

# Bridging the Digital Divide : The Case of Nepal Wireless

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## Abstract

Information and Communication Technology (ICT) has become a vital instrument for delivering a number of services such as education, healthcare and public services. Community wireless networks are community-centric telecommunication infrastructure developed to provide affordable communication for those who live in remote areas. This chapter discusses the role of Nepal Wireless in achieving socio economic development of rural communities by facilitating affordable Internet access. We analyze the challenges Nepal Wireless faced and articulate on the approaches it took to address those challenges such as lack of technical skills, appropriate technology and funding, difficult geographical terrains, unstable political situation, and expensive devices. In addition, we address the success and failure factors of this community-based ICT4D approach in order to guide similar endeavors. We conclude the chapter by some suggestions for policy makers, community developers, and academicians.

Keywords : ICT4D, Wireless Networks, Wi-Fi, VoIP, Digital Divide

## 1. Background

Governments and individuals in developing countries usually give higher priority to fundamentals of living such as healthcare, education, agriculture, clean water, roads, and other public infrastructures. It is greatly overshadowing the concept of the development of information and communication technologies (ICTs) in remote areas where majority of the population of developing countries live [Aitkin, 2009]. As a result, IT services are available mostly for the people living in big cities and their peripheries. In other words, access to information and online resources in most of rural areas in developing countries is difficult [Heeks and Kanashiro, 2009]. This is one of the reasons why there is a huge digital divide between people living in rural and urban areas in developing countries.

Nepal is a small country located between China and India. It has about thirty million people. It is mostly a mountainous country with majority of the highest mountains of the worlds. Politically, Nepal is the youngest republics of the world, which is officially called the Federal Democratic Republic of Nepal.

A brief overview of IT and telecommunication services that are presently available in Nepal has been given in order to make the readers understand clearly the reason behind the evolution of Nepal Wireless in 2001. Even if the mobile penetration rate has increased significantly in recent years in Nepal, many people in rural areas are still deprived from communication services including the Inter-

net. As shown in <Table 1>, the MIS report of June 14, 2011 of Nepal Telecommunication Authority, which is the telecommunications regulatory body of Nepal shows the percentage of the people of Nepal using telephone and Internet services [NTA, 2011]. The figures in the table show that about 55% of Nepali people do not have telephone services and almost 90% of them have no access to the Internet.

However, the statistics of the telephone and Internet users in October/November 2003 [NTA, 2003] and June 2011 (See <Table 2>) can help readers to guess how the situation was like in 2001, when Nepal Wireless was born informally to connect some of the mountain villages of Nepal using wireless technology.

<Table 1> Percentage of People Using Telephone and Internet Services

Voice Services being provided by different operators	Users	Penetration Rate %
Fixed	837,705	2.93
Mobile	11,299,735	39.53
Others (LM, GMPCS)	695,893	2.43
<i>Total</i>	<i>12,833,333</i>	<i>44.90</i>

Note : Projected population for 2010 was 28,584,975(Source : cbs.gov.np).

<Table 2> Telephone and Internet Users in 2003 and 2011

Telephone and Internet Users	2003	2011
Fixed Telephone Services	379,235	837,705
Mobile Telephone Services	88,551	11,299,735
Others Voice Services (LM, GMPCS)	5470	695,893
Email Subscribers and Internet Users	180,000	2,940,623

## 2. Setting the Stage

Prior to the initiation of the IT project in the mountain villages by Nepal Wireless in 2001, no villager had any idea as what an Internet was or what a computer looked like. There was no telephone or electricity in the villages. The villagers had to walk five to eight hours to the nearest city just to make a telephone call. As a social worker, the author of this chapter was involved since 1993 with several community development projects such as building schools, starting income producing programs, building health clinics in the villages, and being involved in nature conservation projects. Some of the income producing projects that were started then and still running successfully is yak farming, cheese making, yak and cow crossbreeding farm, fishery, paper making, camping and lodging facilities for trekkers, jam making, and mushroom farming, etc. In the absence of modern communication and transportation means, villagers had to use human messengers to send messages from one village to another, which is the oldest form of communication used in remote corners of the world. Nangi was using the same age-old communication means until 2001.

Thus Nepal Wireless was born with the desperate need of a modern communication system for local use to help villagers communicate and run community development projects in different villages effectively and successfully. However, the political situation at that time was not favorable. Wi-Fi equipment had to be smuggled with the help of international volunteers. Dif-

ferent kinds of antennas had to be built by team members and tested at different ranges. Because of lack of knowledge and lack of funding the project had to adopt cheaper solutions using donated Wi-Fi equipment, normal hubs and homebuilt antennas including large recycled television satellite dishes. As for the power needed at the repeater stations, solar panels and wind generators were used to charge the storage batteries.

For the first year of the project Internet connectivity was provided through a dial-up proxy server based in the city of Pokhara. Five villages shared the dial-up Internet link. In 2004, the Internet link was upgraded from dial-up to 64/64 kbps dedicated wireless link from the Internet service provider based in Pokhara. Now Nepal Wireless subscribes to a 5 Mbps Internet link from the Internet Service Provider to its base stations in Pokhara and Kathmandu. The base stations are running a web server, a proxy server, a network management server, an Internet bandwidth management server and an audio/video streaming server.

Step by step, IT services through different applications such as e-learning, tele-medicine, tele-teaching, tele-training and e-commerce were introduced. Moreover, Nepal Wireless is working with different research groups for monitoring glacial lakes, weather and climate change in the Himalayas. It is also working on developing a surveillance system based on IP cameras at Chitwan National Park to monitor poachers and to help save endangered animals like tigers, leopards, and rhinos.

### 3. Description of Nepal Wireless

The idea of using wireless networks to provide affordable local communication services to some mountain villages evolved few years before the real start of Nepal Wireless. In particular, community developers informally implemented testing phase of the wireless network in Nangi village of Nepal in 2001. Nangi is a small mountain village of 800 inhabitants. It is located in the foothills of the Annapurna and Dhaulagiri Himalayas of western Nepal at 7,300 feet elevation. It takes pedestrians about 7 hours to climb the mountain from the nearest highway to Nangi. The low population and harsh geography of Nangi make it less attractive for telecommunication companies to invest in it. In addition, Nangi is an isolated and remote village that lack infrastructures and economic opportunities other than farming. More specifically, its residents are subsistence farmers who use primitive farming tools such as wooden plows, iron spades, axes, and sickles etc. There are no roads in the area. Therefore, villagers carry all kinds of loads such as supplies, fire wood, building materials, composts and others on their back, which they have been doing for centuries.

Currently, Nangi has a robust wireless network and a community computer lab. This lab serves as the main hub for the wireless networks that connects more than 120 villages in the 13 districts of Nepal. Several reporters from around the world such as BBC [BBC, 2004], ABC News [Harsany, 2004], PC Magazines [Harsany, 2003], and The Sydney Morning Herald [Levett, 2004] and many more have writ-

ten about the role of Nepal Wireless in connecting and improving the economic conditions of such rural communities. Several academic research articles have been published about the project, for detail read references [Thapa, 2011; Sein, and Sæbø, 2012; Thapa and Sæbø, 2011].

In 2001, when the plan was made to connect Nangi village to Pokhara city to bring the Internet through Wi-Fi, the responses from several communication engineers and experts in the communication field were negative. Their main concern was the lack of proper equipment and the long distance the radio signals from simple Wi-Fi equipment had to cover. In spite of the negative feedback, the team members of Nepal Wireless had decided to go ahead for doing field experiments to find if a long range wireless link can be made using simple Wi-Fi radios and homebuilt antennas. The experiment was successful to the surprise of many technical experts who had been skeptical of the project. As a result, Nepal Wireless has now expanded its network to more than one hundred twenty villages in thirteen districts of Nepal. It is expanding its network to more districts of Nepal in coming years. A brief description of network design, technology used, and server setup has been given below to explain the technical part of the network.

#### 3.1 The Telecommunication Infrastructure

Nepal Wireless network was built step by step and expanded to many villages over a time span of about ten years and it is still growing. The villages that are connected to the network

get Internet and intranet services via a server in Kathmandu or in Pokhara. The servers in Kathmandu and Pokhara are linked through a leased optical fiber line. A series of mountaintop repeater stations relay the signal from Kathmandu and Pokhara up into the mountain villages. There are also access points at the mountaintop relay stations to distribute Internet to end users in the neighboring villages. Villages are connected to the access points using point-to-point wireless links or by connecting to a wireless access point that serves many villages at once. The table below shows the progression of users through 2011.

The high-speed backhaul radios at the relay stations operate on a dedicated core local-area network (LAN) that reaches from the base stations [Pokhara and Kathmandu] to different districts through relay stations. The longest point to point link the project has made is 42 km from a mountain top to another mountaintop. The distance of the villages from the Access Points ranges from 2 km to 18 km. The districts that are connected to the network are divided into different subnets in order to manage the network smoothly. Thus the villages in each of the network's coverage areas from the relay stations operate on separate local LANs through VLAN switches. Routers at each of the relay

stations provide DHCP services to the end users and interface between the backbone LAN and the local distribution LANs.

### 3.2 Objectives of the Project

The goals and objectives of the project have evolved over time. At the initial stage of the project, the goal was to connect just a few neighboring villages of Nangi and provide communication services such as IP telephony and email communication. The founders of the project did not know what other purposes the wireless technology could be used for. New objectives and services have emerged after several years of experience and collaboration and interactions with similar community wireless networks. For example, it was found that the minimum intranet bandwidth in local wireless network was around 2Mbps, which was enough to run simple video conferencing application for teaching and training purpose. Therefore the current objective is not to bring only the Internet and computers in the rural areas but to maximize the benefits of wireless and information technology for the rural population in remote areas. Nepal Wireless is trying its best by introducing useful applications and services in the field of education, health, communication, e-commerce activities and climate change mo-

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
No. of Villages	1	2	5	13	22	35	60	82	102	122
No. of Rural Schools	1	2	5	8	19	24	40	58	74	80
No. of Rural Clinics	0	0	0	2	3	5	5	6	8	10
No. of Individual Users	0	0	0	0	0	0	0	15	40	65

monitoring activities. The project is even working on helping national parks of Nepal to set up IP based surveillance system to monitor the movements of poachers in that park. Using the wireless technology, we hope to make the life of rural people easier and bring some socio-economic transformation. Besides, the long-term goal of Nepal Wireless is to become one of the biggest rural Internet Service Providers in Nepal to help bridge digital gap narrower. The digital gap in this context expand beyond physical access and agree with the reconceptualization of digital gap by Warschauer [2003] as social, political, and economical gap. According to the final report of APT ICT J3 project in Nepal presented to Asia Pacific Tele-community, Nepal Wireless specifically aims to achieve the following goals, divided into six main areas [E-Networking Research and Development, 2009].

1. **Education** : Increase better educational opportunities in the rural communities by creating tele-teaching and tele-training program, and by making e-learning materials in local language available to students, teachers and villagers through e-libraries.
2. **Health** : Connect rural health clinics and health workers to city hospitals in order to provide quality medical assistance through a tele-medicine program and make available highly needed healthcare in rural communities by virtually bringing medical doctors to villages.
3. **Communication** : Increase communication facilities in rural areas by providing telephone services through Internet phone sys-

tem (VoIP)<sup>1)</sup>, make Internet available for email communication, and help villagers to discuss by using Nepali language bulletin boards for community discussion.

4. **Local e-Commerce** : Help villagers to buy and sell their products in the local market and international market through local intranet and Internet.
5. **Job creation** : Create jobs in the rural areas for younger generation through ICT related services such as communication centers, VoIP phone services, remittance services, and virtual ATM machine.
6. **Research and Field Testing** : Help researchers of climate change monitoring projects to collect data remotely and provide real time weather information about air routes in the Himalayan valleys during bad weather and the monsoon season for airlines. Moreover, provide technical support to the Department of National Park of Nepal to install surveillance system at the parks to monitor the movement of the poachers to save the endangered species in the park.

### 3.3 Funding resources

After the successful completion of testing phase of the long range Wi-Fi link in May 2002, Nepal Wireless Networking Project started getting modest financial and some in-kind support from individual supporters and donor organizations from around the world. Some organizations supported the wireless project di-

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1) Voice over internet protocol gives a platform for voice communication with the use of internet as a medium.

rectly and some did it through Himanchal Education Foundation in Nebraska, USA. The donors who helped the project at the initial years are International Center for Applied Studies in Information Technology (ICASIT) in Virginia, Huguenin Rallapalli Foundation in California, and Poverty Alleviation Fund Nepal. Moreover, International Telecommunication Union (ITU), AMD, and Asia Pacific Tele-community (APT) also provided financial support for buying some more equipment in order to expand the network to reach more villages and for doing a pilot project for tele-medicine. Even while the project was still in its learning phase, the team leader of the project, Mahabir Pun, was awarded one of the most prestigious awards in Asia, the Ramon Magsaysay Award for Community Leadership, in 2007 from the Philippines for connecting Nangi and its neighboring villages to the global village through the Internet.

International recognition for the team leader of Nepal Wireless helped to get some more support for the project from more individuals and organizations. Used computers and wireless networking and communication gear and accessories were received from several individuals and international companies like KDDI Japan, Cisco USA, National University of Singapore, Polycom Australia, and Swiss Re, Switzerland. In 2009, the project got financial support from ISIF Asia for building its human capacity. The project got financial support from Juniper Foundation, USA to provide training for the wireless networking operators and computer teachers. Most recently, Asia Pacific Tele-community provided a research grant for de-

veloping an open-source multi-destination audio/video conferencing system for tele-teaching, tele-medicine and tele-training purposes. Nepal Wireless is working with E-Networking Research and Development for developing the video conferencing software and testing it in twenty five high schools in seven districts of Nepal.

Rather than being dependent upon external support, Nepal Wireless encourages local stakeholders such as community members, local schools, not-for-profit organizations and local governments to donate money to build wireless networks in rural areas and to bring ICT services for the benefit of rural population. As a result, the district governments of Myagdi, Makawanpur, and Mustang invested significant amounts of money to build wireless network in those districts. Similarly, several other local governments are contributing funds every year to buy computers for schools and wireless equipment to connect villages to the wireless network.

The received financial support was not enough to build a wireless network across the entire country. Therefore, Nepal Wireless started a campaign in July 2008 called "Donate One Dollar a Month to Help Build Wireless Broadband Information Highway in Nepal" with the help of some Non-Resident Nepalese (NRNs) residing the USA. The project has received more than US\$50,000 so far as contribution from countries like the US, the UK, Japan, Hong Kong, and Malaysia donated by NRNs.

One of the reasons the NRNs want to contribute to the project is that the wireless broadband information highway can open opportuni-

ties for them to connect to relatives or family members in their home villages in Nepal using low-cost VoIP phone services, and live audio/video conferencing systems such as Skype or Google chat. Therefore, it is a good investment for the NRNs as well. Because of such interest of NRNs living in different parts of the world, Nepal Wireless has helped NRNs to connect more than fifteen villages to the wireless network and build computer labs in the schools.

### 3.4 Business Partners

Nepal Wireless was started entirely with the help of technical volunteers from abroad. It still does not have all the expertise it needs, or adequate human resources to fully implement the goals of the project. Therefore, Nepal Wireless works with partners that have different expertise. Now Nepal Wireless is working with several partner organizations and institutions to implement the projects and to provide IT services to the rural people. The names of its partner organizations are given below to make clear how Nepal Wireless is providing services to rural people.

1. E-Networking Research and Development : This organization has been helping as a technical partner since 2006 to build wireless networks in rural areas and to provide training for local wireless technicians, network operators and computer teachers. It is helping the tele-teaching and tele-training program to rural areas through audio/video conferencing (<http://www.enrd.org>).
2. Open Learning Exchange-Nepal : it develops contents in Nepali language for the elementary level student and makes the contents accessible online for the students in community schools. It has also developed e-library contents in Nepali language for the students and villagers. Nepal Wireless is working with this organization to connect the schools and make the contents available (<http://olenepal.org>) in the rural areas.
3. Nepal Research and Education Network : it uses the network as a platform for research and development (R&D) and is supporting for technical issues like network designing, equipment testing, routing, server building and maintenance (<http://nren.net.np>).
4. Kathmandu Model Hospital : Doctors in this hospital uses the network as an electronic facility for delivering tele-medicine services and tele-training programs for rural health workers (<http://www.phectnepal.org>).
5. Thamel.com : This entity has created a virtual ATM system for implementing credit card transaction services for the trekkers in trekking routes of Annapurna region (<http://www.thamel.com>).
6. Kathmandu University : engineering and computer science students volunteer to develop applications needed for the project such as local e-commerce and phpBB applications, and customizing them in Nepali. The students are also helping to develop video conferencing software for tele-teaching and tele-training using open source.
7. Japan International ICT Association (JIIA) : it is providing technical support by frequently



sending their experts to Nepal. JIIA is also providing support to collect used computers and networking gears for the project (<http://www.jiiasec.com>).

Moreover, Nepal Wireless is continuously getting technical support from many national and international volunteers, who either come to Nepal for a short stay to provide technical support or provide online support from abroad for managing the wireless network, and for developing applications that the project needs.

### 3.5 Technology Used

At the beginning stage, Nepal Wireless did not have any funding to buy high end equipment for building wireless network. It had to use mostly used equipment including wireless radios, switches, power sources and computers donated by individual donors. Now, the network has grown bigger and better equipment and applications have been added as mentioned below.

#### 3.5.1 Transport Technology

A considerable amount of resources have been dedicated over time to the network infrastructure and management. This includes wireless devices, network servers and associated software, and power generation systems at the relay stations. The transport devices that are being used in the network are high speed and long range backhaul radios, access points and cheaper client radios that are available in the market, directional and Omni directional antennas with different capacities, routers, manage-

able switches, normal switches and IP phones. Some of the Omni directional antennas were built by volunteers and staff. Thus the wireless network has used a variety of wireless devices to maintain connectivity between the nodes. Conceptually, the network has been divided into two parts, as follows:

1. Network backbone, which connects base stations in Pokhara or Kathmandu to a series of mountaintop repeater stations
2. Client connections that connect villages to the relay stations. In some cases, a connected village has also acted as a relay station.

Proprietary devices made by Alvarion and Motorola Canopy at 5.8 GHz bands were used for the backbone connection due to their high reliability, robustness, and to avoid signal interference. However, several brands of 802.11b/g radios such as smartBridges, EnGenius, Ubiquity, Deliberant, Mikrotik and TP Link were used for the last mile connections due to their lower cost and the compatibility between manufacturers. All the wireless equipment including backhaul radios, access points, client radios and wireless routers installed by Nepal Wireless use de-licensed frequencies of 5.8 GHz and 2.4 GHz.

#### 3.5.2 Access Technology

Before the wireless network was built for Internet connection, most of the “computers at the schools were assembled in wooden boxes” [BBC, 2001] using used computers parts brought by volunteers coming to Nepal. Now access to

the IT services is provided through desktop computers and laptops. With the addition of an Internet telephony system, the project added a number of network telephones in the villages. The addition of Internet telephony equipment has enabled phone users to make international phone calls at cheaper rates.

### 3.6 Network Servers

Several servers such as web server, sip server, proxy server, network management server, Internet bandwidth management server and video conferencing server have been set up for different purposes. For example, the network server in Pokhara facilitates network monitoring and management. The video conferencing server is dedicated for tele-teaching, tele-medicine and tele-training purposes only. All of the server computers are branded computers. The servers run Ubuntu with additional third party software and are configured for maximum redundancy to guard against failure. Ubuntu was chosen for a multitude of reasons, primarily due to the large abundance of high quality Open Source software included with the standard distributions and easily available online. It is well tested and proven in production environments and thus made a perfect choice for the server.

Currently, the servers provide the following services :

1. Voice over IP Phone system for local use through SIP server and Internet telephony.
2. Community (Nepali) bulletin board service and locally hosted home pages for the vil-

lages through the Intranet :

3. File sharing service through the server as the central point of coordination for sharing teaching materials and network maintenance software for the network
4. Database for additional projects on the network, like the Haat Bazaar trading forum, which is hosted on the server.
5. Network name and route monitoring through which the system can resolve IP addresses to names and also maintains a table of availability for each host on the network.
6. Video conferencing for tele-teaching and tele-medicine

The server also contains dozens of custom scripts to tie all the functionality together in a usable interface. Administering such complex functionality, even from a GUI interface like WebMin, is too difficult for the average users. Thus custom scripts written in Perl and PHP have been implemented to provide a user friendly server management system.

### 3.7 Delivered Services

Nepal Wireless delivers a wide range of services. The following section discusses the most important ones :

#### 3.7.1 E-Learning

Nepal Wireless is providing e-learning content produced by Open Learning Exchange Nepal (OLE-Nepal) in the schools connected to the wireless network. The students of grade two through six are using the interactive learn-

ing materials based on their textbook. So far OLE-Nepal has developed content for English, Math, Science and Nepali. Moreover, OLE-Nepal has also created an e-library (<http://www.pushtakalaya.org>) with contents in Nepali and English for the students and villagers as well. Nepal Wireless is teaching villagers how to use those contents. Teachers and students now can have access to the contents through intranet. Nepal Wireless has also created a Wiki in Nepali language for the villagers with more than four hundred useful articles on health, education, agriculture and technology. The villagers can access the materials through the intranet. This opportunity creates a new paradigm in the education system of Nepal as there is always the problem of accessibility of printed content and qualified teachers in rural areas. In addition, an audio/video conferencing application is under development using open source for tele-teaching purposes. Once the software is complete, Nepal Wireless is planning to teach live through the network to fulfill the shortage of qualified teachers in the rural schools.

### 3.7.2 Tele-medicine

In order to address the absence of clinics and doctors in rural areas, Nepal Wireless has found that connecting a rural health worker to a doctor in city hospital using audio-video conferencing through an intranet can be very useful to provide some medical assistance to the rural people, who have never visited hospitals. By connecting one clinic in a village to a hospital in Pokhara in 2006, so far Nepal Wireless has connected eight rural clinics to a hospital in

Kathmandu for tele-medicine purpose. The health workers in the villages can consult with medical specialists at a city hospital whenever they need help to treat patients. With this service, Nepal Wireless has assured a virtual presence in remote areas of doctors who otherwise would never have made it physically. Moreover, it has been realized that it is a much cheaper and faster way to deliver basic health services in the remote rural areas than building clinics and hospitals, which takes several years.

### 3.7.3 E-Commerce

With the emergence of Internet in remote villages, people are also using it to communicate with other villagers to tell about products they have to sell. Villagers are doing this through an application called Haatbazar where they can put information about the produce and products with pictures. It is actually a virtual marketplace, accessible in the network through intranet. With the connection of Internet, villagers have also been able to promote their local areas for tourism. Nepal Wireless has helped villagers to develop a room booking system for lodges built by the communities along the trekking trails. The rural connection established by Nepal Wireless has helped people to establish money transfer stations in some of the villages. Moreover, Nepal Wireless is providing virtual ATM service to trekkers with the help of Thamel.com so that trekkers can get cash in the villages or pay their bill using their credit card.

### 3.7.4 Technical Training

Human resources development is also highly

needed for technical sustainability. Nepal Wireless frequently runs training programs to provide training in the design, setup, running and maintenance of a WISP (Wireless Internet Service Provider). The training package includes setting up access points and clients, managing bandwidth, IP sub-netting, line of sight calculation, link budget calculation, firewall control, etc. It also runs basic and intermediate level computer training for villagers, teachers and communication center operators from the villages.

### 3.7.5 Research and Field Testing

Nepal Wireless is helping some researchers on climate change to access the weather and climatic data online by connecting sensors and field servers set up in remote mountain sites to the Internet. It has installed three weather stations to date in the remote Himalayan Mountains. It is also working with Wild Land Security (<http://wildlandsecurity.org>) in the US to set up an IP based surveillance system developed by them for monitoring the movement of poachers in one of the national parks of Nepal to help protect endangered animals. The researchers of Nepal Wireless are also developing a cheaper Electro Cardio Graph (ECG) machine in its laboratory. Once it is developed, the machines will be put in rural clinics and will be used for telemedicine.

### 3.8 Project Management

Until 2009, the school management committee of Himanchal High School managed the Nepal Wireless Networking Project because the wire-

less network was limited to few villages and not many services were provided. Himanchal High School had not obtained a license to become an Internet Service Provider. While Himanchal High School helped to build the network with the technical support from E-Networking Research and Development and managed it, it did not provide services directly to the end-users of the villages. The services to the end-users were provided through village communication centers. Each of the centers was managed differently and independent from the others. The project did not collect revenues directly from end users, but instead billed communication centers to cover the operating cost of the network. Common caretaker organizations included mother's groups, social clubs, school management committees, and communication center management committees formed by the villagers. By running the communication centers, the respective caretaker organizations also gained an opportunity to share in the revenue produced by usage fees. Additionally, the telephone users were charged a surcharge on telephone calls (Approx. \$0.01 per minute more than is billed by Nepal Telecom), resulting in an additional profit for paying the operating costs of the network.

In order to comply with the rules and regulations of the Nepal Government and to become a legal rural Internet service provider, Nepal Wireless was registered as a not-for-profit sharing company on July, 2009 from the Office of Company Registrar. The company consists of a board with five board members. As a nonprofit sharing company, it can provide IT services, technical support to build wireless networks

and training for bringing IT related services to users in rural Nepal.

Until it became a nonprofit sharing company, Nepal Wireless provided connectivity only to rural schools, health clinics, and community communication centers. However, now it is providing services to individual home users in the villages if they can afford to have it. Still, villagers who can't afford to have computers and Internet connection at home can get IT services through communication centers in each village or school. Nepal Wireless charges a monthly connectivity fee directly to the schools, rural communication centers, and local service providers to cover the operating and maintenance cost of the network, such as monthly costs for the Internet bandwidth, rent for the server rooms, electricity bills, and salaries for the repeater station manager and fulltime technical staff.

In addition, Nepal Wireless also works with local internet service providers to provide internet connectivity to home users. A group of individuals or schools or organizations can form a committee to become a local ISP. Local representatives from the villages have been put in the management committee so that they can come up with their own ideas and make their own plan on how to use and maintain the wireless network.

Thus an organizational structure has been developed in which public and private partners have taken responsibility to manage the local network and provide IT services with the technical support of Nepal Wireless as a partner. The reason to make public partners involved in

the management of the network is to develop Nepal Wireless as a business enterprise with public and private stakeholders. Now there are many community stakeholders involved including local schools, local governments and individual partners. This allows an avenue for democratic participation as well as risk and profit sharing.

### 3.9 Status of Nepal Wireless

Unwin [2005] describes that there must be seven key elements for the ICT4D partnership to operate in a successful manner. They are as follows :

1. Trust
  2. Focus
  3. Champions/Leaders
  4. Sustainability
  5. Balance between demand and supply
  6. Networking
  7. Transparency and sound ethical basis
- (pp. 64-67)

This project has achieved most of the components of Tim Unwin's explanation about an ideal ICT4D<sup>2)</sup> partnership. It is entirely focused on providing IT services to rural communities and is driven by local champions. Working with the local partners, it has built

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2) ICT4D : The full form of the abbreviation is Information and communication Technology for Development. It is usually used when information communication networks are used for the sake of development through e-services like e-learning, e-commerce, tele-medicine, e-governance etc. to raise socio economic standard of life.

network in more than 120 remote mountain villages of Nepal and is expanding the network to more districts. With its constant progress and nonprofit structure of operation it has gained huge trust from the rural people as well. Moreover, Nepal Wireless has created 6 full time and several part time jobs for rural people. Because of these reasons, Nepal Wireless has become one of the most reputed projects in Nepal. Thapa and Sein [2010], transcribes an interview with a villager at Nangi while they were making a research on Nepal Wireless. The villager says that “Mahabir has done entire thing. He is the one who brings computer and internet in village. All the credit goes to him, as long as Mahabir is with us, there is no fear” (p. 18).

With a long experience in the field of ICT4D, Nepal Wireless has overcome several challenges such as legal, technical, financial etc, and is progressing steadily with a hope to narrow the digital divide to some extent in Nepal. There are defined goals and objectives, and the operation of the organization is according to those defined goals. Organizational transparency is another positive part of Nepal Wireless. That is why Nepal Wireless has been able to establish its network in more than thirteen districts of Nepal. Nepal Wireless is focused and determined to extend rural networks with public and private participation as much as it is possible.

#### 4. Current Challenges

Thus we can argue that Nepal Wireless is

really contributing to the socioeconomic development of Nepal through ICTs and online resources. With Tim Unwin’s model of successful partnership, Nepal Wireless lacks some components such as full sustainability, and balance between supply and demand. Nepal Wireless is aware of those shortages and it is trying to address them step by step as it progresses. Over a decade of efforts to connect the mountain villages with wireless and bring IT services, Nepal Wireless has faced the following challenges :

1. Lack of technical expertise : It was decided to build a wireless network with the desperate need of creating local communication system between the villages to run community development projects without the team leader and team members having much technical know-how. Therefore, lack of technical knowledge and expertise was certainly the first challenge.
2. Lack of appropriate technology : Wi-Fi was just an emerging technology in 2001 and it was primarily built for indoor use. Therefore many of the communication engineers with whom the author had communicated did not believe that it would be possible to build long range wireless network using the indoor Wi-Fi equipment available in the market. The Wi-Fi equipment that was donated to the project to build the first 40 km long wireless link with a 3,300m tall mountain between Nangi village and the city had just 60 mW transmit power without any amplifier and long range antennas.

3. Difficult geographical terrains : Geographical barriers created by the high mountains also made it look impossible to accomplish the project. Many of the villages were not in Line of Sight (LOS) because of the high mountain ranges in between. Moreover, the repeater stations that had to be created on the mountain tops were far from the villages with no human settlements. Therefore powering the equipment and ensuring the security of the equipment was a big challenge for the project.
4. Unfavorable political situation : The wireless networking project was started at the peak time of political instability in Nepal. The conflict in rural Nepal made the wireless networking work extremely difficult hence the project had to be implemented while constantly facing threats of closure. The villagers were often reluctant to participate due to fears of violence from the government soldiers and the Maoist rebels.
5. Legal issues : The autocratic regime of the king had severely restricted import and use of wireless networking equipment. The restrictive laws requiring a license to import and use any kind of wireless gear made acquiring equipment from abroad almost impossible. Also, the requirement to get a license from the government to become an Internet Service Provider by paying expensive license fee seemed impossible to overcome for a grassroots project like Nepal Wireless.
6. Expensive Internet cost : The monthly connectivity fee during the early days of the project was at the range of USD 2,500 per

month for a 1 Mbps link. Therefore the project had to use a dial-up link at the beginning. Even though the Internet bandwidth cost has come down to approximately USD 500 per Mbps per month in 2011, it is still expensive. The 5 Mbps of Internet bandwidth Nepal Wireless has subscribed to provide to more than 120 villages is too little for the villagers. Therefore Internet bandwidth is still the main bottleneck for the project to provide IT services smoothly in an affordable and cost-effective way in the villages.

7. Sustainability of funding resources : This is the major challenge many of the organizations like Nepal Wireless have been facing in Nepal and in other developing countries. The challenge is not only to make a project financially sustainable but also to make it technically sustainable.

Looking at the numerous challenges and problems mentioned above, it is clear that the idea of building a long range wireless network in 2001 was a crazy idea then. Despite that, the team members could overcome most of the challenges and problems with persistence. The credit for making the project successful at the initial years goes to the international volunteers.

Seeing that it was almost impossible to get import and user license from the government, the project decided to take the risk to import the equipment and use them illegally. The international volunteers helped to smuggle the wireless equipment in their backpacks to Nepal and carried them to the villages through many strict security check points along the highway. The

team built different types of antennas and tested them at different ranges in the mountain villages. The mountain barriers were overcome by building relay stations on tall trees at mountain tops. Solar power and wind power were used to power the equipment up.

Recalling the risky situation of that time, one can imagine that anything could have happened to the team members. They could have been arrested or shot dead by the rebels or the government forces had any of the team members had been found carrying wireless equipment or using them to build a local communication system. Luckily, no such incident happened and the wireless networking project kept expanding slowly to more villages. Thus the dream to build long range wireless network and to connect the villages was fulfilled. In short, Nepal Wireless Networking Project could not have come into existence without the courageous support of the international volunteers.

After the restoration of democracy in 2006, a hard lobbying was done by the Nepal Wireless team along with the members of the Association of Internet Service Providers in Nepal demanding the government to de-license 2.4 GHz and 5.8 GHz frequencies on ISM band. The team leader of Nepal Wireless gave two presentations to the Members of Parliament and Members of Development Committee of the Parliament on how Nepal Wireless had been set up and how the rural communities were benefiting. As a result Nepal Government de-licensed those frequencies in September 2006. Now the wireless equipment at those de-licensed bands can be easily imported and used.

Another regulatory obstacle to bring IT services in the rural areas was also overcome. That was the requirement of license by paying high license fee to become Internet Service Provider, which was almost \$4,000 a year [NTA, 2010]. As a result no investor was motivated to become a rural Internet Service Provider because there was almost no chance of the return on the investment. Nepal Wireless lobbied with the regulatory body of the government to reduce the license fee and Nepal Telecommunication Authority (NTA) brought a new law making the licensing procedure simple and bringing down the license fee to become rural Internet Service Provider to Nepali Rupee 100 (Approx. USD 1.50) a year. As a result Nepal Wireless has now received a license and it can legally provide Internet and IT services in the rural areas.

Similarly, financial and technical sustainability of Nepal Wireless itself is a challenge. From the interview transcription of Thapa and Sein [2010] with a villager, he expresses his worries on the sustainability of the project, "until Mahabir is here, it will function properly, however in his absence, we need another person like him for the sustainability of this project" (p. 18).

The issue of the balance between demand and supply is still a big challenge for Nepal Wireless. Nepal Wireless receives requests from many enthusiastic villagers and local governments from around the country for help to connect their villages to the Internet. They are also able and willing to raise some funds for connectivity. At present, Nepal Wireless can't sup-



port all of them in funding even if it can definitely provide technical assistance. Thus there is huge demand and Nepal Wireless is unable to balance between supply and demand of IT services in rural Nepal.

## 5. Recommendations

The main issue that has been discussed in this chapter with Nepal Wireless as an example is the issue of finding ways to make IT services accessible to the majority of rural people in developing countries in sustainable manner and to bridge the most publicized issue of digital gap as far as it is possible. The way Nepal Wireless has been trying to address the issue in Nepal might or might not be applicable in other countries. It is mainly because Nepal Wireless was started on the grassroots level by local champions of a specific area in Nepal. Nepal Wireless can't provide solutions for others, but it can propose some recommendations.

The important point that should be noticed here is that Nepal Wireless is inspired more by the social cause to help bridge digital gap in its capacity than as a business venture for financial gain. No commercial Internet Service Provider has gone to the rural areas where Nepal Wireless Networking Project has been working. The long term goal is not only to help bridge the digital gap but to bring about socio-economic transformation of rural areas in Nepal by optimum use of information and communication technology. Therefore Nepal Wireless is helping to connect rural side of Nepal to urban areas so that the transfer of technologies from

urban to rural area would be possible through Internet and intranet. Nepal Wireless has been an "unusual" case for the following reasons [Ruth and Schware, 2008].

*There are several aspects which make the Nangi case unusual. First of all, it was not initiated through government, NGO or multilateral interventions. Second, it was managed entirely by Nepalese local leaders, with assistance provided through skillful selection of outside helpers, mostly volunteers, from developed nations. There was no role of the USAID, UNDP or World Bank in the project. Third, the hardware used was top-of-the-line, and not a compromise among cheap or aging technologies. Fourth, the cost of the project was relatively modest, since there were no "middle-man" charges and because several equipment suppliers were so impressed with the Nangi concept that they gave large price concessions. Perhaps the most unusual aspect of the case is that the entire effort was not driven by an application, like licensing, taxation or finance. Instead, the idea for Nangi was, "if you build it they will come", like the theme from the film "Field of Dreams."*

The cases of Nangi and Nepal Wireless case is unusual in some senses because it has been able to bridge some digital divide successfully under difficult circumstances by connecting more than 120 villages with Wi-Fi technology and by bringing IT services in the remote mountain villages, where the people did not

know what an Internet is. It is the persistence of the team members for about a decade that made it possible. The team members are still working in their full capacity with a hope to connect many more villages. Based upon its accomplishment so far, Nepal Wireless case can be taken as one of the examples for bridging the digital divide in remote rural areas. However, it should not be taken as the best solutions to meet the huge need of Nepal.

Over time, the project has learned an important lesson to make IT projects like Nepal Wireless self-sustained. The lesson learned is to make local stake holders such as local private partners, local community organizations and local governments involved as operating partners as much as possible for the long term sustainability of rural IT projects in rural Nepal. This lesson has become a guideline for Nepal Wireless to help bridge the digital divide more effectively especially in the rural areas. Without community involvement, an ICT4D project will survive for the project period only, and then may flounder.

The issue of technical sustainability has been solved by hiring some full time and part time staff after Nepal Wireless was established as a nonprofit sharing company in 2009. Still the number of full-time technical staff is not adequate. Therefore there are quite a number of people volunteering or doing internship in the project, and Nepal Wireless seems it depends more on the support of the volunteers.

The issue of financial sustainability has been addressed to some extent through community participation. Each user, whether it is an in-

dividual, a school, a business, or a clinic or an office, has to pay the installation cost and monthly Internet connectivity cost. The monthly connectivity fee is based upon the Internet bandwidth used by a user, which is from USD 15 to USD 30 a month. The contribution received from outside donors is spent to build the backbone of the network and to install backup power systems at the relay stations. Support from local government and district government also goes to build local networks and backup power systems. Nepal Wireless also provides ongoing trainings to teachers, administrators and local people to manage and use the network effectively. Since the community members have also invested money for the installation cost, there is a feeling of ownership towards the network. While support from donor organizations are helpful, Nepal Wireless always believes in the maximum level of local participation for achieving its goal.

After looking at the decade long efforts of Nepal Wireless, it has been realized that it is very difficult to bridge the digital gap of the whole country with the efforts of a single organization like Nepal Wireless no matter how hard one tries. An organization or some organizations like Nepal Wireless can help to develop a model or system and connect only a few hundred or so villages for bridging the digital gap<sup>3)</sup> if it works in its full capacity. However, there are over 6,000 villages in Nepal and many or-

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3) Digital Gap/Digital divide : There is a huge difference between the people with the access of information and without access of information. In case of developing countries the gap is more. This gap is defined by digital divide or digital gap.

ganizations like Nepal Wireless will be needed to bring IT services to the Nepalese society at large. A majority of the 80% people living in the rural areas of Nepal will not get fast broadband services from ISPs without government subsidy.

Therefore the government must take initiative to build broadband information highway in rural areas using wireless technology or it must provide financial support to grass root level organizations or companies like Nepal Wireless. This is important to make IT services available throughout the rural areas and to bridge digital gap. One of the reasons government intervention is recommended is that it is less likely for commercial companies to invest in the remote rural areas. It is unwise for commercial operators to invest huge amounts of money to build infrastructure to bring broadband information highway and to provide Internet services in sparsely populated and scattered rural areas of Nepal because there is a slim chance for them to get a return. In addition, the low income of rural residents and the mountainous nature of the area decrease the viability of any telecommunication infrastructures.

Based upon the experience Nepal Wireless has gained, it is recommended that the government intervention for bridging the huge digital gap in developing countries must come both in the form of open policies and favorable spectrum regulations for the expansion of wireless or optical fiber networks, whichever is feasible, in the rural areas. In addition, governments should also subsidize the service or provide fi-

nancial support to rural operators that are interested to bring Internet and IT services in the remote rural areas for which it is recommended to provide subsidized financial support for building infrastructure and for paying the cost of the Internet access. Governments can use the Universal Service Obligation Fund (USOF), which the commercial operators pay to the government.

Most of the countries require the incumbent operators to pay a part of their net earnings to provide information and communication services to rural population, which is called Universal Service Obligation Fund in India. Chile has the Telecommunications Development Fund (FDT). Pakistan has the Universal Service Fund Company, and Taiwan has the Universal Service Fund [Wikipedia 2012]. It is called Rural Telecommunication Development Fund in Nepal and Nepal government is planning to use the fund for connecting all the 75 district headquarters through optical fiber link and then the villages through wireless link. The amount of money collected for Universal Service Obligation Fund in each country is quite a large amount. Therefore it will be good resource for bridging digital divide in developing as well as in developed countries. According to the National Broadband Plan of America, approximately 100 million Americans do not have broadband at their home. Therefore the US government has set up "Create the Connect America Fund (CAF) to support the provision of affordable broadband and voice with at least 4 Mbps actual download speeds and shift up to \$15.5 billion over the next decade from the existing

Universal Service Fund (USF) program to support broadband” [Connecting America, The National Broadband Plan p. xiii].

Another recommendation for helping to bridge digital divide is by providing ICT in education programs in all the schools supported by government. The initiative taken by Nepal Government can be an example. As part of the ICT in education program, the Ministry of Education of Nepal Government recently “has started an initiative for introducing information and communication technology (ICT) in education with UNESCO’s support. It aims at harnessing the power of ICT for teaching and learning. This initiative is part of an ongoing major education initiative in the country such as the School Sector Reform Plan, the Education for All campaign and teachers education projects” [UNESCO, 2010].

Even the government of a developed country like the United Kingdom feels that they are obliged to do more for ICT in education. That is why the “rural areas in England and Scotland have been allocated nearly £363m to improve their broadband connections.” In addition, the British government has brought forth a scheme to give “free laptops to 270,000 pupils from poor backgrounds in England” [BBC, 2011]. In order to target digital divide, “low-cost computers are to be offered as part of a government scheme to encourage millions of people in the UK to get online for the first time” [BBC, 2010].

One example of government intervention for bridging digital divide is through the “One laptop Per Child Program.” Under this program, “over 1.7 million children and teachers in Latin

America are currently part of an OLPC project, with another 400,000 in Africa and the rest of the world” [OLPC, 2011]. Similar projects have been started by governments in Gaza, Afghanistan, Haiti, Ethiopia, and Mongolia. There is no doubt that such programs will be able to bridge not only the digital divide but make people connected to each other, to the world and create new opportunities to the people of remote communities [Thapa et al., 2012]. Open Learning Exchange Nepal has successfully done “One Laptop Per Child Program” as a pilot project with the Department of Education in five districts of Nepal. The pilot program was done in two phases and it distributed more than 2,500 laptops to the students and teachers [OLE Nepal, 2011].

Finally, the time is not that far when a person will require IT in every step for one’s living as one of the basic human needs such as food, shelter, and clothes etc. However, there are billions of people deprived of such opportunity. Therefore, getting an opportunity to learn IT in education should be included by all the responsible governments of the world as one of the fundamental rights of a child under the right to get a basic education. Without such a provision, many children still will stand across the digital divide from opportunities of the modern world.

## 6. Conclusion

In this chapter we discussed the importance of ICT in promoting education, healthcare and public services particularly in the remote communities. Examples include how the Nepal Wire-

less Networking Project created the socioeconomic opportunities to the mountain villages by facilitating affordable Internet access. The chapter also demonstrated how the project turned challenges into opportunities. The founder of the project—Mahabir Pun—was awarded an Honorary Doctorate of Humane Letters by University of Nebraska, USA for his outstanding work. Furthermore, the chapter addressed the factors that may influence the success and failure of community-based ICT4D approaches. Finally, the chapter suggested some practical implications for policy makers, community developers, and academicians.

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## ■ Author Profile

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