SPARSE AND RURAL AREA COMMUNICATION SYSTEMS

Ashok Jhunjhunwala
Department of Electrical Engineering, IIT-Madras, Chennai, India

Sangamitra Ramachander
Consultant Development Economist, IIT - Madras, Chennai, India

Keywords: Rural Communication Infrastructure, Sustainable Connectivity, Information and Communication Technologies (ICTs), Backbone Network, Access Network, Switching, Access Area, Optical Fiber Communications, Microwave Radio Communications, Satellite Radio Communications, Wireless Access Network, Access Switching Unit, Base Stations, Omni-Directional Antenna, Directional Antenna, Fixed Wireless Subscriber Unit, Mobile Subscriber Unit, Line of Sight (LOS) Technology, Non Line of Sight (NLOS) Fixed Wireless Technology, Analog Multi-Access Wireless Systems, TDM-TDMA Point to Multi Point Systems, corDECT Wireless in Local Loop System, GSM, CDMA, Broadband corDECT System, 3G Technologies, HSDPA, EVDO, OFDM, OFDMA, Point to Point Digital Microwave Links, WiFi/802.11, Medium Access Control, Sparse Area Communication Systems.

Contents

Summary

Rural areas tend to differ from urban areas across the world in terms of their social and economic attainments as well as the available physical infrastructure. The disparities are particularly pronounced in developing countries, and this has a direct impact on the ability to deploy Information and Communication Technologies (ICTs) effectively in rural areas and to ensure that the technologies are commercially viable. In this chapter we have looked at the appropriate technology options to connect rural areas, by considering three broad scenarios, defined on the basis of population density and bandwidth requirements: Extremely Sparse, Sparse and Dense Rural Areas.

For Dense Rural Areas, with over 200,000 people in an Access Area, and with increasing bandwidth requirements over time, an optical fiber network as the backbone is the most suitable option, with a Wireless Access Network that connects each individual population cluster. For Sparse Areas, the choice of technology depends on the number of population clusters and the amount of bandwidth required in the Access Areas. If the number of clusters is approximately 20 and the total bandwidth required in the Access Area is less than 2 Mbps, a satellite backbone is the best option. The individual clusters could be connected by terrestrial wireless. If the number of clusters in the Access Area is greater than 20 and the bandwidth required is over 2 Mbps, it is best to use an optical fiber network or microwave radio link to the Access Area as the backbone, with the individual clusters being connected using Wireless Access Networks. In Extremely Sparse Areas, each population cluster must be served by a satellite link.

With regard to data connectivity on wireless, Line of Sight (LOS) fixed wireless systems is a viable option in rural areas, but has the disadvantage that any obstacle in the path would disrupt the connectivity. In terms of voice connectivity on wireless, mobile communications would be very useful, but it is only economically feasible today when the number of subscribers in a 2000 sq km area is several thousand. Non LOS fixed wireless systems that can enable both data and voice connectivity is therefore the ideal future solution. The chapter considers various wireless technologies that can provide both data and voice connectivity and comments on their relative merits and operational and economic feasibility in the rural context.

1. Introduction

In this chapter we will look at the Information and Communication Technologies (ICTs) that are suitable for rural and sparse areas of the world, as well as the special features associated with the design, manufacture and deployment of technologies in these regions. However, in order to understand why rural needs must be addressed separately, we first look at the various ways in which rural and urban areas differ. As we will see in the discussion that follows, these differences have direct implications for the technical design and commercial delivery of communication technologies in rural areas.

1.1. Rural Areas of the World

Region	Rural Population (%)	Rural-Urban Ratio

World	53	1.123596
More developed regions	24	0.315457
Less developed regions	60.1	1.515152
Least developed countries	74	2.857143

Source: Derived from World Urbanization Prospects, The 1999 Revision, United Nations

Table 1. Rural and Urban Populations in Various Regions of the World
Source: Derived from World Urbanization Prospects, The 1999 Revision, United Nations

There are a multitude of definitions of what constitutes a 'rural area', based on parameters such as population size, population density and distance from urban centers, which vary from country to country. Despite a lack of consensus on a single definition, most global studies estimate that a little over half the world population lives in rural areas today (see Table 1). The proportion of rural populations is much higher in regions that are less developed (60%) compared to more developed regions (24%). This is also evident from the rural-urban ratio. The rural population is over one and a half times the urban population in less developed regions, whereas it is less that a third of the urban population in the more developed regions of the world.

Geographically, the continents where the rural populations are the majority are Africa and Asia, while Europe, North America and South America have predominantly urban populations (Figure 1).

Figure 2 presents the ten most populous countries in the world, and among these, six nations have a predominantly rural population. Although the growth rate of rural populations has slowed over the latter half of the twentieth century, in absolute terms the size of the world rural population is significant today and is likely to remain so even in the future, based on projections as shown in Figure 3.

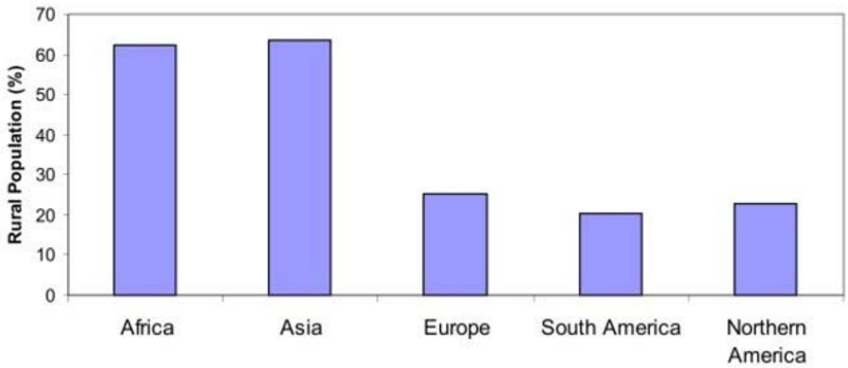

Figure 1. Rural Population in Various Continents
Source: Based on data from World Urbanization Prospects. The 1999 Revision, United Nations.

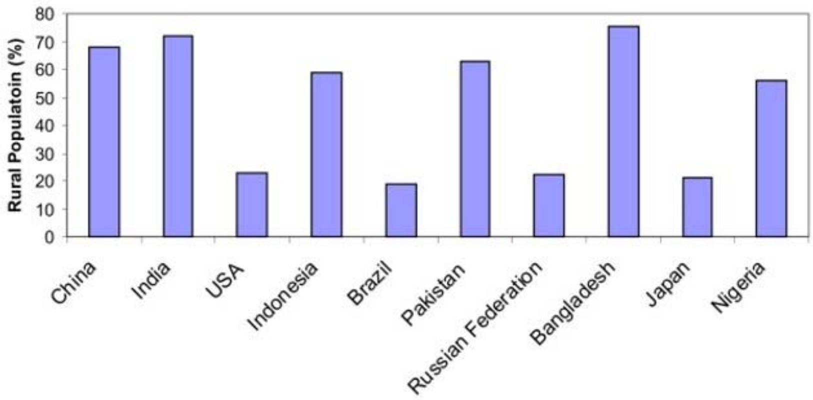

Figure 2. Rural Populations of Ten Most Populous Nations
Source: Based on data from World Urbanization Prospects. The 1999 Revision, United Nations.

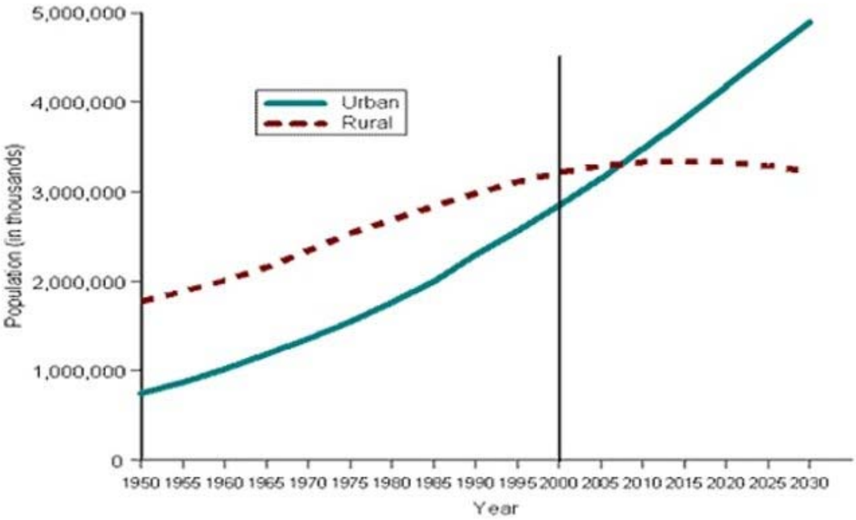

Figure 3. Rural Vs Urban Population 1950 – 2030
Source: World Bank Data

1.2. Rural-Urban Disparities in Economic and Social Spheres

Despite the large size of the rural population globally, the level of socio-economic development is markedly lower in these regions of the world. Studies show that 75% of the world's poor live in rural areas, and even in 20 years, this is expected to remain at 60%. In India, a country with one of the largest rural populations in the world, the annual per capita rural GDP was $ 211 in the year 2000, which was less than half that of urban India, $ 431. In terms of monthly per capita expenditure (MPCE), rural India stood at only $11 in 2000-01, a little over half the urban MPCE of $20 Such a disparity is especially alarming given the fact that about three-fourths of the Indian population lives in rural areas, spread across some 630,000 villages. Social attainments are also markedly biased toward urban areas in the Indian context (Table 2). As can be seen, rural areas lag behind in terms of health and education. These findings are echoed in most other parts of the world, except the industrialized nations. However, the worst inequities are seen in Sub-Saharan Africa and South Asia. Figures 4 and 5 show the differences in terms of access to sanitation and Figures 6 and 7 show the differences in terms of access to improved sources of drinking water.

Social Indicators in India	**Rural**	**Urban**
School going children (5-14 years)	63.3%	82.4%
Literacy rate	59.3%	80.6%
Life expectancy at birth	58 years	64.9 years
Infant mortality rate	77 per 1000	45 per 1000
Death rate	9.6 %	6 %
Sex ratio (women per 1000 men)	901 per 1000	946 per 1000
Access to piped water	18.7 %	70.1 %
Access to proper sanitation (toilets)	23 %	84.4 %

Source: Great Indian Divide, Prabhat Datta, Frontline Magazine, Volume 21 - Issue 14, Jul. 03 - 16, 2004

Table 2. Differences in Rural and Urban Social Attainments in India: Education and Health
Source: Great Indian Divide, Prabhat Datta, Frontline Magazine, Volume 21 - Issue 14, Jul. 03 - 16, 2004

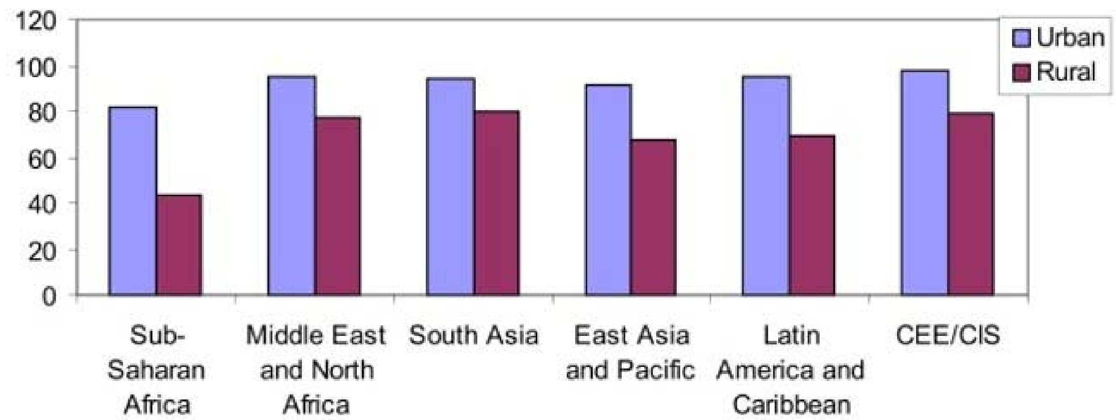

Figure 4. Rural Urban Differences in Access to Improved Sources of Drinking Water by Region
Source: UNICEF

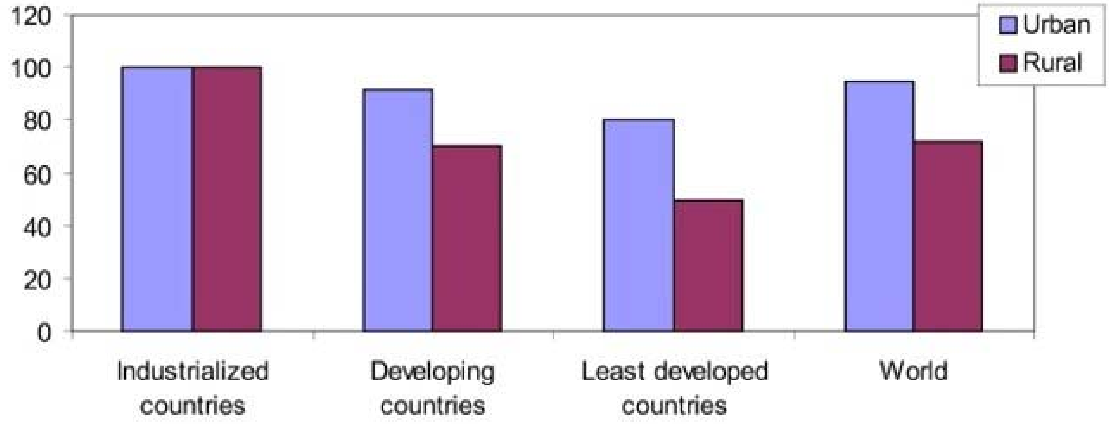

Figure 5. Rural Urban Differences in Access to Improved Sources of Drinking Water in Various Nations - Source: UNICEF

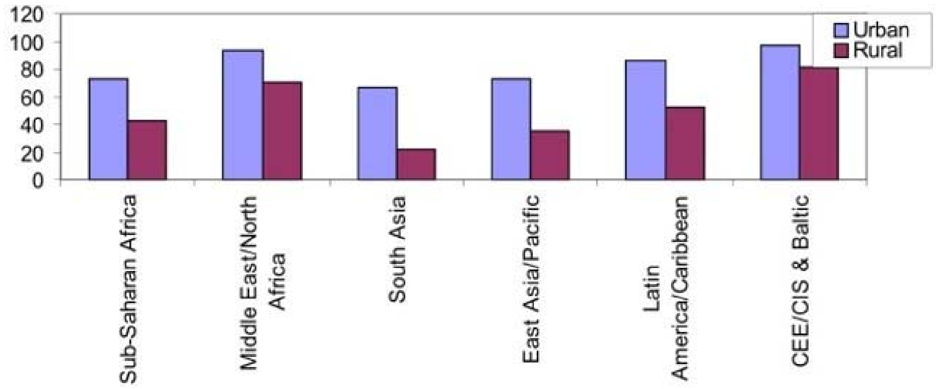

Figure 6. Rural Urban Differences in Access to Sanitation by Region
Source: UNICEF

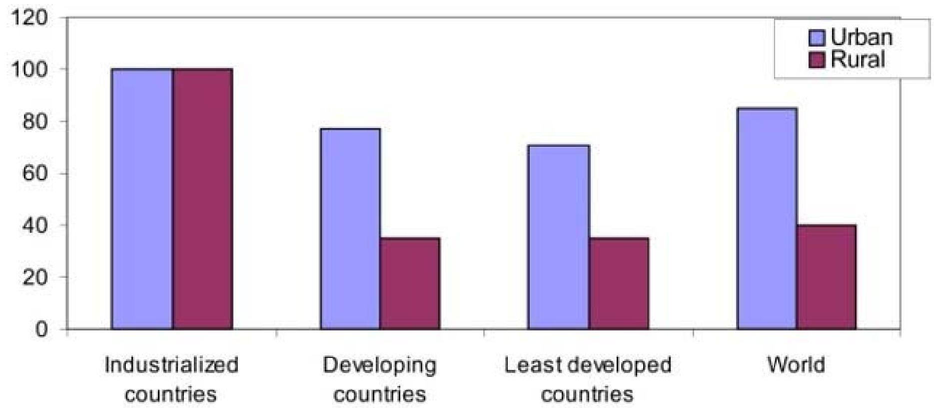

Figure 7. Rural Urban Differences in Access to Sanitation in Various Nations
Source: UNICEF

The implications of the low levels of socio-economic development in rural areas for communication systems are many. Given the low levels of income, the price of the communication systems must be correspondingly lower such that they are affordable to the rural population. This in turn means the cost of production of the communication system must be reduced in order for such pricing to be economically feasible.

Organizations involved in the commercial delivery of communication systems also need to have a thorough understanding of the rural consumer. For example, the shared use of ICT infrastructure such as mobile phones, computers and Internet connectivity – which might not be the most popular option in urban areas today - may in fact be far more appropriate in rural areas, both from a need and an affordability point of view. Therefore appropriate business models need to be devised taking into account the specificities of the rural environment.

Where societies have low levels of social development, the adoption of communication systems may also take a longer time, due to barriers of illiteracy and ignorance. While these are additional challenges, this would also imply that the potential for these technologies to make an impact, by opening up access to information, resources and opportunities in these regions, is likely to be significant.

1.3. Rural-Urban Differences in Physical Infrastructure

The successful deployment of communication systems pre-supposes the existence of certain supporting infrastructure. Most important among these are optical fiber and electricity. Unfortunately most rural areas of developing countries lack a proper fiber network and a reliable supply of electricity. In India, however, optical fiber is available in nearly all county headquarters and towns in the country due to early efforts by the government. Since 85 percent of Indian villages are situated within a 15-20 km radius of these county towns a wireless system with a radius of coverage of about 20 km deployed at these towns would be able to connect nearly all of these villages. The situation with regard to electricity supply, however, is rather poor. According to the Human Development Report of 2002, only 30.54 % of the rural population in India had electricity supply, whereas in urban areas it was 75.78 %. A proper road network also helps in the process of deploying communication systems, and rural areas once again tend to be lacking in this regard.

Given the challenges in rural areas in terms of the physical, social and economic environments, we will now look at the implications for the communication systems in these areas.

2. Connectivity

The challenges confronted when speaking of rural connectivity are many. How does one provide telephone and Internet connectivity to areas that are characterized by remote and scattered habitations, poor supporting infrastructure and low levels of socio-economic development? More importantly, how does one provide connectivity in a manner that makes commercial sense? Without the latter, while it may be possible to set up a number of experimental connections, the connectivity is unlikely to scale and reach the majority in these regoins. For commercial viability, an operator in a rural area who provides Internet services to the local population must be able to recover the cost of investment within a reasonable period of time, and also meet the costs of operation and maintenance. Even if the funds required for the initial capital expenses were somehow obtained, the network would not sustain itself over time, unless the stream of revenues exceeds the operating and maintenance costs. Therefore, it is crucial that the purchasing power is understood even at the stage of design of the communication system.

Let us begin by taking a look at the technology options for connecting rural and sparse areas of the world.

2.1. Telecom Networks

A telecom network consists of three sub systems, as explained below:

a) The Backbone Network brings the connectivity into the region to be connected and connects the region to other parts of the world. The area of this region would vary depending on the geography; but as a rough estimate, it is today considered desirable to extend the backbone network to regions with a radius of about 20 to 25 km (about 1000 to 2000 sq km area)
b) The Access Network takes the connectivity from the backbone to each village, household or individual. As the backbone network spans regions of about 1000 to 2000 sq km, the access network must provide the connectivity from the backbone within these areas.
c) Switching is an element that switches voice or Internet traffic from one village (individual) to another within a region or from a village (individual) to the backbone. The switches or exchanges (for voice traffic) and routers (for data traffic) were expensive elements until the early Nineties but with the subsequent digitization of the telecom network, the emergence of Integrated Circuit technology and the software control of the switches and routers, these elements have become less complex and quite inexpensive. Today they are to a large extent integrated into the Access part of the network itself.

We will examine the Backbone Network and Access Network for Rural and Sparse Area Communications in detail in sections 3 and 4 respectively.

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Biographical Sketches

Ashok Jhunjhunwala is Professor of the Department of Electrical Engineering, Indian Institute of Technology, Chennai, India and was department Chair until recently. He received his B.Tech degree from IIT, Kanpur, and his MS and PhD degrees from the University of Maine. From 1979 to 1981, he was with the Washington State University as Assistant Professor. Since 1981, he has been teaching at IIT, Madras.

Dr. Jhunjhunwala leads the Telecommunications and Computer Networks group (TeNeT) at IIT Madras. This group is closely working with industry in the development of a number of Telecommunications and Computer Network Systems. The TeNeT group has incubated several technology companies that work in partnership with the TeNeT group to develop Telecom and Banking products for rural and urban markets in India. Dr, Jhunjhunwala chairs the Rural Technology and Business Incubator (RTBI) at IIT Madras and the Mobile Payment Forum of India (MPFI).

Dr. Ashok Jhunjhunwala has been awarded the Padma Shri in the year 2002, the Shanti Swarup Bhatnagar Award in 1998, the Dr.Vikram Sarabhai Research Award for the year 1997, the Millennium Medal at the Indian Science Congress in 2000, the H. K. Firodia award for "Excellence in Science & Technology" in 2002, the Shri Om Prakash Bhasin Foundation Award for Science & Technology in 2004, the Jawaharlal Nehru Birth Centenary Lecture Award by INSA in 2006, the IBM Innovation and Leadership Forum Award in 2006 and recently, an Honorary Doctorate by the Institute of Blekinge Institute of Technology Sweden. He is a Fellow of the World Wireless Research forum, IEEE and Indian academies including INAE, IAS, INSA and NAS.

Dr. Jhunjhunwala is a Director in the Board of State Bank of India, TTML, BEL, Polaris, 3i Infotech, Sasken, Tejas, IDRBT and Tata Communications. He is a member of the Prime Minister's Scientific Advisory Committee.

He can be contacted at: www.tenet.res.in

Sangamitra Ramachander is a doctoral student at the Department of International Development, University of Oxford, specializing in Development Economics. Prior to this, she spent two years with the Tenet Group at IIT-Madras, leading a grassroots research project on 'information kiosks' in rural India. Her earlier research has been at the International Food Policy Research Institute (IFPRI) in Washington DC, in the area of food security and social safety nets, and at the Joint Global Change Research Institute (JGCRI) in College Park, Maryland, on the economic impacts of climate change. Sangamitra has an MA in Economics from the University of Maryland, College Park (2003) and an MSc in Economics from the Madras School of Economics, Chennai (2001). She also has a Diploma in French from the Alliance Française de Chennai.