan. The pricing plan is set in such a way that it maximises revenue for the VLE, thus incentivising performance. Steady growth in revenue generation by the VLEs suggests that the model will perform well and also offers lucrative value for the investment made. Initial research shows that both models appear sustainable and that local villagers are using the services offered[159].

Organizational sustainability

The Gram Marg initiative pioneered the Public-Private-People-Panchayat Model (4P). This model is based on the introduction of the *Panchayat* (i.e. the local administration) in the partnership model alongside the private and public partners and a 'bottom-up' approach which comprises active involvement of villagers and focuses on the local and regional connectivity needs. The anticipation of *Panchayat* adds value to the partnership model, as it is elected by the people of the village and represents the village administration[160]. The various partners take up different roles within the project. The *Panchayat* owns the network at the village level and plays a major role in determining priorities based on the digital needs of local villagers. The public sector played an important role in technology innovation, deploying the network and providing the capital expenditure funding for setting up the network infrastructure in the villages. The private sector partners provide the bandwidth through their backhaul network. Moreover, the communities are engaged in maintaining the network and managing the security of the devices, while local youth from the village community are effectively engaged through skills development and training[161].

Operational sustainability

Initially, the Gram Marg tested TV White Space (TVWS) for reaching non-line-of-sight locations, but following the non-renewal of the trial licence, the project had to revert to unlicensed Wi-Fi frequencies such as 5.8 GHz for middle-mile connectivity[162]. Internet access differs depending on the type of institutional model in the villages. In the first cluster of 15 villages which employs the institutional model, Internet access in the form of Wi-Fi is offered at *Gram Panchayat* offices only. In the second cluster of villages that employ the village entrepreneur model, Wi-Fi access points are deployed at strategic locations that can be accessed in and around those locations. Overall, 60 Wi-Fi hotspots have been deployed in the ten villages at the *Gram Panchayat* office, primary healthcare centres, at least one school, and at a community centre[163].

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158 Belur, 'Addressing Sustainability in Rural Connectivity: A Case Study of Gram Marg Community-Led Networks', 155.
159 Belur, 'Addressing Sustainability in Rural Connectivity: A Case Study of Gram Marg Community-Led Networks'.
160 Belli and Hadzic, 'Community Networks: Towards Sustainable Funding Models'.
161 Belur, 'Addressing Sustainability in Rural Connectivity: A Case Study of Gram Marg Community-Led Networks'.
162 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'; Belur, 'Addressing Sustainability in Rural Connectivity: A Case Study of Gram Marg Community-Led Networks'.
163 Belur, 'Addressing Sustainability in Rural Connectivity: A Case Study of Gram Marg Community-Led Networks'.

In addition to providing connectivity, the initiative facilitates a wide range of services through the government e-service centres at the *Gram Panchayat* offices. The VLEs also help community members carry out government transactions and make payments, such as for TV and electricity bills, on their behalf[164].

Policy sustainability

The initiative is well integrated with all sectors of society, including local and national governments and is aligned with Government of India policies. However, Gram Marg is also limited to using unlicensed spectrum through India's regulatory environment as the experimental licence for TVWS was not renewed following the trial period[165].

Socio-cultural sustainability

The initiative aims to build the capacity of VLE by offering training that enables them to operate the network and earn a living. IIT Bombay also partnered with Impact India to support an outreach and adult learning programme based on videos developed by Tata Trust, which are shown at the premises of *Gram Panchayats* and in some schools[166].

Key learnings

The Gram Marg project in India demonstrates the importance of multistakeholder partnerships, and particularly the involvement of government, for organizational sustainability. The project pioneered the Public-Private-People-Panchayat Model (4P), which includes the involvement of the local village administration and a bottom-up approach. The project also involves partnerships with private and public sector partners. The former provides the bandwidth through their backhaul network. The latter plays a vital role in technology innovation, deploying the network, and providing the capital expenditure (CAPEX) funding for setting up the network infrastructure in the villages. The involvement of different partners in the project has enabled the initiative to achieve organizational sustainability by leveraging the strengths of each partner, ensuring that local needs are met.

The initiative is testing two different financial and organizational models for sustainability in different clusters of villages. While both models have proven to be organizationally and financially sustainable, the entrepreneurial model has shown promising results in revenue generation, more comprehensive Internet access throughout the community, and empowerment of local villagers through their activity as entrepreneurs. The test thus demonstrates that different organizational models can be successfully employed while highlighting that more decentralized models that focus on community engagement can significantly impact the community.

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164 Bidwell and Jensen, 'Bottom-up Connectivity Strategies: Community-Led Small-Scale Telecommunication Infrastructure Networks in the Global South'.
165 Bidwell and Jensen.
166 Belur, 'Addressing Sustainability in Rural Connectivity: A Case Study of Gram Marg Community-Led Networks'.

Computer Laboratory and Internet Community Centre (CLICC), Vanuatu

Country	Vanuatu
Stakeholders / Partners	Local School administration Government
Year initiated:	2016
Type of initiative	School computer labs
Business model	Levies for students and coupons for community members Initially funded by the Government (2-year period)
Technology model	Data subscription from local ISP

Overview

The Computer Laboratory and Internet Community Centre (CLICC) programme was developed together with the Tablets for Schools (TFS) programme under Vanuatu's Universal Access Policy to make schools hubs for community Internet access. Across the country 19 schools were selected for the programme, which involved investments in broadband links, computer labs and networking equipment, gateway servers with educational resources and solar power for off-grid schools. Under the TFS project, investments included class sets of tablets preloaded with educational apps, charging trolleys, and training for IT teachers. Schools and local communities agreed to meet specific requirements to ensure the success of the programme. An important aspect was that the community had to be engaged and that the site would be open for use by the community during non-school periods[167].

Financial sustainability

Over an initial 2-year period, the Government funded the Internet service in the communities. After the end of the government support, the schools moved towards a self-financing model requesting a fee from students and other community members for the use of Internet services. The levies are largely seen as affordable by both students and community members. However, it was observed that some secondary schools have levies that will lead to income beyond what would be necessary for Internet subscriptions and might violate Ministry of Education (MoE) regulations. The financial model has proven to be successful as most schools have renewed their Internet subscription after the government subsidy ceased. However, some schools with unreliable Internet services or problems with other infrastructure have opted not to renew the subscriptions. Additionally, some schools, especially primary schools, struggle to finance trained staff.

Organizational sustainability

The centres are mainly governed by the school administration, although some schools operate under a community board. The successful operation of the centres often relied on finding the "right" person to manage the centre. Furthermore, the engagement and support of the school

[167] TRBR, 'Computer Laboratory and Internet Community Centre (Clicc) & Tablet for Students (Tfs) Programme Evaluation Report.'

principals is essential. However, in some cases, political issues such as rivalries between schools or tensions between different organizations active in the community made managing the centres more difficult. Additionally, the initiatives could benefit from increased engagement with the private and tertiary sectors to provide more services to community members. The centres have also yet to become a hub for e-government services and could benefit from increased cooperation with the Government.

Operational sustainability

Several locations had trouble with the infrastructure, including Internet blackouts and broken devices. The computing system was particularly susceptible to technical problems. While some issues were due to adverse events such as cyclones, they were compounded by a lack of repair procedures, conflicting arrangements with providers, and lack of skilled staff. Furthermore, some schools needed help with electricity supply despite installing solar panels. While the centres include gateway servers with local content that can be used offline, this was not accessible to everyone due to difficulties logging into the server. Additionally, not all local content is relevant to the schools since the content tends to focus on English and Eurocentric content[168].

Some of the schools, in particular primary and more rural schools, needed help to recruit and retain trained staff who are necessary to oversee the computer labs and ensure students and communities can benefit from the services offered. While the centres have proven beneficial for education, teacher preparation, and administrative purposes, they still need to develop into multipurpose service centres with various services. Nevertheless, some services such as disaster warnings, communication with overseas relations, and agricultural and entrepreneurial services also benefit the wider community[169].

Policy sustainability

As the centres are within schools, they fall under the jurisdiction of the Ministry of Education and, as such, do not face policy difficulties. Furthermore, the initiative is directly and indirectly addressed in the National ICT Policy, Universal Access Policy, and various educational policies[170].

Socio-cultural sustainability

To avoid negatively affecting its sustainability the initiative needs to be more closely integrated into the community than originally intended. For instance, some communities question whether it is worth paying for an Internet subscription. There are several barriers to community integration, including technical difficulties and downtime of infrastructure, lack of capacity, issues around ownership, lack of awareness of the benefits of the Internet and the computer lab despite awareness talks, and lack of relevant services. Additionally, socio-economic factors such as gender and age influence facility access. Women in the community and female teachers are less likely to access and benefit from the facility. Moreover, the higher secondary students

168 TRBR, 'Computer Laboratory and Internet Community Centre (Clicc) & Tablet for Students (Tfs) Programme Evaluation Report.
169 TRBR, 'Computer Laboratory and Internet Community Centre (Clicc) & Tablet for Students (Tfs) Programme Evaluation Report.
170 TRBR, 'Computer Laboratory and Internet Community Centre (Clicc) & Tablet for Students (Tfs) Programme Evaluation Report.

take up much of the capacity of the labs to the detriment of the younger students and other community members[171].

Key learnings

The CLICC programme has been successful in providing Internet access to remote communities. The investments in broadband links, computer labs and networking equipment, gateway servers with educational resources, and solar power supplies for off-grid schools have allowed for reliable Internet access in these communities. Additionally, the class sets of tablets preloaded with educational apps and charging trolleys, as well as training for IT teachers, have helped to improve educational opportunities for students in these remote communities.

The centres are mainly governed by school administrations, although some schools operate under a community board. The successful operation of the centres often relied on finding the "right" person to manage the centre. Furthermore, engagement and support by the school principals has been important, but sometimes this also presented challenges.

The centres could benefit from increased engagement with the private and tertiary sectors to provide more services to community members. Additionally, the centres have not become a hub for e-government services and could benefit from increased cooperation with the Government. Overall, the initiative has proven sustainable in terms of organizational structure, but there is room for improvement in community engagement and services offered.

Although the system of levies and vouchers has proven to be financially viable, it also created room for potential misuse in violation of MoE regulations. Therefore, a system of levies should be implemented by the MoE to avoid such abuse. Despite this, the initiative has proven financially sustainable overall, as most schools have renewed their Internet subscription after the initial period of government subsidy. The schools have generated enough revenue to cover the equipment costs and provide Internet access to the community. The initiative has also successfully provided access to educational resources and training for IT teachers, further benefitting the students and community members. It is important to note that while there are some challenges in terms of financial sustainability, the initiative has successfully provided Internet access to remote communities.

[171] TRBR, 'Computer Laboratory and Internet Community Centre (Clicc) & Tablet for Students (Tfs) Programme Evaluation Report.

Kinect – Papua New Guinea[172]

Country	Papua New Guinea
Stakeholders / Partners	Kinect PNG (ISP) Local Community/Local high school Local Members of Parliament (MPs) Kacific (Satellite Service Provider) Gurant Co (Development funder)
Year initiated	2021
Type of initiative	Telecentre
Business model	CAPEX funded by Kacific Operation funded through the sale of Internet vouchers
Technology model	VSAT

Overview

Kinect PNG[173] is an Internet service provider (ISP) providing fixed wireless and satellite services to the wider Papua New Guinea population. In partnership with Kacific Broadband Satellites Limited (Kacific), a satellite service provider and Gurant Co, a development funder, funds were provided to support up to 90 sites across Papua New Guinea as part of the COVID-19 pandemic relief programme[174]. Members of Parliament (MPs) supported the establishment of 63 sites as a community service obligation initiative. Most sites were installed in communities of approximately 150 people and above. Kacific provided the satellite infrastructure, bandwidth, a voucher system, and labour installation costs free to the site concerned, with a choice to include a polar power solution at an additional cost. Of the 90 sites established, approximately 88 sites, including all the government-established sites, have gone dormant, with only two sites still active and generating enough revenue and traffic to maintain sustainability. One of these sites is M'buke, a small island village off Manus Island, which demonstrated high community involvement[175]. Several community members financially supported the purchase of solar equipment and ensured active community involvement in operating the initiative and the sale of vouchers. In the other successful site, the local high school has been involved in the initiative and been responsible for reselling vouchers for the other successful site.

Financial sustainability

A grant provided by Kacific covered the initial CAPEX for setting up the infrastructure. The continued financial sustainability of the initiative then relies on the sale of vouchers to the community. The sites rely on for-profit operators to provide Internet service and Internet access vouchers. Otherwise, there are no commercial ISPs operating in these areas as the newly established VSAT terminals are often the only network infrastructure in these communities.

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172 Interviewee: CEO Kinect PNG.
173 Kinect, 'About Us'. Kinect.
174 Van Kampen and Sorhus, 'GuarantCo and PIDG Technical Assistance Support Investees Kacific Broadband Satellites Group and Acorn Holdings Limited to Respond to the COVID-19 Crisis in Asia Pacific and Kenya'.
175 Namun, 'M'buke Village Sets up an Amazing Community Wi-Fi and Internet Connectivity'.

However, most sites have failed to become financially sustainable. The two remaining sites have managed to ensure that the community can continue to pay for the service by purchasing vouchers. The Internet service provider charges for Internet by volume at USD 3 for 1 Gb per month. Internet bandwidth is sold to the community via vouchers priced at PGK 2 for 150 Mb per day, or PGK 6 for 500 Mb per week, with the daily voucher being the most popular option. The voucher seller keeps the profit as payment for selling the vouchers. Vouchers for at least 100 GB must be sold monthly for the solution to remain viable and operational. Typical revenues amount to about PGK 800-1000 per month.

In some cases, there was no initiative in place to ensure volunteers or support to educate the community, sell the vouchers, and ensure the system's continued operation. In the two operational sites, active community members ensure that the service is maintained and sell vouchers to the community for use. Finding reliable people for the voucher selling in the established locations was particularly challenging, leading to no commitments to repurchase after the stock was exhausted. Consequently, the sites started to fall into dormancy as the community could not purchase access to the Internet. Where sites had active participants such as M'buke, the solution is housed and maintained by a nominated individual, the vouchers are easily obtained, and the community continues to benefit from the solution.

Organizational sustainability

There are no formal organizational processes provided as part of the initiative. In the case of M'buke, the community had a meeting and established some ground rules for the operation of the service, providing some awareness on how it could be used. In the local high school, the general rule is that if the generator is operating, the solution can be used. Other than that, there are no formal rules. However, the community is encouraged to be involved in the initiative, mainly by selling vouchers.

Apart from early engagement by local MPs, there has been no further engagement by any other sector in this initiative. Many sites are in areas relying mainly on subsistence agriculture and some form of small handicraft industry. Some community members have asked how they can make money from the Internet, but there is a lack of advice on this matter. Due to the failure of so many sites and the lack of further direction, the district government has taken over the initiative. Several district governments have set up a business division to manage the resellers; currently, approximately 40 sites are ready to reconnect.

Operational sustainability

The VSAT systems provided have been in operation for many years and are generally seen as highly reliable. Currently, Kinect has an uptime of 99.5 per cent for the operating solution sites. In areas with little telecommunication infrastructure, VSATs are the only infrastructure providing Internet service and access. The quality of the Internet service provided is good and can support a good quality of service for Internet voice and YouTube video streaming services. Bandwidth is ample at 60 Mbit/s down and 5 Mbit/s up.

Depending on the installation method employed, very small aperture terminal (VSAT) solutions can be reasonably robust in extreme weather events. To the extent that any technology is future-proof, VSAT systems have been and will continue to be in operation for many years, and will experience improvements in speed, deployment, and size. Overall, the technology and

infrastructure used are fit for purpose for this environment with a Wi-Fi range of approximately 300-500 metres. Of all the VSAT units installed, only two have been replaced due to failure.

Most sites utilize a solar panel system to provide power to the network infrastructure and some utilize diesel generators. The estimated capital cost of the solar system was PGK 9 000 or about USD 2 600 for a 3-kW inverter, which readily supplies the infrastructure and could also power lights or community electrical equipment. At sites where a solar panel system supplies the power, there is also a battery backup to support the centre after sundown. Where a generator is used, the solution can only operate if the generator has fuel and is running. Consequently, with the necessity of paying for fuel, the site has an extra cost burden.

Local volunteers support the infrastructure. Those doing maintenance are provided with an essential pictorial checklist and instructions on what various lights indicate if an issue occurs. Kinect PNG provides a centralized monitoring system and has visibility over all sites Voucher sellers receive training in voucher procurement, receipting, and the essential reconciliation of funds.

The primary services provided to the community are Internet based. The younger community members predominantly use Internet for social media, whilst middle-aged community members tend to use the Internet to make calls and to view video applications. Although there is a lack of digital literacy, the younger community members are adept at picking up on how to use smartphones and so provide training and assistance to those who do not yet have such skills. Improving skills, particularly beyond basic applications, would be advantageous. To date, there are no government services provided.

Environmental sustainability

Power supply comes from a combination of solar power systems and fuel-powered generators. If solar panels were not included in the price and so not procured, the existing community generator would be used. Overall, there is minimal impact on the environment, apart from disturbances of installation, generator noise and pollution, and waste created by the disposal of electronic devices.

Key learnings

The initiative targeted the provision of Internet access to 90 communities, a target which was achieved during the initial funding period. However, following this period, most of these sites became dormant, highlighting the importance of long-term organizational and financial sustainability planning. The goal of the initiative was to become self-sustaining, but the lack of provisions for the organization and poor voucher sales led to a failed shift towards other forms of funding in many of the sites. Therefore, it is crucial to implement sustainability measures from the outset of any project to prevent the same issues from arising.

The initiative further emphasises the importance of political commitment and community engagement. Owing to the lack of governance mechanisms and organizational structure within the initiative it suffered sustainability challenges in the absence of ongoing political commitment. In contrast, the initiative thrived in areas where there was active community participation and engagement. Therefore, it is essential to incorporate community members and ensure their meaningful engagement when planning connectivity initiatives.

In summary, this case study highlights the importance of long-term planning for organizational and financial sustainability, as well as political commitment and community engagement. Without these elements, even the most well-intentioned initiative is at risk of failing. Therefore, from the outset, it is crucial to take a holistic approach to connectivity initiatives and consider all aspects, including governance, sustainability, and community involvement. By taking this approach, the initiative will have a greater likelihood of success and will serve as a more effective instrument for promoting digital inclusion and social development.

Community Telecentres – Kiribati[176]

Country	Kiribati
Stakeholders / Partners	Local school administration, Local Council, Communications Commission of Kiribati
Type of initiative	Telecentre
Business model	Initially funded under Kiribati's Universal Access Programme (1 year) Further funding through the sale of vouchers
Technology model	VSAT systems

Overview

The Communications Commission of Kiribati (CCK) has supported several telecentre projects under their Universal Access Programme (UAP). A total of 12 telecentres are operational, with four managed by local councils and eight by schools. These telecentres are in remote islands where Internet service is limited or non-existent.

Financial sustainability

The initiative is part of the Universal Access Programme (UAP) under the Communications Commission of Kiribati (CCK), which is responsible for procuring and supplying necessary equipment, such as VSAT, solar power systems and Wi-Fi, and for operating the Internet service. A grant finances the project under the UAP for the first year of service. After the initial year, the centre must be supported by the local council/school and continues to pay for support and for Internet service using internal or earned funds. For councils, the funds would initially be generated in part from voucher sales to the community, priced at AUD 1 for two hours of Internet access. The council of Kuria for example earned AUD 10 000 to support its centre. While a portion of the funds is allocated to payments for the Internet service and support arrangements, it remains unclear whether any surplus funds are reinvested. It should be noted that there are no mobile or other telecommunication services in this area, so the revenue may be much lower where additional services are available. Possible sources of further funding for Internet services remain unclear, but they may include an internal levy on parents or the sale of vouchers.

Services in the telecentres rely on commercial service providers to provide Internet. The cost of the Internet service provided is based on standard market rates, which are considered expensive in Kiribati. It may be possible for the CCK to negotiate a lower price based on aggregating all the sites.

Organizational sustainability

The governance of the centres varies depending on the local circumstances and is determined by local stakeholders. Council centres are controlled by the local mayor and other councillors, who decide how the centre will operate. The school centres are established mainly to provide services to the school, so the school principal essentially determines operational decisions with

[176] Information for this case study was collected through an interview with the Officer in Charge at the CCK.

the support of the Ministry of Education and advice from the school board, which also serves as a liaison to the local community. In both cases, there is no involvement of private sector or civil society organizations and limited community engagement.

Operational sustainability

The centres are connected to the Internet through satellite using VSAT systems. VSAT has been in operation for many years and is considered very reliable. VSAT systems are also resilient to extreme weather events, although the antennas can be damaged by powerful winds. New developments in satellite technology, are expected to increase the resilience of these systems to extreme weather events. The weakest part of the infrastructure is the end-user computing devices in the centres themselves. Electricity in all centres is supplied through solar cells, as none of the locations have access to grid electricity. This solar-based supply has proven to be highly reliable.

The centres mainly provide Internet connectivity to the communities and generally they provide this service reliably with appropriate bandwidth. However, there could be further improvement in these services, particularly in reducing the price of Internet connectivity. The operation of the centres relies heavily on a working Internet connection through the VSAT terminals as there are often no other forms of connectivity available that could be used as alternatives. Apart from Internet connectivity, there are no services available to the communities. However, since Kiribati is part of the labour mobility scheme the initiative could greatly benefit from e-government services supporting the scheme.

The CCK provided training to a few staff as part of the initial funding. However, for the most part, the local councils are responsible for managing the staff necessary for running the centres. Support for operations requiring specialized skills is contracted out to a service provider. In schools, there is typically an IT staff member on site. No additional personnel are engaged in the operation of the centres.

Policy sustainability

Currently, the centres are being implemented under the UAP. However, no further support is planned after the first year of initial funding. The CCK is reviewing the next round of UAP funding to support additional centres, and the Government is exploring plans to provide more services to schools.

Socio-cultural sustainability

The centres have limited community engagement beyond providing a space for congregation and connectivity. However, there is potential for increased engagement of communities through training in the centres operated at local schools. There are currently no initiatives to raise awareness of online security and privacy issues with community members, but the CCK is considering such programmes.

Key learnings

The telecentre project under the Universal Access Programme in Kiribati has successfully provided Internet connectivity to 12 remote islands with limited or no Internet service. In terms of operational sustainability, the initiative highlights the potential of satellite technology, which

has ensured the system reliability as well as the resilience of the system to extreme weather events. Further advances in satellite technology are expected to make satellite connectivity the preferred option to connect remote and hard-to-reach regions, particularly in the Pacific islands. Furthermore, solar power has provided a reliable and cost-effective source of electricity.

The project has been implemented with the support of the Communications Commission of Kiribati (CCK), which procures and supplies the necessary equipment, and operates the Internet service. The project's successful launch with government funding highlights the potential for governments to kick-start local connectivity initiatives. However, the project also demonstrates that it is crucial for financial sustainability to build a source of finance that can sustain operations after government funding has expired. In the case of Kiribati, successful initiatives have generated income for the local councils through the sale of Internet vouchers, enabling the local councils to continue supporting the centres after the first year of funding. Finally, the project highlights the potential for increased socio-cultural sustainability through community engagement and awareness-raising initiatives. While the telecentres have provided a space for congregation and connectivity, there is scope to increase community engagement through training programmes and other activities.

Telecentres under the Community Telecommunications Grants – Vanuatu[177]

Country	Vanuatu
Stakeholders / Partners	Telecommunications, Radiocommunications and Broadcasting Regulator (TRBR), Local Committees, Local schools
Year initiated:	2018
Type of initiative	Telecentre
Business model	Initially funded under the Community Telecommunications Grant (3 months) Further funding through the sale of vouchers and fees for other services
Technology model	VSAT

Overview

Starting in 2018, the Government of Vanuatu began to fund telecentres in schools, healthcare centres and other community institutions. Utilising a grant under the Universal Service policy the Government supplied equipment and initial funding for Internet connectivity in unserved or underserved communities. Following the expiration of government funding the communities then had to move towards other sources of funding such as the sale of vouchers and other service fees. The initiative was successful in establishing sustainable telecentres at several locations whereas other sites failed to continue operation beyond the government funding period.

Financial sustainability

The Telecommunications, Radiocommunications and Broadcasting Regulator (TRBR) of Vanuatu established a community grants scheme in 2018 called the Community Telecommunications Grant (CTG). The CTG was introduced as a complement to the Universal Access Policy (UAP) initiatives to provide support for improving coverage in unserved and underserved areas and to support ICT-related projects[178] in communities[179]. Since 2018 the CTG grants have continued to benefit schools, healthcare centres and communities. The grants, worth VUV 3 million or about USD 25 000, target small-scope projects focussing on improving access and service in poorly connected areas [180]. The funding supplies a community or school with VSAT equipment, Wi-Fi equipment including a voucher system, Internet service for three months, a solar power system, laptops, printers, and cabling.

Projects receiving grants are expected to be self-sufficient after the expiration of the grant funds. Consequently, the projects must be innovative in their proposed services. Initially, the sale of vouchers allowing timed access to the Internet was the primary means of raising revenue.

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177 The information in this case study was collected through interviews with the Universal Access and Service Co-ordinator at TRBR and the Spectrum Manager at TRBR.

178 Telecommunications, Radiocommunications & Broadcasting Regulator, Republic of Vanuatu, 'TRBR Releases Its 11th UAp Report on The Status of Implementation of the Government's UAP'.

179 Telecommunications, Radiocommunications & Broadcasting Regulator, Republic of Vanuatu.

180 Telecommunications, Radiocommunications & Broadcasting Regulator, Republic of Vanuatu, 'TRBR Releases Its 13th UAp Report on The Status of Implementation of the Government's UAP'.

However, this has been supplemented by other imposed fees, such as for charging devices, printing documents, and holding events for the community. An example from one site at the village of Erata, Tongariki Islands, provides an indication of the innovative fees that can be applied and the revenues that can be raised. Here the centre having achieved a level of self-sufficiency, managed to raise enough to have funds available beyond the operation costs. Continued monitoring of such cases will provide a greater understanding of the revenue streams available and of the propensity of the communities to use the service. It should be noted that the village of Erata is in an unserved area, so the community does not spend any income directly with the mobile operators and only uses this service.

Internet subscriptions are based on market rates and are currently VUV 20 000 or about USD 172 per month. This price is relatively high for the provision for this type of service. Future alternative services and increased speeds may see these prices drop to more realistic levels. When considering affordability for the consumer, the current price for a voucher for the village of Erata is VUV 100 (USD 0.86) for 24 hours and VUV 500 (USD 4.28) for seven days with no download limits. These are in line with market rates such as Vodafone's mobile prepaid broadband rates. However, there are limitations on the download volumes across the mobile network. At another site in Veni Matupavu, the cost of the voucher was VUV 50 (USD 0.43) for 2 hours, with no download limits, which compares favourably with standard mobile prepaid tariffs for data on the local mobile networks (VUV 50 for 300 Mb and 2 hours). There is no requirement from the TRBR that free services should be provided to any group, so it is therefore up to the community to decide whether to offer services at no cost to various interest groups. The Erata telecentre provides free Internet to several groups, including to persons with disabilities promoting a degree of equity for these users.

Organizational sustainability

The centres are owned and operated by the communities. To receive funding, the grant application must be submitted by the community and must demonstrate how the community intends to operate the centre and provide services. Therefore, substantial community participation is required to secure the grant, which ensures that subsequent services properly operated and maintained. Furthermore, the CRG grant requires that the community forms a representative committee to manage the centre. This committee is responsible for managing, operating, and planning the service provision of the centre. When the centre is in a school, representatives from the school, such as the principal and teachers, must be included in the committee. Some community centres have documented their governance procedures, while others have not. Documenting governance provides a better level of accountability and performance, and is an activity that the TRBR is considering replicating across all centres.

The TRBR can also play a role in facilitating conflict resolution. Although no official policies regarding conflict resolution exist, the community may initially seek assistance from the TRBR when traditional resolution methods fail. For example, at Venie Matupavu, several tablets went missing and were taken by a former teacher. The TRBR intervened to facilitate a resolution with the identified individual who took the tablets. In another instance, the TRBR is currently working to resolve a conflict among community members around the building that houses the facility.

There is no further engagement with private sector entities or other government agencies. However, other community-based initiatives may become involved with the centres. For example at the Erata Community Internet facility, an active committee established by the community

known as the Erata Development Committee oversees projects aimed at supporting the welfare of the Erata people. In other cases, however, such community initiatives have not always proven to be a reliable avenue for hosting and managing the facility.

Operational sustainability

The centres are connected to the Internet via VSAT systems. These VSAT systems have proven to be very reliable and relatively resilient to storms. However, in extreme weather conditions, the equipment can be damaged. Vodafone does provide a guide to disassembling and reassembling the VSAT dish in the event of severe tropical cyclones. Although this is a good idea, realigning the VSAT to the required satellite can be complicated, potentially resulting in prolonged communication outages. Newer satellite solutions, which allow users to disassemble the antenna quickly, bring indoors during such events, and promptly reassemble it after the event has passed, will improve system resilience.

Overall, the centres are highly reliant on functioning network infrastructure and failure of any component part can render the centre unusable. Network services are the most critical element, as Internet access is essential for operation; the centres do not host offline servers and are partially unusable if the Internet service is down. However, this setup reduces the support overheads typically associated with server-based environments. In cases where solar power is employed, a backup battery is used to support the centre after hours, while when grid power is utilized, a backup generator is required in case of power failure. The use of solar power presents challenges particularly when batteries run out and when they are not sufficiently recharged due to lack of sunlight, or when the system is undergoing maintenance. Even generators used to back up solar power can fail when fuel supplies have been exhausted. The low cost of a VSAT installation can be overshadowed by the expense associated with solar power infrastructure, including maintenance costs, as many installations are susceptible to corrosion from saltwater exposure. Power supply remains a persistent challenge in remote areas.

The primary purpose of the centres is to provide Internet services to the communities, and overall, the quality of Internet service is good based on current performance data, with no significant network downtimes reported. Other services offered to the communities include financial, educational, and health services. The delivery of educational services online has increased due to significant upgrades in educational systems driven by the COVID-19 pandemic. However, government services remain minimal. Although government websites are available, it is often challenging to use services such as requesting birth certificates online, and labour mobility services, requiring people to come to village to complete the transactions.

However, despite the low level of services, the telecentres have allowed communities to use the Internet and other services to communicate with friends and family. Telecentres also enabled persons participating in seasonal employment programmes to conduct research and take preliminary steps before committing completely. This group is pushing for improved government services so that all the preliminary checks and documentation can be completed remotely without the expense and requirement to travel until the date of departure for employment.

Insufficient human resources remain and will continue to be a challenge in supporting these centres. TRBR does provide some initial training and has in place several service providers that can provide further training. However, if there is little to no remuneration, people will consider alternative sources of employment, such as the Labour Mobility schemes, to support their families. People may also move into more populated areas where they can continue to grow

their skills, potentially leading to a need for constant training of people to support the centres. Trained staff is especially important, as the average user has a low level of computer literacy, although most are familiar with mobile phones and their operation. Despite low levels of digital literacy, access to the telecentre and the availability of services helps to improve the general users' level of computer literacy. Nevertheless, there remain opportunities for further training to improve the general users' literacy level in all aspects of digital technology.

Policy sustainability

The centres are established under the UAP and are led by the TRBR. Beyond this, there is no other government involvement in these projects, including for the provision of e-government services. However, a CTG grant application may require a community centre to be formally established under Vanuatu law to ensure proper governance.

Socio-cultural sustainability

Each community is relatively small and closely knit, which is typical in Vanuatu. The ability to develop a proposal for the grant and subsequent service demonstrates reflects a degree of solidarity and trust in the people leading the initiative. Moreover, within small and remote communities, these centres can provide a meeting place where people can come together to discuss issues or engage socially. An example of social engagement was the World Cup, where the Eratas centre provided the facilities for the community to come together and watch the event in comfortable surroundings. Additionally, the community centre is a centralized location where the community can access telecommunications services and access training in various online and ICT-related matters. Notably, the TRBR has provided ICT literacy training to centres in the past, and the expectation would be that such support would continue. Additionally, communities may benefit from a combination of government initiatives concerning cybersecurity and financial literacy, as well as TRBR initiatives in online safety and other ICT matters. In all cases, enhancing the knowledge of communities on ICT services enables better engagement and contributes to broader community development.

Environmental sustainability

Most sites have no grid electricity infrastructure; therefore, all power is solar generated. Some localities, such as Brenwai in Malekula, are connected to the grid and have access to hydroelectric generated power. Where centres are located on the grid, power is predominantly provided by diesel generators. All locations utilize generator backup in case battery systems fail. There are currently no policies or initiatives regarding e-waste in Vanuatu. However, the TRBR is considering developing an e-waste guide as, to date, e-waste is disposed of together with general waste, posing potential environmental risk. The issue will be the costs associated with shipping waste offshore for recycling; however, any revenue generated by the programme would help offset these costs.

Overall, the initiatives have minimal environmental impact apart from building construction. Construction activities have been carried out in specific locations to improve accessibility, service provision and future extensions to other local sites. Furthermore, VSAT infrastructure has little impact on the environment, as the structures are very small but do require a concrete plinth to be constructed to support them. Depending on the antenna's pointing angle, clearing of vegetation is generally unnecessary as the VSAT infrastructure site is typically already cleared.

Key learnings

The Community Telecommunications Grant (CTG) in Vanuatu provides community infrastructure to improve access to information and ICT-related projects in underserved and unserved areas. The implementation of the CTG in Vanuatu demonstrates how government can support connectivity initiatives by taking on the initial capital expenditures which are often beyond the financial capacity of local communities. The initiative further demonstrates that it is possible to become financially self-sufficient if the appropriate framework is in place.

The project further demonstrates that community engagement in the initiative can be achieved if the appropriate framework is adopted. Applying for the funds requires communities to cooperate and show sufficient commitment and community organization. However, to further build on this community engagement and fully benefit from the establishment of the telecentres, the initiative should also include services and training that go beyond connectivity.

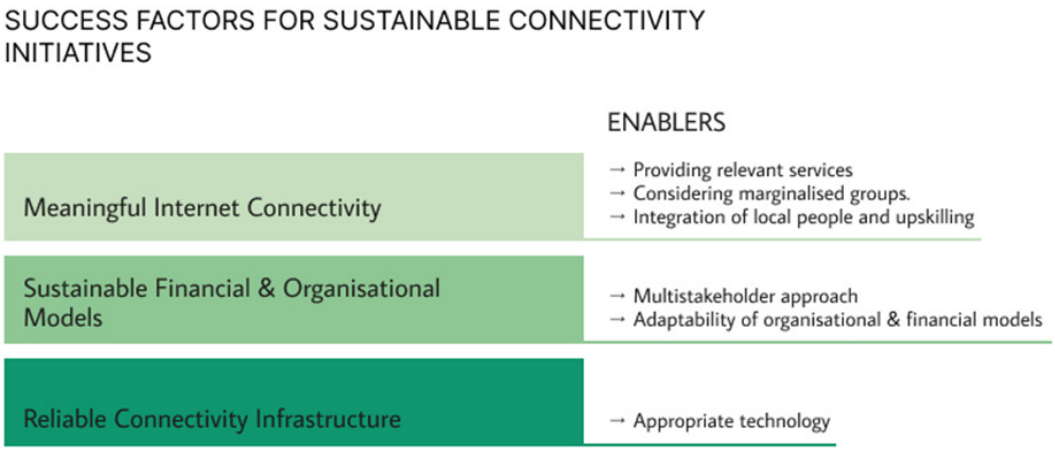
The telecentres in this case study demonstrate the potential of VSAT technology to connect remote and hard-to-reach areas such as the Pacific islands. While the initial investment is substantial, VSAT terminals are very robust and can withstand extreme weather conditions. This technical setup also provides a reliable, high-bandwidth Internet connection with minimal environmental impact. Likewise, solar panels have proven to be a reliable and environmentally friendly solution for power generation within the context of these connectivity initiatives.

Section 5: Conclusion

Summary of key learnings

Analysis of the case studies reveals their strengths and weakness across several sustainability dimensions including financial sustainability, socio-cultural, organizational, operational, policy, and environmental aspects. Key factors contributing to sustainability include meaningful connectivity, the existence of sustainable financial and organizational models, and the development of reliable connectivity infrastructure. Meaningful Internet connectivity is enabled through the development and provisioning of relevant services, consideration of marginalized groups, and the integration of local people and the development of their skills. Reliable connectivity infrastructure is enabled by the deployment of appropriate technology.

Figure 4: Factors for successful sustainable connectivity initiatives



Source: ITU

Multistakeholder approach

The analysis of the case studies underscores the significance of a broad coalition for the sustainability of connectivity initiatives. Local government engagement and support, as exemplified by the Gram Marg project in India, can greatly contribute to organizational sustainability. Incorporating the private sector can establish sustainable backhaul connectivity and strengthen operational sustainability. Private sector involvement can also take the form of social enterprises, such as TakNet in Thailand or the Ungu CoLTE network. Academic institutions, as observed in many of the projects examined, can further support connectivity initiatives. Effective relationships between various stakeholders are crucial for a multistakeholder approach to succeed. Overcoming barriers related to the remoteness of target communities, as exemplified by the TPOA initiative in Malaysia, can be addressed through the deployment of appropriate technology.

Integration of local people and upskilling

All the case studies have shown that successful engagement with local community members is beneficial to both the community and the sustainability of the project. Conversely, poor engagement, can result in underutilization of the services offered and to sustainability challenges, as observed in the CLICC project. Establishing an initial presence in the community that demonstrates the benefits of connectivity, such as the digital resource centre in the W4C initiative in India, can be beneficial to the effective engagement of the local community. Furthermore, training the local community to operate, maintain and extend the networks is crucial to successful community engagement, as demonstrated by the TakNet initiative in Thailand and W4C in India. The Barefoot Engineers in the W4C project demonstrates the significant potential of this approach. Finally, as was demonstrated in their institutional model, the GramMarg initiative highlighted that while connectivity initiatives may potentially be sustainable without a great deal of direct community engagement, as demonstrated in their institutional model, the project will be more beneficial to the community if the community is fully engaged.

Adaptability of organizational models

To effectively bring connectivity to underserved communities in the Asia and the Pacific region, it is important to adopt a flexible approach that considers the varied contexts of each country and environment. The case studies highlighted above demonstrate that there is no one-size-fits-all solution to connectivity challenges. Instead, sustainability can be achieved through creativity, and flexibility in the deployment of technological, organizational, and financial solutions. These can include multiple approaches with different advantages and disadvantages for the same location, as shown by the GramMarg initiative. TakNet also demonstrates the importance of adapting to changing circumstances and growing networks to increase sustainability. In contrast, the Ungu CoLTE initiative showcases the potential for innovative technical solutions, such as establishing a data-only mobile network to increase operational sustainability while navigating regulatory challenges. By being open to flexible and creative solutions, connectivity initiatives can better serve the needs of underserved communities and promote digital inclusion and social development.

Appropriate technology

The case studies indicate that regulatory conditions can limit the technologies available for providing connectivity to communities, leaving many of the initiatives analysed with little choice but to utilize unlicensed Wi-Fi spectrum. However, innovative technological solutions can enable sustainability across various dimensions beyond operational sustainability. For instance, the implementation of a virtual remote management system (VRMS) in the TPOA initiative in Malaysia, has been crucial in enabling organizational sustainability through the construction of an interactive ecosystem between the four communities with telecentres, other indigenous communities, telecentre managers, and university researchers. Similarly, the creative solution of the CoLTE network in the Ungu community in Indonesia, has allowed the project to offer better services, thus increasing operational sustainability while addressing regulatory concerns. Another important consideration must be value for money of the connectivity infrastructure. In particular, the chosen technology must provide Internet services that are affordable for the community, otherwise, there is a risk of the operation becoming dormant as was demonstrated at the Kinect Network in Papua New Guinea. The case studies show that in the context of remote islands in the Pacific, VSAT can provide an alternative to other backhaul connectivity

solutions. The relatively low cost of the terminals and the ability of VSAT to provide connectivity to otherwise hard-to-reach communities make it a viable solution. Therefore, the appropriate technological solution can support various sustainability dimensions and contribute to the success of connectivity initiatives under various conditions.

Importance of relevant services

Local relevance is a crucial aspect of sustainability for connectivity initiatives. Across the case studies, services that are tailored to the needs of local communities have been shown to play a significant role in determining both operational and socio-cultural sustainability. The case of W4C is a prime example of how connectivity can be used to empower local livelihoods. In the village of Chanderi, connectivity combined with relevant services resulted in a doubling of the average household income. However, the benefits of appropriate services go beyond the economic sphere. In the TPOA programme, services were tailored to the specific needs of indigenous communities. This tailoring of services made the initiative relevant and beneficial, ultimately allowing communities to gain recognition of ancestral land through engagement with the community telecentres.

Consider vulnerable groups

The success of connectivity initiatives relies on the consideration of the needs of vulnerable groups including person with disabilities, women, indigenous peoples, and youth, along with overall cultural sensitivity, to ensure benefits for the whole community. The W4C initiative serves as a successful example of this, as the initiative prioritized empowering women through improved connectivity, leading to improved livelihoods for many women in the community. This emphasis on gender equality was pivotal to the overall socio-cultural sustainability of the initiative.

Recommendations for Smart Villages and Smart Islands

Leverage appropriate technology

The literature and the case studies highlight the importance of selecting technology that provides reliable services at affordable prices. However, initial employment of connectivity infrastructure can be expensive. It is therefore recommended to leverage partnerships with donors and private sector companies for initial CAPEX for connectivity initiatives. Furthermore, regulatory environments can sometimes limit the choice of technology. It is therefore recommended to work closely with relevant agencies to find ways to leverage the existing policy environment and work towards connectivity policies that support local connectivity initiatives. Lastly, technology beyond the network infrastructure itself can support connectivity initiatives. Appropriate management systems and end user devices can support the overall sustainability of connectivity initiatives.

Employ a multistakeholder approach

The literature and case studies illustrate the value of a multistakeholder approach in achieving various dimensions of sustainability for connectivity initiatives. Therefore, it is recommended that such initiatives adopt a broad multistakeholder approach in their operations, involving

both local and national government actors. Government actors can provide resources and ensure the legal and political legitimacy of the initiative while also integrating government services to make the initiative more relevant to local communities. Partnerships with the private sector can also be beneficial since they can contribute to deploying or operating the infrastructure, providing funding or expertise, and offering other services that are relevant to the community. In addition, civil society organizations such as NGOs, social enterprises, or academia can support the initiative's sustainability through capacity building exercises and activities, managing infrastructure and services, developing new relevant digital services, and identifying new innovative solutions to address the initiative's sustainability challenges.

Ensure local community participation and ownership

The participation and ownership of the local community is vital for the sustainability of connectivity initiatives. Without their involvement, most projects are likely to fail. The community should be engaged from the outset to ensure that the project serves their needs, and a thorough needs assessment should be conducted to ensure that these needs are addressed by the proposed connectivity initiative. Sustainable connectivity initiatives should also offer services beyond connectivity to remain relevant to the community. Additionally, the community should be viewed as an asset for the deployment and operation of the project. Initiatives should include training for local community members so as to involve them in maintenance and operation tasks. In the long term, sustainable connectivity initiatives should aim to be financially self-sufficient, and managed by local community members, requiring as little external support as possible.

Consider the local context

Sustainable connectivity initiatives can employ various operational and organizational models, depending on the local context. The technology, business model, or form of organization should be carefully selected to ensure the success and sustainability of the initiative. While innovative technologies can contribute to sustainability, they need to be well-matched to the local context to avoid failure. Factors such as weather conditions, maintenance requirements, local skills and external support, and existing infrastructure need to be considered. Moreover, the appropriate form of organization should encourage ownership by the local community, and the organizational and business model should reflect the local cultural and political context and the attitudes of the community towards the project. Therefore, before designing any sustainable connectivity initiative, a thorough assessment of the local context and conditions should be carried out.

Increase data availability

To evaluate the sustainability of a connectivity initiative, it is crucial to have access to relevant data. However, this report has revealed that many initiatives fail to collect or publish data on their operations and impact. Therefore, it is recommended that connectivity initiatives prioritize impact reporting to ensure transparency, knowledge sharing, enable communities to drive similar connectivity initiatives, and the continued success of their projects. Additionally, further research is necessary to validate the findings of this report. In both future research and reporting of initiatives, all sustainability dimensions should be considered. It is important to recognize that the dimensions discussed in this report are interconnected. Data collection and comprehensive analysis of the overall sustainability an initiative requires consideration of all dimensions of sustainability.

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Annex 1: Case study guiding questions

Financial sustainability

Resources:

- To which extent does the initiative manage to survive economically, i.e. to afford the necessary hardware and labour necessary for the continuous operation?
- To which extent can the initiative ensure that it has enough resources, supporters, workers, volunteers, and users?

Business model

- What is the business model of the initiative?
- To which extent does the initiative rely on internal funding sources?
- To which extent does the initiative rely on external funding sources? How regular are they?
- Are there possibilities for the initiative to obtain public or municipal funding, or to cooperate with municipalities, public institutions or the State in providing access and services?
- To which extent does the initiative rely on a single individual, or a on small group of actors to provide the necessary resources (time, skills, money)?

Relationship with for-profit operators

- To which extent does the initiative rely on a commercial provider? What is the nature of this provider (e.g. for-profit vs social enterprise or local vs non-local)?
- To which extent does the model of network provision face competition from commercial for-profit telecommunication companies based on the quality of signal/provision, lower cost and/or better network maintenance?

Network wealth for all:

- To which extent does the initiative provide gratis/cheap/affordable network and Internet access for all and services?
- If subscriptions are used, are they affordable?
- To what extent are there different pricing schemes, such as for residential users, small enterprises, bigger firms, and public institutions (e.g. schools)?

Organizational Sustainability

Governance

- How is the initiative governed? How does it decide on which rules, standards, licences, etc., are adopted?
- To what extent does the initiative allow and encourage the participation of community members in governance processes?
- To what extent are there mechanisms in place for conflict resolution and for proceedings in the case of the violation of community rules?

Data ownership and control:

- What are the policies and practices in place to protect the data privacy of the community?
- Does the initiative provide capacity and awareness building of the community around issues of online safety and privacy?

Multistakeholder engagement

- To what extent are stakeholders from various sectors part of the initiative?
- To what extent is the initiative controlled by the community? Is the initiative collectively controlled by its members as a commons?
- To what extent is the initiative controlled by the local/municipal authorities?
- To what extent is the initiative controlled by private corporate interests?
- Is the initiative part of large regional networks or organizations?

Operational sustainability

Infrastructure

- How robust is the network infrastructure used for service delivery?
- To what extent does the Initiative rely on a single infrastructure, or to what extent is service delivery dependent on functioning network infrastructure?
- How reliable is the electricity supply, and what type of electricity supply is used?
- How resilient is the infrastructure to adverse events such as extreme weather?
- Is the technology used "future-proof"
- Is the technology used suitable for the purpose of the network?

Service delivery

- How reliant is the initiative on the Internet?
- To what extent does the initiative have the capacity to deliver good quality services?
- Are there enough trained staff?
- Are the services offered high quality and relevant for the local populations?
- Are government services involved?
- What technological skills are required of the average user to benefit from the initiative?
- To what extent are the community needs served by the initiative?
- To what extent are the needs of local businesses served by the initiative?

Policy sustainability

- To what extent is the local/regional/national government involved/supportive?
- To what extent are e-government services part of the initiative?
- Is the initiative recognized/supported by relevant policies?
- What is the legal framework of the initiative?
- Is the initiative legally incorporated in a form that supports its primary functions?

- Is the initiative engaged in a dialogue with policy-makers and/or advocacy?

Socio-cultural sustainability

- How closely knit is the community? To what extent are trust and solidarity present, and how are they manifested?
- To which extent does the initiative provide mechanisms for learning, education, training, communication, conversations, community engagement, strong democracy, participation, cooperation, and well-being? In what ways?
- To which degree is the initiative able to foster a culture of togetherness and conviviality that brings people together? In what ways?
- Are those who work professionally for the maintenance of the network fairly remunerated for their labour so they can lead decent lives?
- To which extent are the needs of diverse individuals (e.g. by gender, age, nationality) and groups in the community served by the initiative?

Environmental sustainability

Energy use

- To what extent does the initiative rely on relatively environmentally friendly energy sources (wind, solar, tidal, wave, geothermal, biomass and waste energy)?

E-waste

- To what extent does the initiative have policies and practices in place to reduce the amount of e-waste through repairing, recycling, and use of sustainable hardware?

Impact on the environment

- To what extent does the initiative's infrastructure impact the environment?

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