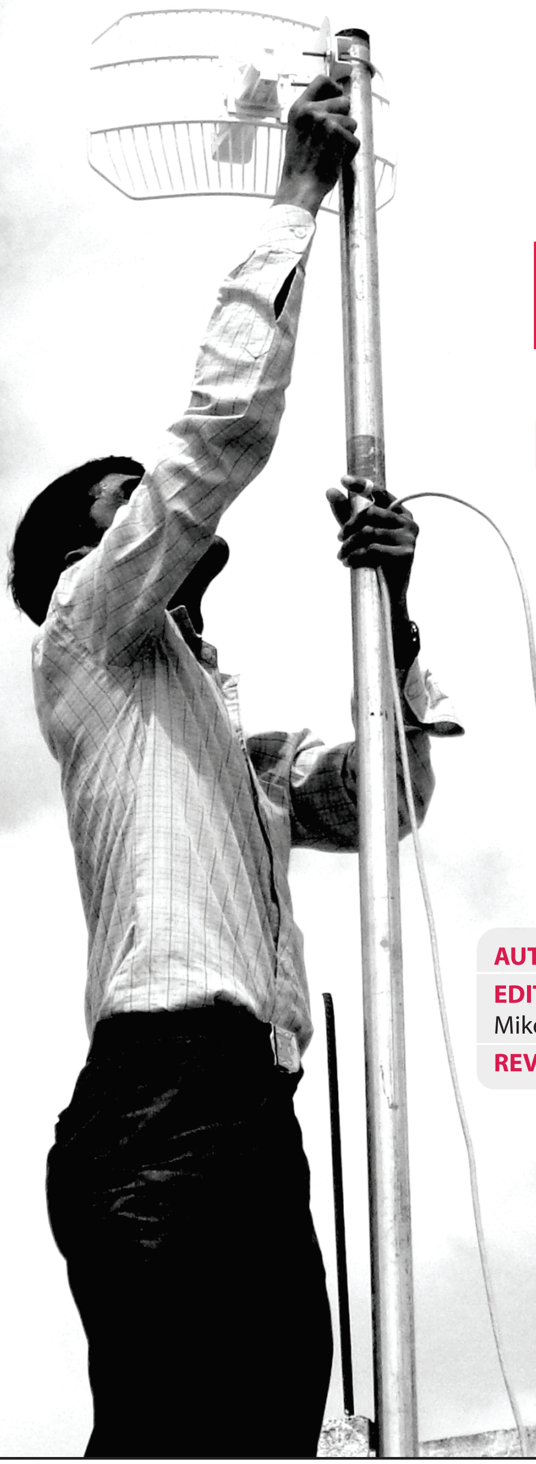
POLICY PAPER



Community Networks

REGULATORY ISSUES AND GAPS

EXPERIENCES FROM INDIA

AUTHOR: Ritu Srivastava (Digital Empowerment Foundation)

EDITORS: Konstantinos Komaitis (ISOC), Jane Coffin (ISOC), Mike Jensen (APC) and Michael Oghia (ISOC)

REVIEWER: Osama Manzar (Digital Empowerment Foundation)

Internet Society

DEF DIGITAL EMPOWERMENT foundation

Community Networks

REGULATORY ISSUES AND GAPS

EXPERIENCES FROM INDIA

AUTHOR: Ritu Srivastava, Digital Empowerment Foundation

EDITORS: Konstantinos Komaitis, ISOC; Jane Coffin, ISOC; Mike Jensen, APC; and Michael Oghia, ISOC

REVIEWER: Osama Manzar, Digital Empowerment Foundation

Community Networks: Regulatory issues and gaps
Experiences from India

Written by Ritu Srivastava
Edited by Konstantinos Komaitis, Jane Coffin, Mike Jensen, and Michael Oghia
Reviewed by Osama Manzar
Cover designed by Ravi Kumar Yadav
Design & layout by Ravi Kumar Yadav

Published & distributed by Digital Empowerment Foundation

You can read the online copy at www.defindia.org/publication-2

Contact
Digital Empowerment Foundation
House No. 44, 2nd & 3rd Floor (Next to Naraina IIT Academy)
Kalu Sarai, (Near IIT Flyover), New Delhi – 110016
Tel: 91-11-42233100 / Fax: 91-11-26532787
Email: def@defindia.net | URL: www.defindia.org

CONTENTS

ACKNOWLEDGEMENTS

This paper reflects views and opinions of community network providers who are trying to build their own low-cost and effective infrastructure for providing Internet connectivity. We would like to express our gratitude to all the stakeholders and members from community networks that provided their input. The report improved considerably thanks to the feedback from those who read its initial versions: Konstantinos Komaitis, Jane Coffin, Mike Jensen, and Michael Oghia. Special thanks to Ritu Srivastava for making this report possible. Furthermore, we would like to thank the Internet Society, which commissioned this research effort and provided generous support and guidance.

ACRONYMS & ABBREVIATIONS

3G	Third-generation wireless mobile telecommunications
4G	Fourth-generation wireless mobile telecommunications
AAI	Airports Authority of India
AGR	Adjusted gross revenue
ANATEL	National Telecommunications Agency of Brazil
BDMA	Beam Division Multiple Access
BSL	Basic service licenses
BSNL	Bharat Sanchar Nigam Limited
BTS	Base transceiver station
BWA	Broadband wireless access
C-ISP	Community-based Internet service providers
CDMA	Code Division Multiple Access
CIRC	Community Information Resource Centre
CMTSL	Cellular Mobile Telephone Service License
CN	Community network
CPR	Common-pool resources
CWIRP	Community Wireless Infrastructure Research Project
dBm	Decibels relative to one milliwatt
DEF	Digital Empowerment Foundation
DFS	Dynamic frequency selection
DoT	Department of Telecommunications
DSL	Digital subscriber line
DTH	Direct to home
E-commerce	Electronic commerce
EC	European Commission
EGoM	Empowered Group of Ministers
EFP	Effective radiated power
EU	European Union
EV-DV	Evolution-Data and Voice
FBG	Financial bank guarantee
FCC	Federal Communications Commission

FM	Frequency modulation
FMC	Fixed-mobile convergence
Gbps	Gigabits per second
GHz	Gigahertz
GSM	Global System for Mobile Communication
HSDPA	High-speed Downlink Packet Access
HSUPA	High-speed Uplink Packet Access
IAB	Internet Architecture Board
IAENG	International Association of Engineers
ICT	Information and communications technology
IEEE	Institute of Electrical & Electronics Engineers
IETF	Internet Engineering Task Force
IGF	Internet Governance Forum
IIT	Indian Institute of Technology
INR	Indian rupees
IP	Internet Protocol
ISM	Industrial, scientific, and medical
ISOC	Internet Society
ISP	Internet service provider
ITU	International Telecommunication Union
Kbps	Kilobit per second
Km2	Square kilometer
KYC	Know your customer
L&R	Licensing and Regulation
LAN	Local area network
LMSC	Last-mile satellite connectivity
LoI	Letter of intent
LRK	Little Rann of Kutch
MAN	Metropolitan area network
MEIRP	Maximum Effective Isotropic Radiated Power
MHz	Megahertz
MIIT	Ministry of Industry and Information Technology
MIMO	Multiple input, multiple output

MLV	Medium-large villages
mW	Megawatt
NCBC	National Commission for Backward Classes
NFAP	National Frequency Allocation Plan
NGO	Nongovernmental organisation
NIC	National Informatics Centre
NTIA	National Telecommunications and Information Administration
NTG	New Technology Group
NTP	National Telecom Policy
NYU	New York University
OFDMA	Orthogonal frequency-division multiple access
OTP	One-time password
PBG	Performance bank guarantee
PoP	Point of presence
RF	Radio frequency
RFC	Request for comments
RISP	Rural Internet service provider
RLAN	Radio local area network
SDR	Software-defined radio
SMS	Short Message Service
SVB	Small villages and below
SACFA	Standing Advisory Committee on Radio Frequency Allocation
Test-Bed	Spectrum Sharing Innovation Test-Bed
TPC	Transmit power control
TRAI	Telecom Regulatory Authority of India
TSP	Telecommunications service provider
TTC	Tibetan Technology Centre
TVWS	TV white space
UASL	Unified Access Service License
UHF	Ultra high frequency
UMTS	Universal Mobile Telecommunications System
UN	United Nations
U-NII	Unlicensed National Information Infrastructure
USF	Universal service fund

USOF	Universal Service Obligation Fund
UWB	Ultra-wide band
VLV	Very large village
VOIN	Villages of India Network
VoIP	Voice over Internet Protocol
W2E2	Wireless Women for Entrepreneurship & Empowerment
W3C	World Wide Web Consortium
W4C	Wireless for Communities
WAS	Wireless Access System
W-CDMA	Wideband Code Division Multiple Access
WCN	Wireless community networks
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless local area network
WLL	Wireless in local loop
WMNT	Wireless mesh networking technology
WPC	Wireless Planning and Coordination Wing
WRC	World Radiocommunication Conference

EXECUTIVE SUMMARY

The emergence of a global "information society" is driven by the continuing development of converging telecommunications, multimedia broadcasting, and information technologies linked together by the Internet. The flow of information facilitated by the Internet strengthens democratic processes, stimulates economic growth, and allows for cross-fertilisation of knowledge exchange and creativity in a way never seen before. However, not everyone is able to benefit from this revolution yet, and many remain excluded mainly as a result of limited coverage of affordable broadband access and services. Efforts to address this situation at a small-scale at a local level often face a number of challenges in obtaining the necessary permits and resources – in particular for licenses and access to backhaul capacity, masts, and radio spectrum.

This document describes India-based Digital Empowerment Foundation's (DEF) Wireless for Communities (W4C) network project strategy for improving the availability of affordable broadband as a case study in understanding the legal and regulatory challenges of spectrum allocation and management, licensing regulation, and bandwidth issues in India. The first section of this document maps out the common elements of these challenges among community network providers, while the next section addresses the policy, legal, licensing, regulation, and bandwidth issues in India. This document investigates the efficacy of creating wireless community networks (WCNs), rural Internet service providers (RISPs), or community-based Internet service providers (C-ISPs), and explores policies that could help in creating widespread information infrastructure for the country to better connect the subcontinent.

The final section includes a number of recommendations for policy-makers, regulatory bodies, legislators, and related stakeholders. National recommendations include suggestions to minimise regulatory hurdles for small/rural Internet service providers (ISPs) and community networks in India, and exempt such networks from certain fees and taxes, in order to promote last mile connectivity, especially by making sufficient spectrum affordably available for use by rural and remote communities. The recommendations to regional and international organisations focus on creating a more enabling policy and regulatory environment for community networks more generally, applicable to any national context, specifically by:

1. Creating and implementing minimal and proportionate regulation that is technology neutral;
2. Ensuring spectrum is available for community networks to help close digital divides, expand Internet access, develop remote and rural regions, and promote the digital economy;
3. Promoting, disseminating, and supporting the adoption of the community network model through their existing communications channels; and
4. Implementing/expanding universal service funds so that community networks can draw from them in order to build infrastructure, develop networks, and maintain and scale operations.

The author,

Ritu Srivastava, has over 10 years of professional experience in Information Communication and Technology (ICT) development, managing programmes and projects. Her current area of interest, activities and research is in ICT at the grassroots level, Internet security, women empowerment, environmental issues, etc.

INTRODUCTION

Access to connectivity is now well recognized as an enabler of socio-economic development, and can help address many of the barriers that presently exist for marginalized members of society. However the 2016 International Telecommunication Union's (ITU) State of Broadband report points out that there are still about 3.5 billion people out of 7 billion people who are still not connected to the Internet[1]. This means that it took about 25 years to connect half of the world. To help ensure it does not take another 25 years to get the other half online, Digital Empowerment Foundation (DEF)[2] of India has been working to support unconnected communities obtain access to the Internet. Barriers to connectivity exist around the world, but these barriers can be eliminated through community-driven solutions and partnerships, maintains the director of DEF, Osama Manzar, who notes: "Most of the 3.5 billion people who are unconnected are socially underserved and economically impoverished. Innovative last mile connectivity as the means of providing basic infrastructure would make the world better and [more] equal."

Empowering individuals who are living in remote areas is only possible if Internet connectivity is not only available but also affordable enough to allow access to the wide range of information available on the Internet, from market prices, weather information, new opportunities, and new skill sets, to discovering dances, food recipes or how-to videos. Internet content covering the various economic, social, educational, and cultural aspects of human life, which is a democratic mechanism in and of itself, is growing every day, yet many communities are denied the current opportunities that the Internet provides due to non-availability of the Internet or limited access.

Working over the last 15 years, DEF has established one of the largest groups of community wireless Internet connectivity networks in India. By providing digital literacy skills through training programmes, it has enabled connectivity in regions where traditional and mainstream Internet service providers (ISPs) either do not wish to expand, or simply do not consider as relevant markets. DEF has also pioneered the process of training local community members (many of whom have not completed a formal education), to maintain community infrastructure[3].

Wireless community networks, also called community-based Internet service providers (C-ISPs)[4] are networks whose infrastructure is built, managed, operated, and administered

1. Available at: http://broadbandcommission. org/Documents/reports/bb-annualreport2016.pdf.
2. For more information, see: https://defindia.org. Additional information is also available at: https://www.internetsociety.org/sites/default/files/pub-IEEEIC-201205-en%20Wireless%20for%20Communities%20%281%29.pdf.
3. For more information, see: https://www.internetsociety.org/blog/development-asia-pacific-bureau/2016/12/build-internet-training-barefoot-network-engineers.
4. "Community networks, which can be broadly defined as telecommunications infrastructure deployed

by a community-driven organisation or by a community itself by pooling their existing resources and working with partners to start-up and scale their activities. These networks provide affordable access to the Internet, while also strengthening the local economy (Center for Neighborhood Technology, 2006). There are now hundreds of community networks around the world spread across diverse countries, located in underserved and geographically challenging areas[5]. Among them, more than 100 community networks have adopted a bottom-up approach instead of adopting the classic, telecom operator-driven, top-down approach. Some of these networks are located in Latin America(Argentina, Brazil, Mexico), Sub-Saharan Africa (South Africa, Kenya, Ghana, Congo), Asia-Pacific (India, Nepal, Pakistan, Indonesia, Australia, Afghanistan), the United States, Canada, and Europe (Germany, Austria, Hungary, Spain, Greece, Sweden, Croatia). Even though many community networks share common characteristics, each may use a different technology, or work under different governance or regulatory models within different socio-economic and cultural conditions. Even the management and governance structure of each of the community networks have been found to be different and diverse.

DEF's Wireless for Communities (W4C) programme[6] aims to provide affordable, ubiquitous, and democratically controlled Internet access in rural regions of India. Nevertheless, the program has faced – and in some cases, still faces – regulatory, policy, licensing, and legal challenges which hamper the process of establishing wireless networks in rural parts of the country.

This document uses DEF's Wireless for Communities programme as a means to understand the regulatory, policy, spectrum, and legal challenges in India and how they affect Indian community networks. The document identifies the common elements of policy, legal, and regulatory challenges among community networks that may challenge operations in other countries around the world, and presents recommendations that aim to inform national, regional, and international policy and regulatory frameworks. This document is part of a series of policy briefing papers, a collaborative effort between DEF & ISOC that address technological, content, sustainability, and organisational challenges, among others, which require further discussion in relevant national, regional and global policy fora.

---

and operated by citizens to meet their own communication needs, have been part of the foundations of Internet infrastructure since [its] early days. In recent years, the community networks movement has grown consistently, leading more and more voices to point to them as a solution for connecting the next billion, due to [the] increasing evidence of the role they do, and can, play." Quoted on page 6 of the May 2017 Internet Society report, "Supporting the creation and scalability of affordable access solutions: Understanding community networks in Africa," available at: https://www.internetsociety.org/sites/default/files/CommunityNetworkingAfrica_report_May2017_1.pdf.

5. For extensive catalogues and lists of community networks, see: https://goo.gl/oahE3H and http://netcommons.eu/sites/default/files/attachment_0.pdf.

6. For more information, see: http://wforc.in/.

RESEARCH OBJECTIVE

The primary objective of this document is to describe the legal issues surrounding spectrum allocation and management, licensing regulation, and bandwidth issues in India as they relate to community networks. The report outlines the technological and infrastructural challenges from a policy perspective in India, and identifies some of the common issues that may be faced by other community networks across the world. Finally, it also provides policy recommendations and suggestions to assist in deploying community networks in India.

METHODOLOGY

The research for this report draws on academic literature, and government and regulatory documents to analyze existing policies and programs. Two mapping methodologies were adopted, one that examined existing policies and the other that examined relevant stakeholders. Aside from the DEF networks, the community networking professionals in countries other than India also interviewed included:

NAME	COMMUNITY NETWORK AFFILIATION	COUNTRY
Mahabir Pun	Nepal Wireless Networking Project	Nepal
Josephine Miliza	TunapandaNet	Kenya
Carlos Rey-Moreno	Zenzeleni Networks	South Africa
Anya Orlova	Amazon Digital Radio Network using High Frequency	Brazil
Leandro Navarro	Gulfi.net	Spain

SECTION I: DEFINITION OF COMMUNITY NETWORK

The architecture of community networks (CNs) is usually based on wireless technologies designed to support their users' online interactions, including messaging or sharing data, and to bring Internet-related services to locations where ISPs do not offer Internet access. Various definitions of CNs exist, ranging from academic and technical definitions to government and regulatory definitions. For instance, Baig, Roca, Freitag, and Navarro (2015) define community networks as "crowdsourced networks" that are structured to be free, open, and neutral, built by community members and managed as a common resource. Elkin-Koren (2006) defined CNs as distributed architectures in which users implement a physically decentralised network through the decentralisation of hardware. The European Commission (EC) uses the phrase "community broadband model" and defines it as "a private initiative by the local residents of the community using a so called bottom-up approach."[7]

Overall, it can be said that CNs are an alternative and complementary approach to the traditional commercial model wherein Internet connectivity is not sold to end-users – instead, users effectively club together to establish connectivity between themselves, and then may use their collective bargaining power to purchase capacity to the rest of the Internet. Networks that are built this way are still just as much a part of the Internet, but present various "exceptional" features, in particular low cost and transparency. They are usually operated on a cost-recovery basis and provide public documentation on all technical and non-technical aspects. They are often based on collective digital participation - as crowdsourced networks, they may be structured to be open, free, and neutral,[8] relying on the active participation of local communities in the design, development, deployment, and management of the shared infrastructure as a common resource. Usually owned by the community and governed according to democratic principles, in terms of institutional models, community networks may be operationalised wholly or partly through local stakeholders and individuals, local non-governmental organisations (NGOs), private sector entities, and/or public administrative or governmental bodies.

CNs often rely on wireless mesh networking (WMN) technology[9] comprised of nodes and Wi-Fi access points that relay data, and route other nodes' traffic. The structure of these mesh

7. The idea of a decentralized network was key in creating the Internet: a network of networks without any central node would have been more resilient to possible attacks. Yet, the Internet then evolved in a different way, as today it is infamously clear that it mainly relies on a few operators and on large nodes. For more information, see: Pp. 20-21 of Elkin-Koren, N. (2006).
8. For a comprehensive history of community networks, see: http://netcommons.eu/sites/default/files/d5.1_history_v1.1.pdf.
9. For an overview of wired and wireless networking technologies, see: Settles, C. (2017). "Fiber & wireless: Stronger together for community broadband." Community Broadband Snapshot Report. Available at: http://cjspeaks.com/wp/wp-content/uploads/2017/01/snapshot-01-17.pdf.

networks permits the connection of numerous nodes which interlink members and connect them to the rest of the Internet. Data travels from one connected node to another in order to reach a node that is connected to the Internet, also known a "gateway node." In this way, the community network connects the community, and also allows them to access the Internet for their specific purposes relevant to their local interests and needs.[10]

In India, community networks are not specifically defined – the concept is still relatively unknown and, as a result, it is not in common parlance or in government ICT policy or regulation. The 'Consultation Paper on the Proliferation of Broadband through Public Wi-Fi Networks' by the Telecom Regulatory Authority of India (TRAI) in November 2016 identified them as "public Wi-Fi networks." The 'Consultation Paper' assigns a broader meaning and is not limited to the Wi-Fi hotspot created and/or licensed by telecommunications service providers (TSPs)/ISPs in public places (TRAI, 2016). The paper generally indicates that a commercial model is envisaged in which small entrepreneurs and even smaller private entities would sell Wi-Fi network services for public use.

Given the aim of this report and the importance of community networks in India and around the world, the paper highlights the challenges DEF's CN deployments have faced. To address these, recommendations to remove barriers for community networks in India have been identified which could benefit communities and empower people throughout the subcontinent. It is also hoped that these recommendations will be of value to people outside the country who are interested in developing and deploying their own networks to connect the unconnected around the world.[11]

Community Network Models in India

Compared to the level of need, there are relatively few examples of initiatives working to support or deploy wireless networks which focus specifically on communities that are excluded from access as a result of income levels, size, geography or discrimination. DEF[12], AirJaldi[13], and Gram Marg[14] are among the few community networks operating in India, providing basic Internet connectivity and enabling access to information for people who are living in the most rural and remote regions of India and to those unable to afford traditional Internet services provided by the established telecom providers.

10. For more extensive information, read Wireless Networking in the Developing World. It is a free e-book about designing, implementing, and maintaining low-cost wireless networks. Available at: http://wndw.net/.
11. For an extensive list of policy recommendations for connecting and enabling the next billion(s), see: https://www.intgovforum.org/multilingual/index.php?q=filedepot_download/3416/549.
12. DEF is also involved in an initiative called Barefoot College, which trains middle-aged women from rural villages worldwide to become solar engineers. In partnership with local and national organisations, the Barefoot College team establishes relationships with village elders, who help identify trainees and implement community support. For more information, see: https://www.barefootcollege.org
13. See: https://airjaldi.com
14. See: http://grammarg.in

AirJaldi began as a social nonprofit enterprise in Dharamshala, Himachal Pradesh, providing affordable wireless broadband connectivity in the most remote rural areas of India. Two engineers from Israel, Yahel Ben-David and Michael Ginguld, who had frequently visited Dharamshala wished to contribute to the development of Tibetan refugees by providing Internet connectivity to the Tibetan refugee community and help to connect them with local support institutions. There was no other connectivity infrastructure available at the time so they founded AirJaldi to provide affordable Internet access in cooperation with the Tibetan Technology Centre (TTC) in Dharamshala. Gradually, AirJaldi became a brand name, and lended its name to a newly established company called Rural Broadband Pvt. Ltd. Operating as a social enterprise on a commercial basis, AirJaldi is a national ISP (Class A) which presently owns and runs ten networks in six Indian states with a total of about 60,000 users[15]. There are more than 2,000 computers connected to the mesh network, of which roughly 500 have Internet access, while others connect via Wi-Fi hotspots, and the remainder are connected locally to an intranet.

Mumbai-based Gram Marg is in pilot/test phase. It was created by the Rural Broadband Project of the Department of Electrical Engineering at the Indian Institute of Technology (IIT) in Bombay in 2012 to test a commercial franchise model for rural connectivity using TV white space (TVWS)[16] to provide backhaul connectivity for Wi-Fi hotspots and kiosks. Currently there is no formal regulatory framework for the use of TWVS in India, however the Department of Telecom (DoT) of the Government of India granted an experimental license to IIT Bombay in 2015 to conduct tests using the TVWS bands in 13 villages in Maharashtra.

Along with the DEF project, these two alternative models also face various levels of policy and regulatory challenges, from spectrum management and regulation, spectrum availability, licensing processes, regulation of ISPs, and compliance-level issues that hamper the growth of Wi-Fi services or community networks in India, as outlined further below.

15. See: https://airjaldi.com/company
16. Gram Marg takes advantage of underutilised UHF TV band spectrum (called white space) to provide the backhaul for rural broadband access using LTE-A. For more information on TV white space, see: http://wireless.ictp.it/tvws/book

SECTION II: DEF WIRELESS FOR COMMUNITY (W4C) NETWORK PROJECT

W4C is a non-profit initiative of DEF supported by Internet Society (ISOC) and various other partners over the years. Launched in 2010, W4C's goal is to connect rural and remote locations of India where mainstream ISPs are unwilling to provide Internet connectivity (usually because their operations would not be commercially viable). W4C uses line-of-sight and low-cost Wi-Fi equipment based on the 2.4 gigahertz (GHz) and 5.8 GHz unlicensed spectrum bands to create community-owned and community-operated wireless networks in rural and remote locations of India. The project strives to provide affordable, robust, ubiquitous, and user-centric Internet access in order to enable local development, reduce poverty, and encourage civic participation. Aside from improving access to information in rural and remote parts of the country this also requires addressing the lack of content, products, and services originating from rural areas, which inhibits their economic development. Even in areas with infrastructure, people often lack the skills to use the Internet to its full potential. The lack of content in local languages as well as inadequate information and communications technology (ICT) training are also reasons for lower adoption in rural areas as compared to urban areas. In summary, the W4C programme has four main components:

1. Train the trainers in wireless network technology and transform them into barefoot wireless engineers (BWE) to link rural populations to the Internet;
2. Deploy wireless connectivity across rural communities, especially in clusters;
3. Create an open forum to discuss best practices and lessons learned, and to educate on issues from both a technical and policy perspective; and
4. Advocate for social enterprises and NGOs to be rural Internet service providers, especially by opening new channels to decision-makers, regulators, government officials, the private sector, civil society, and the technical community.

Most of the W4C networks are located in tribal and underserved areas where people have not used a computer or smartphone before, and where communities are unaware of how the Internet can be a part of their lives and help to fulfill their needs. Similarly, the community is unaware of the legal and regulatory frameworks involved in setting up the network.

For example, Baran is a unique district in Rajasthan where time appears to stand still. Spread across a 7,000 square kilometer (km2) area, Baran has just 82 km2 that is designated as urban. Out of the population of 1 million, more than 40 per cent are scheduled castes and scheduled tribes [17]. About 60 per cent of women are illiterate, while 85 per cent of the residents live in rural areas. The Sahariyas and Bheels are the majority among the tribes of

17. See: http://in.one.un.org/task-teams/scheduled-castes-and-scheduled-tribes/

Baran, who are mostly nomadic, homeless, and bonded laborers. They make a living on a day-to-day basis. Most people outside the area are not even aware of the Sahariyas' existence, as they live in a media-dark location.

DEF started working with Bheel and Sahariya tribes in Baran in 2007 and established Community Information Resource Centre (CIRC) to facilitate health and educational information services. DEF started its Baran network with the help of Sankalp, a community-based nonprofit organisation that has been working in Baran in the areas of Bhanwargarh and Mamoni, two major locations that could be identified as village councils. DEF provided 10 computers to begin the network, although there was no nearby tower in Bhawargarh. Five centres were created in different locations with two computers each which showed high demand, but there was no connectivity to connect these five centres. The only connectivity that was available at the time was via a mobile phone close to the signal tower.

Within the interior of Baran, there are a few wireless local loop (WLL) towers erected by the state-owned telecommunications company Bharat Sanchar Nigam Limited (BSNL). However, a few of those that were erected are not operational. None of the ISPs or telecom operators were interested in providing connectivity, perhaps because of low volumes and the high cost of infrastructure. So community members living in Bhawargarh used scrap material to build a 40-foot-high (12.2 meter) tower. Now that the tower is built and operational, it provides connectivity to seven centres. In most cases, however, community members were not aware of the regulatory challenges that exist. For instance, they were not familiar with the legal and regulatory conditions that govern telecommunications towers, and as a result, they did not realise they had actually committed an illegal activity while constructing the tower.

Now, the Baran W4C network is one of the widest coverage networks in the project, spread across 200 kilometers, connecting about 10 community information resource centres (CIRCs), which facilitate access to health and educational information services among others. The Baran network serves Rajasthan's two tribal communities, Bheel and Sahariya. Even if there is a disruption to the backhaul[18] link providing Internet connectivity, communities living in two different villages can still communicate using the intranet infrastructure that exists in the network. In this way, they are connected to both the Internet and to the local intranet infrastructure. Baran is a "backward district"[19] in the state of Rajasthan in India, which is largely populated by tribal communities and the district is also known for the practice of bonded labour. CIRCs are digitally enabled resource centres that are established at the village level to offer information and knowledge services in addition to digital, financial, and functional literacy to village folks. CIRCs are often used for services such as photocopies, printing, digital photography, lamination, etc., for which villagers would otherwise travel

18. Backhaul comprises the intermediate links between the core network or backbone network and the small sub-networks on the "edge" of the hierarchical network. For more information, see: https://www.youtube.com/watch?v=v-Jog34Ovco

19. There are 200 backward districts, identified by the Planning Commission, Government of India. These are least developed areas of the country comprising mostly marginal farmers and forest dwellers.

miles, often at the cost of the loss of their daily wages.

Attaining sufficient height for the tower can be a difficulty for community network providers, because if the height of the tower from the roof top is 5 meters from any building or 30 meters from the ground it requires SACFA clearance. A community network provider without an ISP license needs to use the tallest structure such as a water tank or naturally high locations such as a hill or bamboo trees to set up the tower.

These problems were apparent when establishing the network in Nichlagarh block, Rajasthan, located in the foothills of Mount Abu. It consists of many hamlets and is part of the Abu Road Tehsil (administrative division) of the Sirohi district. Nichlagarh is a tribal community without any functional telecom service, and the nearest backhaul connectivity was available 40 kilometers away. Being surrounded by mountains, it was not easy to bring backhaul connectivity from that distance, and setting up a sufficiently high tower was not an affordable option. As a result, it was necessary to place a router on a nearby mountain to bring backhaul connectivity from Abu Road to Nichlagarh CIRC. From there, the connectivity is provided to other institutions such as the local police station, school, shops, and ration outlets. In addition, the youth, who also have mobile connectivity, come to the centre every day to request they be allowed to access the Wi-Fi connection.

A similar issue was faced while setting up the wireless network in the Nalbari district of Assam. The town of Nalbari has a high density of trees and other green vegetation which limits visibility between sites. Thus, the setup and maintenance costs of the needed infrastructure is high, and to bring the bandwidth to such locations is also more difficult and expensive. To service the Nalbari District, DEF established one main W4C centre in Nalbari Town with access to a 10 Mbps Internet link. To provide the connectivity for the surrounding region, the team used bamboo poles as masts for the wireless routers in 8 locations, which provide Internet connectivity in 28 state government schools.

In an experimental project conducted by DEF under the W4C program, a line of sight connection was established from a moving vehicle with specialised and customised antenna. Called ZeroConnect, the vehicle is deployed in the large salt desert known as Little Rann of Kutch (LRK) in the state of Gujarat. The salt desert in the LRK is usually only functional from September to March, and in those months the Agariyas – the community that traditionally farm salt using salt pan farming techniques – move into the salt desert where they live in makeshift houses and their children go to makeshift schools in the desert.

The ZeroConnect project was designed to identify the locations in the desert where children gather to experience school learning. ZeroConnect mapped 17 locations where temporary line of sight links to a telecom tower located in a local police station could be created. After obtaining permission from the police station to share the tower infrastructure, the ZeroConnect vehicle established links to the 17 locations each day. With a fixed schedule, the special vehicle routinely travels to each location where the team adjusts the onboard antenna to link to the police station. Once the vehicle is connected to the Internet, connectivity is provided with the Wi-Fi hotspot which connects 20 tablets – enabling the Agariya kids to access the Internet and the unlimited source of learning content and games for entertainment.

ZeroConnect has also been using the connectivity to conduct a census of the deprived and uncounted population of the Agariyas, and locate them on online maps in order to demonstrate their existence to the government in order to help them obtain their entitlements. The whole area of LRK is called Survey Number Zero because they have never been surveyed by the government of India.

Overall, it can be noted that DEF has been using alternative approaches for providing connectivity which avoids setting up towers where possible. In this way, DEF limits the need to comply with regulatory procedures and the extensive paperwork required for building towers.

In summary, over the last six years, W4C has connected people in rural and remote locations in 38 districts across 18 states of India by deploying about 200 hub-base access points. These access points currently connect more than 4,000 people and user numbers are growing. Over the years, several other initiatives have emerged from the W4C umbrella project to build on the underlying connectivity that is provided. One such initiative has been the Wireless Women for Entrepreneurship & Empowerment (W2E2) project which helps women in grassroots businesses to make use of digital tools and e-commerce[20]. Similarly DEF has provided training to local community members to operate wireless technology to link rural populations to the information available on the Internet. To further localise the initiative, the project strengthens grassroots expertise by training community members in basic wireless technology, enabling these "barefoot engineers" to not only run and manage these networks, but also to pass on their skills to others. The programme also provides local content development and technology support to barefoot engineers.

In addition to the deployment of community networks in remote regions of the country, DEF advocates for rural ISPs to help democratise Internet access more uniformly. The W4C programme has proven that the use of unlicensed spectrum is an effective method of creating community networks and providing last mile connectivity. However, it is necessary to address the restrictions related to policy and regulatory challenges, which hamper the growth of community networks.

The next section of the paper identifies the regulatory frameworks regarding access to spectrum, bandwidth, and technical regulatory challenges in India.

20. For more information, see: http://defindia.org/w2e2/.

SECTION III: PUBLIC POLICY AND REGULATORY ENVIRONMENT ISSUES FOR COMMUNITY NETWORKS

The success of any community network depends upon a variety of factors such as organisational strategy and the participation of community members, but also on a favorable policy environment. In this respect the possibility of establishing and operating CNs may be directly or indirectly affected by public policies and regulations at the local, national, and/or international levels. For example, legislation may place data retention obligations on network operators or impose the responsibility to identify all users, and these requirements may jeopardise the development of CNs since the CN operator could be an undefined community without the capacity for data retention, and its users may be not identifiable.

According to the community networkers around the world that were interviewed for this report, most countries lack clarity or specific policies and regulation for community networks, which often creates additional challenges. It was also noted that much of the information related to CN policy and regulation is not easily accessible or the awareness of such policies is limited within regulatory bodies or the appropriate authorities. Most governments have some kind of spectrum management authority in place, but there is no specific spectrum allocated for community networks. On a positive note, many countries have allocated some spectrum for unlicensed use, although unlicensed spectrum bands can be either general purpose or application specific[21]. Nevertheless, most of these community network providers are using unlicensed spectrum to provide connectivity in rural and remote regions. However they lack specific regulations or operational guidelines set by the government and/or related authorities. This also means that CNs have generally not been able to access support from Universal Service Funds.

Unlicensed Spectrum & Spectrum Sharing – The Global Perspective

Unlicensed spectrum simply refers to a spectrum band that has pre-defined rules for both the hardware and deployment methods of the radio in such a manner that interference is mitigated by the technical rules defined for the bands rather than it being restricted for use by only one entity through a spectrum licensing framework. The continuously evolving nature of wireless communication technologies has created a need to devise methods in which radio spectrum can be managed more effectively and efficiently. Modern technologies such as orthogonal frequency-division multiple access (OFDMA), spread spectrum, frequency

21. For more information, see: https://www.itu.int/osg/spu/ni/spectrum/RSM-AWT.pdf.

hopping, Beam Division Multiple Access (BDMA), fixed-mobile convergence (FMC), ultra-wide band (UWB), and the potential for software-defined radio (SDR)[22] further facilitate spectrum sharing, enabling wireless users to coexist with each other, at speeds that continue to increase day-by-day (for example, see: Clarke, 2014; and Idachaba, 2017). By not requiring operators to obtain a costly license and special permission for its use, unlicensed spectrum[23] is an inexpensive and barrier-free option for meeting communications requirements.

The unlicensed 2.4 GHz bands have lately become very noisy and crowded in urban areas due to the high penetration of WLAN and other devices that are communicating in the same frequency range, such as microwave ovens, cordless phones, and Bluetooth devices. The 5 GHz unlicensed bands provide the advantage of less interference and higher bandwidths, but links are usually shorter due to the higher adsorption rate of these frequencies resulting in greater signal loss.

The Radiocommunication Sector within the ITU is the forum in which nation states agree to harmonise the use of radio frequency (RF) spectrum at the international level. According to the ITU, both vision and commitment are required when implementing policies for use of unlicensed spectrum to ensure the most optimal sharing of the resource. So far, spectrum policy development has not taken into account the innovation and flexibility needed to allow communities to also participate or engage in the process, particularly around unlicensed spectrum and spectrum sharing. However, international trends indicate that unlicensed spectrum is increasingly being seen as a viable approach to spectrum management, although still for a relatively limited number of bands.

During the 2003 ITU World Radiocommunication Conference (WRC), spectrum in the 5-6 GHz range was allocated for unlicensed use, and countries such as the United States, United Kingdom, and Canada have unlicensed these frequencies consistent with the decision made at the WRC (Longford & Wong, 2007). The FCC de-licensed the 5.15-5.35 GHz and 5.725-5.825 GHz frequencies, and also added 5.47-5.725 GHz to the unlicensed national information infrastructure (U-NII) band. The EC proposed that all of its member states de-license the 2.4 GHz and 5 GHz bands in 2003, which resulted in an increase of Wi-Fi bands in most EC member states[24]. The EC has also de-licensed the 433-434 megahertz (MHz) band, along with Australia, Malaysia, New Zealand, and Singapore.[25] In Brazil, dynamic frequency selection (DFS) is only required in the 5.470-5.725 GHz band, while China expanded the number of unlicensed channels in December 2012 to add U-NII-1, 5150 ~ 5250 GHz, U-NII-2, 5250 ~ 5350 GHz (DFS/TPC).

22. Unlicensed Spectrum. (2011). ICT Regulation Toolkit. Retrieved from: www.ictregulationtoolkit.org/en/Section.2843.
23. For more information, see: https://www.wi-fi.org/discover-wi-fi/unlicensed-spectrum.
24. No author. (20 July 2005). "Commission frees up frequencies for Wi-Fi." EurActiv. Retrieved from: https://www.euractiv.com/infosociety/commission-frees-frequencies-wifi/article-142740.
25. For more information, see: https://www.itu.int/en/ITU-R/study-groups/workshops/RWP1B-SRD-UWB-14/Presentations/International,%20regional%20and%20national%20regulation%20of%20SRDs.pdf.

A large number of countries now also are engaged in piloting the use of cognitive radios with dynamic spectrum assignment and the associated use of TV whitespace technologies [26]. Some countries, such as Singapore and Ghana, have progressed to develop regulatory frameworks for use of TVWS and dynamic spectrum sharing but no specific provisions have been made for community networks, and in some cases where national digital television broadcasting platforms are being established, the policy and regulatory environments are still in flux.

The next section examines the policy environment for CNs in India and how spectrum is being managed and allocated by the Indian government and its related bodies.

India: Policy & Regulatory Environment

Telecom Policy and Access to Internet

The Indian government has been addressing support for access to the Internet through a variety of strategies. In 2004, it published the Broadband Policy of the Government of India[27], which defined broadband as:

"An 'always-on' data connection that is able to support interactive services, including Internet access, and has the capability of the minimum download speed of 256 kilobits per second (kbps)."

In 2012, the National Telecom Policy (NTP)[28] was published, which aimed to "provide secure, reliable, affordable, and high-quality converged telecommunication services anytime, anywhere for accelerated, inclusive socio-economic development". The vision of the policy is to transform India into an empowered and inclusive knowledge-based society through telecommunications as the catalyst. The NTP underlined the need for reliable and secure telecommunications services in rural and remote areas, and mandated affordable high-quality broadband and telecom services throughout the nation to address the digital divide. Although the policy also worked toward establishing the "right to broadband", unfortunately the policy did not recognize community networks as a resource to provide last mile connectivity.[29] The NTP also did not identify community networks or public Wi-Fi services for the growth of rural Internet penetration in India.

Further, NTP 1999 envisaged the implementation of an Universal Service Obligation Fund (USOF) to encourage service providers to provide connectivity in rural remote areas of

26. See: http://dynamicspectrumalliance.org/pilots/
27. Available at: http://pib.nic.in/archieve/image/broadband_policy04.pdf.
28. Available at: http://meity.gov.in/writereaddata/files/National%20Telecom%20Policy%20(2012)%20(480%20KB).pdf.
29. Last mile or last kilometer connectivity is a colloquial phrase widely used to refer to the final segment of the telecommunications networks that deliver telecommunication services to end users. For more information, see: http://internet-governance.fgv.br/sites/internet-governance.fgv.br/files/publicacoes/community_connectivity_-_building_the_internet_from_scratch_0.pdf.

the country. The idea of creating an USOF was to strike a balance between the provision of Universal Service to all uncovered areas, including the rural parts and the provision of high-level services capable of meeting the needs of the country's economy. The resources for meeting the Universal Service Obligation (USO) were to be generated through a Universal Access Levy (UAL), at a prescribed percentage of the revenue earned by the telecom licensees to be decided in consultation with the Telecom Regulatory Authority of India (TRAI).

The USOF fund aims to:

1. Incentivise telecom service providers to venture into rural and remote areas;
2. Facilitate rural roll out of infrastructure;
3. Reduce costs and, hence, end user prices; and
4. Increase the affordability of telecommunications services.

According to DoT data, India has used just 30 per cent of the USOF it has collected since the fund was set-up in 2002-03. By comparison, Colombia used 84 per cent of USOF in 2011 according to global cellular industry body, GSMA. DoT usually provides USOF funds to the state-run operator Bharat Sanchar Nigam Ltd (BSNL) to improve connectivity in rural areas, however the services provided are not competitive, while private operators are not willing to go to rural areas because it is not commercially viable.

More recently, in 2011, the National Fibre Optic Network (NOFN) was initiated by the government to connect 250,000 gram panchayats through optic fibre to provide high-speed data connectivity. The government used the USOF to finance NOFN with an expenditure of INR 20,000 crore (2,00,000 million – about USD 4 billion). NOFN was expected to be finished by December 31, 2013, but it has been extended a number of times and is still not complete. Once NOFN is completed, private operators will still need to set up the access network and lease bandwidth from BSNL, which is not seen as a particularly attractive commercial proposition for private operators, given the high upstream bandwidth costs. Moreover, the current strategy for NOFN does not allow non-profit organisations or other small entities to connect with NOFN for provision of further connectivity from panchayat level to village level to household level.

In 2016, TRAI published a recommendation paper titled 'Encouraging Data usage in Rural Areas through Provisioning of Free Data'[30] in which the authority recommended creating a public subsidy programme to enable ISPs to provide free Internet access to rural consumers in line with the existing national frameworks. Yet again, however, the recommendation paper does not provide support for community networking, or rural-level ISPs, to utilise the fund to provide rural connectivity.

30. Available at: www.trai.gov.in/sites/default/files/Recommendations_19122016.pdf.

Thus, it can be seen that awareness of the potential for community networks to address the stated goals of national policy is largely absent from the Indian national government at this time.

Spectrum Policy & Regulatory Environment

Spectrum management and regulation is the collective responsibility of more than one agency in India. There are different bodies handling spectrum licensing, regulation, pricing, and the levy of penalties, and some bodies have only an advisory role. The key decision-makers on spectrum allocation and assignment include the TRAI, the Wireless Planning and Coordination Wing (WPC -also informally known as the Wireless Planning Commission), the Department of Telecommunications under the Ministry of Communications, the Ministry of Electronics and Information Technology, and ad hoc groups such as the Empowered Group of Ministers (EGoM) for third-generation wireless mobile telecommunications (3G) and Broadband Wireless Access (BWA) spectrum auctions.

Similarly, the regulations and rules governing spectrum management in India are elements of several policies and legislation, namely:

1. Indian Telegraph Act, 1885[31]
2. Indian Wireless Telegraphy Act, 1933[32]
3. Telegraph Wires (Unlawful Possession) Act, 1950[33]
4. Cable Television Networks (Regulation) Act, 1995[34]
5. Telecom Regulatory Authority of India Act, 1997 [35]
6. Telecom Regulatory Authority of India (Amendment) Act, 2008[36]

The WPC is responsible for managing the "policy of spectrum management, wireless licensing, frequency assignments, and international coordination for spectrum management and administration of the Indian Telegraph Act"[37]. The WPC has different sections, such as Licensing and Regulation (L&R), New Technology Group (NTG), and the Standing Advisory Committee on Radio Frequency Allocation (SACFA). The DoT takes a minimum of three months to process a letter of intent (LoI) for a new spectrum license. With so many different yet interlocking authorities, it is evident that processes for obtaining authorisation are not transparent or easy to understand, and are complicated for any new organisation, institution, and individual to negotiate, let alone a remote rural community unfamiliar with this territory.

31. Available at: http://www.dot.gov.in/Acts/telegraphact.htm.
32. Available at: http://www.dot.gov.in/Acts/wirelessact.htm.
33. Available at: http://www.indiankanoon.org/doc/980662/.
34. Available at: http://www.trai.gov.in/Content/cable_television.aspx.
35. Available at: http://www.trai.gov.in/Content/act_1997.aspx.
36. Available at: http://www.trai.gov.in/Content/Act2001.aspx.
37. For more information, see: http://ictregulationtoolkit.org/action/document/download?document_id=3271.

Unlicensed Spectrum in India

In February 1995, the Supreme Court of India declared airwaves as public property and Justices P. B. Sawant and S. Mohan specified in their decision that the use of airwaves "has to be controlled and regulated by a public authority in the interests of the public and to prevent the invasion of their rights" (India Together, 2001). In this context, P.K. Garg, the former wireless advisor to the Government of India, stated:

> "The government had de-licensed the present bands for reasons that their de-licensing would provide a benefit to society, and the regulation of the bands through license issuance for such low-power usage by the common public would have been impractical normally. Hence, to make the decision to de-license more bands, the spectrum regulator looks at the social benefit/impact that it would make, and whether they can shift current licensed users to other frequencies if interference concerns are present."[38]

The WPC has set the following regulation for the unlicensed bands in the 2.4-2.4835 GHz range, with virtually the same regulation for the 5.150-5.350 GHz and 5.725-5.875 GHz bands:

> "Notwithstanding anything contained in any law for the time being in force, no license shall be required by any person to establish, maintain, work, possess, and deal in any wireless equipment, on non-interference, non-protection, and shared (non-exclusive) basis, in the frequency band 2.4-2.4835 GHz with the transmitter power, effective radiated power (ERP), and height of antenna as namely specified." (WPC, January 28, 2005).

Frequencies in the 5.15-5.35 GHz bands as well as the 5.725-5.775 GHz bands are unlicensed for indoor-use only.

38. Personal correspondence with P. K. Garg (India).

MAXIMUM OUTPUT POWER OF TRANSMITTER	MAXIMUM REP	HEIGHT OF ANTENNA
(1)	(2)	(3)
1W (30 dBm[39]) in spread of 10 MHz or higher	4W (36 dBm)	Within 5 meters above of the rooftop of existing authorised building

The National Telecom Policy, 2012, outlined an objective under Section 4.6 of the policy that the government will "identify additional frequency bands periodically [in order to] exempt them from licensing requirements for the operation of low power devices for public use"[40]. Presently however, the government controls a large part of the RF spectrum, with only a minimal amount of frequencies being allocated for unlicensed use, nor are there any light-license frequency bands available in India.

The Supreme Court of India in Union of India v. Cricket Association of Bengal[41] declared that the use of airwaves "has to be controlled and regulated by a public authority in the interests of the public and to prevent the invasion of their rights". While large spectrum bands could be appropriated and used for the public interest, such as the UHF band used for TV transmission, so far the approach has been to assign exclusive property rights to certain frequencies, and also raise billions of US dollars through spectrum auctions based on the Supreme Court's understanding of spectrum as a national resource. Given the advancements in transceiver technologies, such as cognitive radios, it is possible to transcend the gridlock of property rights and use strategies such as shared and unlicensed spectrum. Indeed, greater allocation of shared and unlicensed spectrum will result in the growth of public and community wireless networks, including those built on the Wi-Fi standard. Considering that policy-makers in India and worldwide are beginning to recognise the importance of allocating more unlicensed spectrum, this may be an opportunity to make the case for specific measures for community networks.

39. Decibels relative to one milliwatt.
40. See: Department of Telecommunications. National Telecom Policy 2012, section 4.6.
41. See: 1995 AIR 1236. Available at: https://indiankanoon.org/doc/539407/.

SECTION IV: INDIRECT POLICY & REGULATORY CHALLENGES HAMPERING THE GROWTH OF COMMUNITY NETWORKS IN INDIA

Backhaul Connectivity

One of the greatest issues hampering the growth of community networks is lack of sufficient and cheap backhaul connectivity. India has one of the largest and densest populations in the world, and the demand for broadband from new users is high, partly owing to the availability of audio and video content via broadband. This means that there needs to be a large number of Wi-Fi hubs with strong backhaul connections serving a limited number of users. At present, however, this is largely not the case, which is why most — though not all — public Wi-Fi initiatives show disappointing performance. As mentioned earlier, a robust and reliable public Wi-Fi system would need to be based on strong, cross-country, ubiquitous optic fiber backhaul open to all providers. This can be shared public infrastructure, which can be used by all providers, or a private one but with an open access structure.

Regulatory Environment Constraints

Aside from the complexity of spectrum regulation detailed above, any institution or individual applying for an ISP license, is required to engage with all the regulatory bodies listed. The large number of institutions that are involved in the licensing process leads to an increase in waiting time, unnecessary bureaucratic hurdles, and associated costs.

In addition, if any NGO, small organisation, or individual wants to provide last mile Internet connectivity, they either have to become a franchisee of an existing ISP and bill via the ISP, or share their private Internet connection at their own risk due to the grey areas of the licensing requirements here. In the case of the franchisee model, the entity also needs to store user logs for which they need a local data server, which adds to the technical burden which exceeds the management capability of many small entities.

According to DoT guidelines, the height of any telecommunications tower should be 5 meters from the roof of an approved building or 30 meters from the ground. If the height of the tower exceeds that, then ISPs require SACFA clearance[42]. If the aerial distance between the tower and an airport is within 7 kilometers, then ISPs also need the approval from the Airports Authority of India (AAI) – and there are other requirements in case of defense lands

42. For more information, see: http://wpc.dot.gov.in/sacfa_guid.asp.

and borderlands, however most airports are in metro cities.

As ISPs are the only entities that are eligible to apply for SACFA clearance, entities that are acting as franchisees with ISPs which need to establish towers of more than 5 meters above the roof of a certified structure/building cannot apply for SACFA clearance. This adds to the challenges for small organisations to provide last mile connectivity, creating regulatory grey areas, which could lead to prosecution under the current law.

Compliance Challenges

Ambiguity also exists regarding the legal requirements and policy governance of community networks in India. Prior to the infamous Mumbai terror attacks of 2008[43], the use of Wi-Fi services in India was largely unregulated. Today, there are significant regulatory issues and licensing restrictions that hamper the growth of public Wi-Fi services and community networks in the country. After investigations into the Mumbai terror attacks in 2008 revealed that the perpetrators had made use of multiple unsecured Wi-Fi networks to coordinate their attacks (ET Bureau, 2008), the DoT issued a set of instructions in 2009 to all ISPs operating under a Unified Access Service License (UASL), Cellular Mobile Telephone Service License (CMTSL), or Basic Service License (BSL), directing them to adhere to certain procedural mandates designed to bring greater security and accountability to the use of Wi-Fi networks within India (Pawar, 2009). Under the current regulatory framework, public Wi-Fi is subject to licensing requirements, data retention, and "know your customer" (KYC) policies.

Among the DoT mandates is the identity verification of Wi-Fi users either by retaining copies of their photo identification documents or by delivering login details via Short Message Service (SMS), thus retaining their phone numbers as a means of identity verification. It is important to note that these instructions issued by the DoT apply to licensed ISPs along with their franchisees, which means the ISPs are also bound by the numerous general, operational, financial, and security conditions contained therein, including but not limited to maintaining detailed registers identifying their customers, and maintaining logs of all data packets transmitted to and from customer-premise equipment.

The most frictionless model is the unauthenticated model that allows anonymous access, followed by a light KYC regime. The model with the most friction is that with intensive KYC requirements. The existing customer login procedure requirements that have been laid down by the DoT that necessitate a user to provide a photo ID or to avail a one-time password (OTP) through SMS are difficult to comply with for two reasons. First, it does not allow for a user to access the public Wi-Fi network without authentication, which leads to a loss of anonymity over that network when the user accesses any Internet-based service. Second, it assumes that all people will have access to mobile phones/smartphones. So far as the Indian

43. For an overview, see: https://en.wikipedia.org/wiki/2008_Mumbai_attacks.

situation is concerned, this is certainly not the case in many households where only the head of the family, who is more often than not a male member, has access to such devices. Many individuals also use much simpler devices that may not be able to receive One-Time Passwords (for example, Raspberry Pi devices). Such a requirement would, in effect, deprive a large number of individuals from accessing public Wi-Fi services and would defeat the purpose of even establishing such networks. It can also be noted that even in countries with apparently much more challenging national security concerns, the data retention and KYC policies are not so strict.

Another pressing issue hampering the growth of public Wi-Fi services in the country is over-regulation in other related areas. The limitations on the interconnection of the PSTN with Voice over IP (VoIP/SIP) networks for small providers is one area in particular that limits the viability of local community initiatives. There are various other stringent security and regulatory systems surrounding the entire Internet connectivity ecosystem in India. These systems are especially restrictive in certain states and may hamper the growth of Wi-Fi in those states which appear unaware that provision of online public services can aid in the growth and development of these states.

Technical Challenges

A variety of other technical challenges have been encountered in the course of deploying W4C CNs. These include:

1. The accepted service level target is Triple-A compliance, however the technical and logistical issues can make this difficult[44]. Maintenance of Triple-A compliance requires technical support and access to data centres, which are expensive and often difficult to access from rural areas or small towns. This is an additional technical hurdle for small ISP providers who may struggle to maintain the data centre or to receive technical support.
2. As described above, the unlicensed 2.4 GHz band has become relatively “busy” (congested) in urban areas. While the 5 GHz band gives the advantage of lower interference, it faces distance challenges due to its technical characteristics. Access to other unlicensed and shared bands in the lower frequencies would help to address this problem.
3. In DEF’s experience in particular, transmitting Internet connectivity from the ISPs base transceiver station (BTS) to the W4C hub station is another challenge. In urban areas, even if the required bandwidth is available at the BTS, an ISP will not provide power (5-10 W) for wireless equipment, or share the tower for client devices. The ISP will simply provide Ethernet out (a 10-30 meter Ethernet wire)

44. For more information, see: https://www.w3.org/WAI/WCAG1-Conformance.

and not provide any support for the further laying of cable and infrastructure.

4. Maintaining a wireless Internet tower during the monsoon (rainy) season is high-risk due to severe thunderstorms, and this problem will likely grow with the increasingly worsening effects of global climate change. It is also difficult to protect wireless equipment, so the community networks supported by DEF have to maintain extra equipment along with a system backup file to restore a damaged network. This increases the burden on small ISPs, as they need to maintain extra equipment with system backup files to restore the network if needed.
5. Even if a small organisation provides Wi-Fi connectivity in rural areas, the purchase of a leased line from any ISP is a time-consuming process. This requires three-level coordination with all stakeholders who are providing the backhaul bandwidth, and it can take about three-to-four months or longer.

SECTION V: RECOMMENDATIONS

This section identifies a set of recommendations for national, regional, and international policy fora.

National Recommendations

1. Encourage rural/village level ISPs: Rural/village-level ISPs should be encouraged and promoted by the government as well as major ISP stakeholders. Any NGO, small organisation, or individual should be encouraged to become a rural/village ISP and be allowed to further distribute Internet connectivity.
2. Soften the regulations in order to allow unauthenticated access - Some CNs may need to have light KYC norms, especially initially, whereas others may choose to have rigorous KYC norms that are integrated with India Stack, etc.[45]
3. Exemption from service taxes: According to DoT guidelines,[46] ISPs need to pay a 15 per cent service tax and 8 per cent of their adjusted gross revenue (AGR). Therefore, every ISP pays 23 per cent tax in total. "Class C and Sub-Class C or Rural/Village" ISPs should be exempted from the 8 per cent of AGR levy to promote last mile connectivity. We suggest the following sub-categories to consider rural/village ISPs under Class C.

SUB-CLASS C OR RURAL/ VILLAGE CATEGORIES	ENTRY FEE (IN THOUSANDS OF INDIAN RUPEES)[47]	PBG[48] (IN THOUSANDS OF INDIAN RUPEES)	FBG[49] (IN THOUSANDS OF INDIAN RUPEES)	APPLICATION PROCESSING FEE (IN THOUSANDS OF INDIAN RUPEES)
Class C – 1 (Very large village)	15,000	30,000	10,000	10,000
Class C – 2 (Medium-large village)	10,000	20,000	10,000	10,000
Class C – 3 (Small villages and below)	5,000	15,000	5,000	5,000
Class D – 4 (Individual level)	3,000	10,000	5,000	5,000

45. For more information, see: https://indiastack.org/.
46. See the License Agreement For Unified License document for more information, available at: http://dot.gov.in/sites/default/files/Unified%20Licence_0.pdf.
47. As of 18 June 2017, 100 Indian rupees (INR) equals US$1.55.
48. Performance bank guarantee.

5. Tower regulation changes: There is a need to increase the allowance for tower height to be increased to 36 meters from the ground. It is also recommended that for towers falling within the circumference of Class-C towns, very large villages (VLVs), medium-large villages (MLVs), and small villages and below (SVs) as per the Indian Census guidelines,[49] the ISP should be allowed to gain approval from the respective municipality(ies), and the tower infrastructure should be vetted and authorised by local architect(s) and engineer(s).

6. Support development of intranets and links between CNs. Decentralised community networking allows for network managers to provide locally created and locally relevant content on the relatively high-speed intranet. Even in the event of the failure of backhaul connectivity, it would allow people access to such content due to the local storage and sharing of data.

7. Support operationalising of video conferencing and voice over Internet Protocol (VoIP) services over the intranet to allow communication within the network between citizens, and similarly connected public and private institutions, such as schools, primary health centres, government offices, and others.

8. Establish an underserved communications commission or committee that entities like DEF, Gram Marg, Air Jaldi and others could sit on to advise the government on matters related to providing connectivity in rural, remote, and underserved parts of the country.

9. Change existing USO rules to allow funding to innovative projects such as community networks or alternative network models that provide connectivity in rural, remote and underserved parts of the country.

10. Make more license-free spectrum available: De-licensing spectrum would lead to more innovation and entrepreneurship as there will be fewer administrative barriers. This could also lead to lowering the costs of mobile service data plans due to increased competition (Milgrom, Levin, & Eilat, 2011). The approach for de-licensing spectrum should also be technology neutral and find a balance between proprietary, unlicensed, and shared spectrum. Other related recommendations include:

    » Utilizing frequencies in the 6, 11, 18, 23, 24, 60, 70, and 80 GHz bands to facilitate replicating examples like Webpass (United States), which has radios capable of delivering up to 2 gigabits per second (Gbps), both upstream (upload) and downstream (download)[50]. Reducing the barriers to access to spectrum in the 10-20GHz range is especially important (11 GHz and 18GHz in particular) to allow for new equipment from Mimosa[51],

49. For more information, see: http://censusindia.gov.in/Data_Products/Library/Indian_perceptive_link/Census_Terms_link/censusterms.html.

50. "Webpass buildings have radios capable of delivering up to 2 Gbps, both upstream and downstream. Anything beyond 5,000 meters will still work but you lose bandwidth…Webpass radios operate in many different frequencies, including the unlicensed 2.4 GHz and 5 GHz bands used by Wi-Fi, Barr said. Webpass also uses the 6, 11, 18, 23, 24, 60, 70, and 80 GHz bands. These include a mix of licensed and unlicensed frequencies." See: Brodkin, J. (18 June 2015). "500 Mbps broadband for $55 a month offered by wireless ISP." Ars Technica. Retrieved from: https://arstechnica.com/information-technology/2015/06/500mbps-broadband-for-55-a-month-offered-by-wireless-isp

51. See: https://mimosa.co/backhaul-comparison

Cambium[52] , Ubiquiti[53] , etc to offer more comprehensive, cheap backhaul options.

» Currently the 5.15-5.35 GHz bands as well as the 5.725-5.775 GHz bands are unlicensed for indoor-use only. Where interference with radar systems is not an issue, these bands should be unlicensed for outdoor use as well in order to facilitate the creation of wider wireless communication networks and the use of innovative technologies.

» Unused spectrum bands in the 2.4Ghz range should be de-licensed, beyond what is already unlicensed, for the expansion of wireless communication networks.

» The 1800-1890 MHz band, which is earmarked for the operations of low-power cordless communication in India, should be unlicensed in line with international practices. Many bands for this use have already been unlicensed in Europe and the United States[54].

» 50 MHz in the 700-900 MHz band, earmarked for broadcast, should be made available to better utilise available spectrum. Almost 100 MHz is currently unused in most parts of the country and this could easily be made available on a spectrum sharing basis.

Regional and Global Recommendations

The following provides a list of general conclusions resulting from DEF's experience that are likely to be relevant more broadly to developing countries wishing to address Internet and telephony access inequalities.

1. Minimal and proportionate regulation: In terms of regulatory measures, there should be minimal and proportionate regulation – i.e., the regulation of entities involved in the provision of public Wi-Fi networks based on their capacity to harm the public interest and/or individual rights. By this we mean that only public Wi-Fi networks that have a large number of users should be subject to any regulation. The actual number for the ceiling would need to be determined through a needs analysis. Small-scale/public Wi-Fi/community-based network providers, such public Wi-Fi networks in small villages or apartment complexes, should be left to self-regulation. Regulatory burdens, which serve no purpose, only deter these providers from providing such services at all.

2. Technology-neutral regulation: Regulation must be technology neutral, and should focus on the entities using these technologies. This neutrality should be

52. See: http://www.cambiumnetworks.com/products/backhaul
53. See: https://www.ubnt.com/airfiber/airfiber-11fx
54. For more information, see: https://cis-india.org/telecom/unlicensed-spectrum-brief.pdf

reflected in the name of the policy – i.e., "community networking policy," and not "community Wi-Fi policy." The current definition of Wi-Fi is closely coupled with certain frequencies, and public wireless networks should be promoted regardless of technology and specific frequency bands.

3. Promotion of community networks: Stakeholders should promote, disseminate, and support the community network model through their existing channels, networks, and governance processes, especially to help create a more conducive regulatory environment by recognizing the role of CNs and making more unlicensed spectrum available to them – particularly in those bands that are allocated nationally, but not used in rural areas, such as TV, GSM, etc. This includes implementing measures to reduce the backhaul costs such as more open access fiber national networks, and reducing the fees and taxes to import and use telecommunications equipment.

4. Make funds available: Universal service funds (USF), and other funding mechanisms should be made available for the deployment, operation, maintenance, and scaling of community networks. New funding schemes should also be encouraged to avoid delay and to minimise regulatory hurdles associated with many current USF parameters.

5. Provide training to Community Networks: Governments, NGOs, and related organisations, such as development organisations or Internet-related organisations, should provide more support for training and capacity building among community networks, especially since many of the community network professionals interviewed stressed that while they do provide technical and operational training, they lack business and managerial training.

6. Encourage better dialogue between government and community networks: Governments should focus on greater engagement with community networks and initiate dialogue processes and relationship building, especially since CNs want to add value to communities, and many governments are under pressure to expand Internet access and deliver services.

REFERENCES

Baig, R., Roca, R., Freitag, F., & Navarro, L. (2015). Guifi.net, a crowdsourced network infrastructure held in common. Computer Networks, 90, 150-165. doi:10.1016/j.comnet.2015.07.009

Center for Neighborhood Technology. (2006). Community Wireless Networks: Cutting Edge Technology for Internet Access (Rep.). Retrieved 2017, from http://www.cnt.org/sites/default/files/publications/CNT_CommunityWirelessNetworks.pdf

Clarke, R. N. (2014). Expanding mobile wireless capacity: The challenges presented by technology and economics. Telecommunications Policy, 38(8-9), 693-708. doi:10.1016/j.telpol.2013.11.006

Elkin-Koren, N. (2005). Making technology visible: liability of internet service providers for peer-to-peer traffic. NYUJ Legis. & Pub. Pol'y, 9, 15.

ET Bureau. (2008, September 17). TRAI plans to prevent WiFi abuse. Retrieved 2017, from http://economictimes.indiatimes.com/industry/telecom/trai-plans-to-prevent-wifi-abuse/articleshow/3491302.cms?intenttarget=no

India Together. (2001, July). The airwaves are the people's property: The Supreme Court ruling of 1995 . Retrieved 2017, from http://www.indiatogether.org/campaigns/freeinfo/sc95.htm

Idachaba, F. E. (2017, March). Spectrum bundling architectures for increased traffic capacity in mobile telecommunication networks. In Proceedings of the International Multiconference of Engineers and Computer Scientists, Vol II. Retrieved 2017, from http://www.iaeng.org/publication/IMECS2017/IMECS2017_pp624-627.pdf

Longford, G., & Wong, M. (2007). Spectrum policy in Canada: A CWIRP background paper. Community Wireless Infrastructure Research Project. Retrieved 2017, from www.cwirp.ca/files/CWIRP_spectrum.pdf.

Milgrom, P., Levin, J., & Eilat, A. (2011, October 12). The Case for Unlicensed Spectrum. Retrieved 2017, from https://web.stanford.edu/~jdlevin/Papers/UnlicensedSpectrum.pdf

Pawar, B. L. (February 23, 2009). Instructions under the UASL/CMTS/Basic Service licenses regarding the provision of Wi-Fi Internet service under delicensed frequency bands (No 842-725/2005-VAS) (India, Ministry of Communications & IT, Department of Telecommunications). New Delhi. Retrieved 2017, from http://www.dot.gov.in/sites/default/files/Wi-%20fi%20Direction%20to%20UASL-CMTS-BASIC%2023%20Feb%2009.pdf

TRAI. (2016). Consultation Paper on the Proliferation of Broadband through Public Wi-Fi Networks (India, Telecom Regulatory Authority of India (TRAI)). Retrieved 2017, from http://www.trai.gov.in/sites/default/files/Consultation_Note_15_November_2016.pdf.

WPC. (January 28, 2005). 5.1 GHz Notification (India, Wireless Planning and Coordination Wing). Retrieved 2017, from http://wpc.gov.in/WriteReadData/userfiles/file/Gazette%20(%202_4%20GHz)_Outdoor.doc

ANNEXURE A: SEMI-STRUCTURED INTERVIEW RUBRIC

1. Does your country have specific policies that support community networks (CNs)?
   a. If yes, can you describe them and provide us with links to them if they are publicly available.

2. What are the legal and business challenges related to spectrum allocation in your country?

3. Do any spectrum management mechanisms exist in your country?
   a. If yes, what are they and what are their challenges?
      i. For example, does your government publish its spectrum allocations and assignments?
      ii. Does your country hold open proceedings with respect to new and innovative uses of spectrum, including experimental licensing?

4. Does your country allow unlicensed use of spectrum or spectrum sharing or secondary use of spectrum?
   a. If yes, when were these policies put into place?

5. Does your country allocate specific spectrum for community networks?
   a. If yes, what are they?

6. What are the spectrum licensing processes in your country? Please define or provide us with a link to the process.

7. Are community networks allowed to set-up/operate a network in your country, or are there specific policies or regulations that are specific to community network set-up or operations?

8. Do community networks need an authorisation or a license to exist in your country?
   a. If yes, what entity provides those licenses or authorisations and how long does the process take on average.

9. Does your team conduct training?
   a. If yes, what type of training?

10. Has your team had business and management training to sustain your CN?
    a. If yes, was it local training?

11. Do you work with local and national authorities to make them aware of CNs and the difference they make in your local community(ies)?

Internet Society

www.internetsociety.org

DEF

DIGITAL EMPOWERMENT foundation

www.defindia.org