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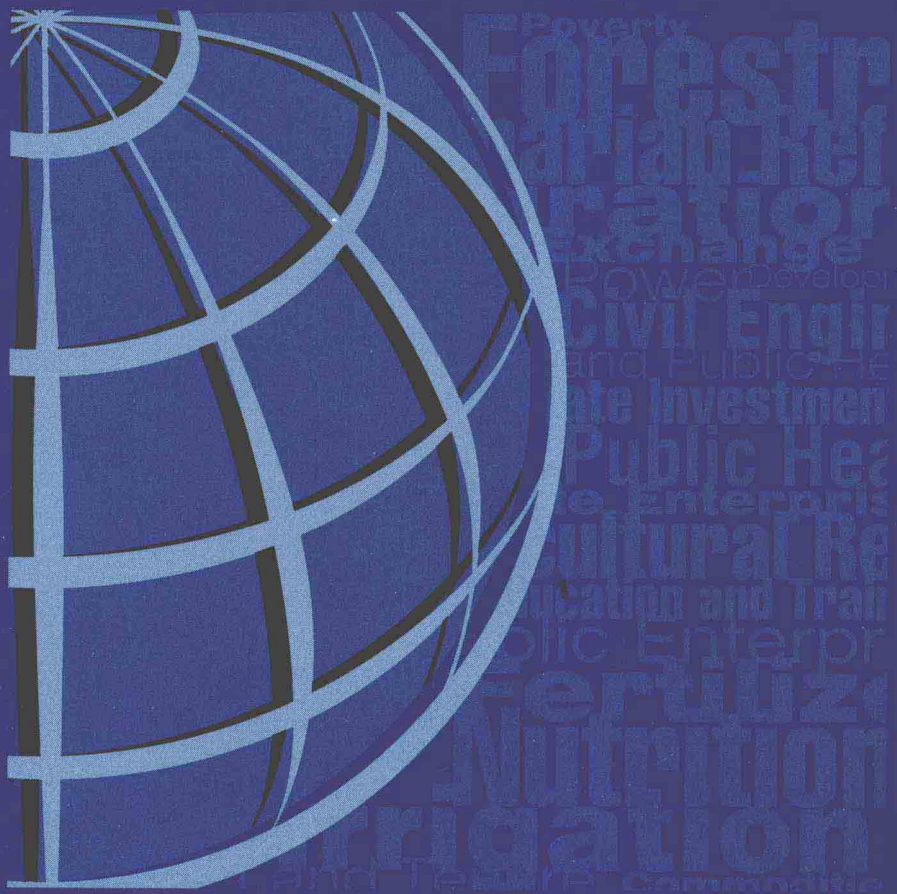
Options for Rural Telecommunications Development



Rogati Kayani
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FOREWORD

Compared to the industrial world, telecommunications facilities in developing countries are notoriously inadequate for their social and economic needs. However, the disparity between facilities in urban and rural areas within the developing countries is often even more acute. For instance, in Bangladesh, the ratio of largest city telephone density to rest of country telephone density is 340, and in Uganda it is 50. On the other hand, in Norway it is 1.4 and in Germany, 1.2. The lack of telecommunications facilities in the rural areas translates to denied opportunities for the rural inhabitants and increasing inequity between them and their urban counterparts. Strengthening rural telecommunications services is thus a vital ingredient of any effort designed to promote the welfare of the rural population.

The present unsatisfactory state of telecommunications services results from both inadequate financing and poor management. More fundamentally, however, these symptoms reflect underlying deficiencies in the institutions and policies that govern the sector. Recognizing these realities, many countries are now enacting comprehensive reforms designed to expand and improve their telecommunications infrastructure. These policies include opening the sector to private investors who would bring in the necessary capital and management, as well as privatizing the existing government-owned telecommunications monopolies that have proved to be incapable of meeting the demand. However, most of the attention to-date has been focused on improving urban services. As the telecommunications sector evolves toward a more competitive environment in which the private actors become the main players, it is essential to develop policies designed to reduce the disparities between urban and rural telecommunications services. This technical report, prepared by a team of consultants supervised by Bank staff, provides a comprehensive analysis of the technical and financial parameters that have to be considered in formulating such policies. The report presents an array of options for commercial operation of rural telecommunications and challenges the general perception that rural telecommunications services are unprofitable. The report demonstrates that services can be economically delivered to rural areas at affordable prices while at the same time providing reasonable financial returns to investors. A planning tool kit to assist in the design of the various options is also presented.

We hope this report will be useful to policymakers as well as telecommunications operators all over the world.

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Director
Industry and Energy Department
Finance and Private Sector Development

PREFACE

The World Bank retained the services of a consultant (*Intelecon Research and Consultancy Ltd. of Canada*) to review relevant international experience, to draw out the lessons to be learned, and to provide an overview of the policy options for effective commercial service development within the context of the ongoing sector reform process. The focus of the study has been to answer the following four pertinent questions:

- Is there an ideal policy environment and regulatory framework for the development of rural telecommunications services in developing countries on a commercial basis?
- Are current technology and cost trends significant enough to change the financial equation, which has until now been viewed as unfavorable?
- If the technology and cost trends are positive, what are the limits of feasibility and what policy interventions would be required beyond these limits?
- Can rural service programs be established that combine commercial viability with enlightened policy intervention, in order to attract sufficient finance to accelerate the infrastructure and service deployment?

The Bank also retained Professor Heather Hudson of the University of San Francisco to review the social and economic benefits of rural telecommunications.

Methodology

The consultant used a wide range of desk research methods in this study and was also able to draw on some related field research. Useful case study data were collected from more than 26 developing countries: 10 in Asia, 9 in Latin American countries and 7 in Africa. The consultant had undertaken assignments in several of these countries and was able to obtain recent reports from others. Also, during the course of the research, the consultant collected up-to-date information on active projects in Bangladesh, Paraguay, Peru, the Philippines, and Sri Lanka.

Basic statistics were gathered on the development of rural telecommunications in many other countries, utilizing such resources as recent studies and papers of the International Telecommunications Union (ITU), conference proceedings in Asia and Latin America, and numerous other related publications and articles. At least seven member countries of the Organization for Economic Cooperation and Development (OECD) provided relevant information on strategic policies, pricing, and funding. In addition, materials from the European Union's Special Telecommunications Action for Regional Development (STAR Program) and other initiatives for Objective 1 (less-favored) regions were consulted.

To assess technology trends and ascertain their costs, the consultant contacted a number of key suppliers, who provided valuable assistance. Recent information on costs and technical applications, written submissions, and application documents and technical papers were obtained from more than 20 suppliers worldwide.

The consultant then constructed a rural telecommunications commercial feasibility model, which, together with the comparative analyses, served as the basis for determining a range of options for commercial supply of rural telecommunications. The first stage of this effort was the design of a "policy tool kit" a framework for decision making on commercial viability, policy direction, and regulatory/licensing requirements. This "tool kit" will assist Bank borrowers as they begin to devise policy strategies and measures for their own unique situations.

ACKNOWLEDGMENTS

It has been possible to complete this report because of valuable contributions from various individuals in the World Bank, Intelecon, and others. We particularly wish to thank those who participated in the workshop of June 1995 where the original draft of this report was thoroughly discussed.

Special thanks go to the following: Richard Stern; James Bond; Elkyn Chapparo; Dennis Anderson; Bjorn Wellenius; Jorge Barrientos; Robert Hindle; A. Zhiri; Nikola Holcer; Barry Mrazek; Heather Hudson; Eduardo Talero; Rajesh Pradhan; Syed Sathar; Dinshaw Joshi; Peter Wright; Omari Issa; Hugh Lantzke; Francoise Clottes; Muhammad Mustafa; Silvano Monti; James Cowie; A. Shanmugarajah; Robert Direnzo; M. Sergo; R. Singh; Oddvar Kvale; David Lomax; Paul Bermingham; David Delgado; Enar Wennerstrom; Richardson Franklin; Philippe Lecharny; Marcel Scoffier; Veronique Bishop; Svetoslav Tintchev; Warren Mitchell; and Ferdo Ivanek.

We also like to thank Barbara Malczak and Helene Masson-Bruno for editing the report; and Teresa Saldana, Beatrice Massoussi, and Arturo Castro who assisted in compiling the report.

RURAL TELECOMMUNICATIONS GLOSSARY OF TERMS

(Key terms are italicized in the definition for easy cross-reference.)

Access (policy definition)

Refers to the policy objective or target of establishing a certain level of telephone service to meet the needs of populations and communities where the existing telephone penetration is low because of income level and/or remoteness. Typical access target examples are 1 public telephone (payphone) per center of 500 population or 4 to 5 telephones (1 payphone plus 3 to 4 business/ institutional lines) per village.

Access (technical definition)

The provision of connectivity between the subscriber telephone terminal and the local exchange (could be via wire or a wireless/radio technique). The term is basically equivalent to the term *Local Loop*.

BOT, BTO

Build Operate Transfer and Build Transfer Operate - Forms of a revenue-sharing agreement in which telecommunications operating companies invite the participation of the private sector (often consortia including major equipment suppliers, operators, and commercial banks) to finance projects and to provide the operating expertise for a stipulated period of time, as defined by the agreement.

Digital

The form of electronic processing and transmission in which all information, including analog waveforms (e.g., speech and video) and control data, is converted to binary format, which is basically the same format used by computers.

Erlang

A measure of telephone traffic intensity. Networks are designed assuming a certain average volume of traffic from each subscriber during the "busy hour" of the day. One Erlang indicates a 100 percent busy condition *during one busy hour*. It is normal to assume a network-wide average traffic of 0.03 to 0.08 per subscriber, although business lines typically average 0.10 to 0.15. Public call offices in developing countries sometimes greatly exceed this average. Rural systems that are designed for optimal commercial operation may average between 0.10 and 0.15 Erlangs per line.

Fixed Cellular

The first generation of *wireless local loop (WLL)* systems. These were essentially cellular systems adapted to the fixed service market by removal of the expensive mobility software. They can offer economic solutions in a "single cell", urban and suburban environment, although the voice quality and the data and facsimile transmission speed capabilities of current generation cellular systems are limited.

GOS

Grade of Service. A design parameter used in the public switched telephone network *(PSTN)* to define the number of call attempts per 100 that are likely to be blocked (uncompleted), given a certain average subscriber calling rate (in *Erlangs*). The GOS is expressed as a

probability. For example P.01 indicates a 1 percent probability of blocking, P.02 a 2 percent probability and so forth. P.05 is considered to be the lowest acceptable design standard for rural telephone service in previously unserved areas (although P.01/P.02 is the international norm).

ISDN — Integrated Services Digital Network. A modern service in which a single subscriber connection is able to carry voice, data, facsimile and multimedia. ISDN service requires an advanced *digital* telephone exchange, a high standard (well-insulated) wire connection or high bandwidth *wireless local loop,* and a special subscriber interface unit that splits out the various service components. The combined "basic rate" digital transmission speed for ISDN service is 144 kilobits per second, comprising two 64 Kbps voice or data channels plus a 16 - Kbps control/data channel.

LEOs — Low Earth Orbit satellite systems, such as Iridium, Globalstar, and Odyssey. These systems are expected to offer fixed and mobile telephone service by the year 2000. In addition to having a potential cost advantage compared to current *VSAT* technology, these systems are not subject to the transmission delays confronting users of the high orbit geo-stationary satellite systems, which is a technical advantage.

M-SAT — Mobile Satellite services, such as recently commenced in North America. These services utilize a geo-stationary satellite that has been optimized to serve small portable or mobile terminals, which can obviously be installed as fixed terminals as well.

Multi-access — An operational feature of *point-to-multipoint (PMP)* radio or *VSAT* networks. Multi-access refers to a micro-processor controlled circuit allocation technique in which a large number of subscribers can be served on a small number of "radio trunks" or circuits. The design is based on statistical traffic averaging and concentration, whereby it is typically possible to concentrate up to 500 subscribers onto, say, 60 commonly available circuits. The concentration ratio actually achievable in practice depends on the calling rate of the subscribers (see *Erlang* for a discussion of the calling rate).

Outside Plant — See *Local Loop.*

PCM — Pulse Code Modulation. A common form of encoding and transmission in which analog speech signals are converted to *digital* format for the purpose of multiplexing (combining together) and transmission over distance. PCM is commonly used in multi-circuit inter-exchange trunk systems, or "subscriber carrier" systems in which a number of telephone subscribers along a route are served from the same cable.

PCO — Public Call Office (payphone). The traditional form of payphone is located in the PTT office, or is a coin telephone located in a public place. A more recent concept is to franchise payphone service to local business people to enable them to operate "phoneshops" or adjunct businesses

within, for example, a retail store.

Penetration — See *Teledensity.*

PIN-based Service — Personal Identification Numbers (PINs), such as are used with direct debit banking and telephone calling cards. PINs can be utilized in rural environments to allow users access to long distance dialing from public or shared telephones. This would require pre-pay or credit pre-authorization. See *Virtual Telephone Service.*

PMP — Point-to-Multipoint. A form of subscriber radio system in which a number of outlying localities within line-of-sight of a single station or repeater can be connected into the telephone network at one central point. The central station is usually co-located or directly connected with the exchange and thus provides the technical network interface between the remote subscribers and the telephone exchange service. This system is commonly used in rural areas to connect widely dispersed subscribers into the network.

PSTN — Public Switched Telephone Network. The nation's main telephone services infrastructure owned by the PTT or telecommunications corporation(s).

RSU — Remote Switching Unit. An extension of a larger *digital* telephone exchange, in which a number of telephone lines (in groups of up to 256) can be located remotely from the main exchange and connected via a transmission system. This obviates the need for a stand-alone rural exchange which may, under some circumstances, be more costly. RSUs are usually dependent on the main exchange for software functions such as long distance call detail records and statistics.

TDMA — Time Division Multiple Access. A form of the *multi-access radio, wireless local loop,* or *VSAT* system in which the circuit concentration and allocation function is achieved by means of *digital* time division techniques. This is the most common technique used in multi-access and circuit concentration systems.

Teledensity — The number of telephones or telephone lines per 100 population, ranging from less than 1 per 100 in many low-income countries to more than 60 in high-income countries.

Universal Service — A term traditionally used in the industrialized world to refer to the policy objective of providing telephone service to all households, regardless of their location and income level. The term is also frequently used to describe *Universal Access* policy objectives.

Virtual Telephone Service — A concept for providing wide access by the population to a limited number of telephone lines, such as may exist in the rural areas of developing countries, via non direct-line services such as *Voice-mail* or *PIN based long distance* calling.

Voice-mail

A stored voice message service to which individuals can receive and gain access, even though they do not have a dedicated telephone line. Subscribers are able to access their voice mailbox from any available public or shared telephone. Voice mail could be operated in conjunction with a locally operated paging service.

VSATs

Very Small Aperture Terminals. Satellite-based systems with low-cost VSATs can offer telephone service economically to the most remote localities (albeit still at relatively high cost compared to less remote locations).

WLL

Wireless Local Loop. Systems that use wireless technology (radio) to connect subscribers to the local telephone exchange. The vast majority of the world's exchange service customers are connected via dedicated copper wire. A range of recent WLL systems, with operating radii ranging from 1 to 2 km to 30+ km, now offer a basic service alternative. To date economics have limited WLL primarily to urban and suburban subscribers. WLL is increasingly seen as a cost-effective solution in developing countries, where meeting basic service demand through build-out of the wire network would take much longer to achieve. WLL systems are usually "single cell", that is, they do not extend beyond line-of-sight from the central station, without the expensive addition of further remote base stations. First generation WLL systems are also limited in their data and facsimile transmission speed capabilities, but this is changing, as some later generation systems have *ISDN* capability.

EXECUTIVE SUMMARY AND CONCLUSIONS

This report addresses the following five fundamental issues regarding commercial provision of rural telecommunications services:

- *The implications of the various sector reform models on rural telecommunications development,* and how these implications are being addressed.
- *Technology and cost trends,* and their application to various demographic, geographic and economic environments.
- *Pricing and tariff setting options,* how they apply to different demand/supply situations and how they relate to the various options for establishing interconnection agreements between operating entities.
- *Commercial viability and revenue generation potential,* and whether there are any good examples of how this can be improved in rural networks.
- *Funding issues,* including what is happening in this area and what strategies are available for mobilizing investment finance for rural telecommunications.

The Study Findings on Technology and Cost

There is indeed significant downward pressure on the cost per line, though there is a very wide range, because costs are very sensitive to subscriber distribution and density. In the ideal environment, where subscriber densities in excess of 0.5 per sq. km. can be achieved within 40 km of an urban center, capital costs can be lower than $1,000 per line using wireless loop technology. This kind of service can be commercially feasible if annual revenues per line are in the $300-400 range.

Over a more widespread area, for example 200 km radius from the urban center, costs are significantly higher. Wireless loop and multi-access subscriber radio (and various hybrids) compete, with costs in excess of $1,500 and usually in the $2,000 - $3,000 range. Costs are dependent on such factors as:

- The calling rate per subscriber (wireless loop costs triple from 0.01 to 0.10 Erlangs).
- The degree to which subscriber lines can be concentrated in villages and towns (multi-access radio costs are very sensitive to the number of lines per station).
- The terrain and environmental conditions (whether radio repeaters, solar power, or special antennas are required).

Per-line capital costs of up to $5,000 are still not unusual in situations where subscriber lines need to be widely spread-out, such as in much of sub-Saharan Africa, or where communities are fairly remote. The total annual operating costs (including equipment amortization) in these situations can exceed $1,500. Some countries face even higher costs because of terrain and remoteness. When capital costs are above $10,000 per

line, satellite solutions become cost-effective but these systems are not likely to change the supply economics significantly in the near term at least. It is possible that several years from now mobile satellite operators e.g., low earth orbit (LEO) satellite systems such as *Iridium,* could be offering lower-cost solutions for rural services; however, this is far from certain and may not improve on solutions that will, by then, be feasible with a combination of conventional wireless and multi-access technology. All costs are dropping by at least 5 percent per year.

Affordability and Willingness to Pay

It has been broadly assumed, based on experience and selective case study data, that rural users in developing countries are able to *collectively* pay 1 to 1.5 percent of their gross community income on telecommunications services. Telecommunications operators in rural areas have rarely achieved this level, but the reason for this failure has more to do with poor distribution, poor access, and unreliability of the service than with people's readiness to use the facilities and pay cost-based prices. Nevertheless, this target level of revenue has been reached in some instances, but these best-case scenarios can be replicated only with careful deployment and marketing that takes all relevant social, economic, developmental, and infrastructural factors into account.

Economic studies have shown that achieving the highest socio-economic benefit is consistent with revenue maximization, within a tariff regime where charges reflect the underlying costs of supply, so long as the subscriber line deployment provides broad access to the community. The proposed strategy for serving villages and rural population centers is to provide lines to (a) institutions and businesses that are engaged in activities related to trade, commerce, and the delivery of social and economic structure, whose economic benefit from telephone use and estimated call revenues exceed the incremental cost of supply; and (b) public payphones, preferably operated as franchised "phone shops" or part of 24-hour communications/information agencies with facsimile and other facilities. If outside coin or card phones are used, they should at least be near public or commercial centers, and responsibility for maintenance or fault reporting should be taken at the community level.

The demand for residential phone lines may be limited at first, if the incremental cost of supply and expected revenue are far apart. The study developed a model that assists planners to estimate the minimum number of lines which are commercially feasible per community or population catchment area. The model is based on estimates of rural per capita income and the cost of supply. The number of lines deployed per community will depend on its:

- Population
- Economic activity and level of development
- Regional administrative importance
- Aggregate income level.

The study has shown that many regions in developing countries, in all continents, could receive a basic level of service commercially. The penetration in most cases will be below 1 line per 100 inhabitants, but access to the network would be available. As the level of use increases, penetration increases and per-line costs decrease such that growth can be self-sustaining.

Nevertheless, service is still not commercially viable in various large areas and localities and thus must be "subsidized" from the more lucrative parts of the network. However, even though subsidization is required for these remote communities, well-planned rural investments represent far less of a resource drain than is commonly assumed.

The Real Costs and Revenues, and Policy Implications

The report argues that the locally generated revenues from rental and call charges represent the *minimum* cash flow from which to calculate viability. Many localities may be loss-making or barely cover costs if only outgoing call revenues are counted. But most rural lines - even many public payphones - generate at least as much incoming revenue, from urban originated calls and reverse-charging. If separate urban and rural operators exist, to whom does this urban-collected revenue belong? Or in the case of a national monopoly, how should this revenue be apportioned in making its investment decisions?

Because of the higher costs and risks associated with rural service provision, the report argues that the total revenues be distributed between rural and urban locations in a skewed fashion, to reflect the asymmetry. If this were done, then most rural operations would become more attractive to investors and would receive funds sufficient to expand the envelope of commercial viability. In establishing the kind of policy environment that would foster this arrangement, the report further argues that options are available whether the sector is dominated by a state-run or a privatized monopoly, and whether or not private rural operators are in existence. There is more incentive to "get it right" in a liberalized environment however, where incremental-cost-based pricing and tariff re-balancing are being taken seriously.

Multiple Operator Environment

In a multiple operator environment, models for cost-sharing or revenue-redistribution can be devised within an interconnection framework which has either: (a) nationally averaged tariffs and access charges, where special repayments are made from the toll settlement account to operators which have higher per-line costs (as in the United States), or (b) interconnection charges based on cost causality, where the high-cost and low-cost operators settle with one another on the basis of asymmetric per-minute charges for the traffic exchanged between them, to reflect their differing cost structures. If call

record accounting proves to be too complex and therefore impractical, then inter-company settlement can take place on the basis of estimated traffic levels and average costs. These figures can be periodically checked and updated by means of traffic studies.

Single Operator Environment

In a single operator environment, it is strongly recommended that the operator apply a similar cost-causality analysis to determine the true financial costs and benefits of rural network investment. Looking at the total incremental costs of carrying the total (*bothways)* traffic caused by rural investments would yield higher returns than conventional analysis, which discounts incoming revenues. The argument for "cross-subsidization" could perhaps be modified from one of justifying support for non-profitable lines to one of recognizing a positive internal benefit/cost relationship, internalizing some of the so-called externalities.

Even if the operator is not doing so, regulators are able to enforce accelerated rural investment targets onto newly privatized monopoly operators and new entrants, as an integral part of their license agreements. Virtually all of the Latin American privatized carriers, for example, are obligated to extend service to rural communities above a certain size. Some Build-Operate-Transfer (BOT) and Build-Transfer-Operate (BTO) schemes, which are successfully attracting private finance in Asia and Latin America, also have built-in rural service obligations.

As an additional means of supporting conventionally nonviable service from internal revenues, at least one country (Peru) has established a *rural telecommunications development fund* to which the monopoly privatized operator contributes. Its purpose is to finance service extension to communities not covered under the operator's license obligation.

Basically this internal support argument can be pursued to the point where the rural operation becomes profitable with the enhanced revenue stream. Beyond this, the operation should be recognized as bona fide loss-making and a candidate for additional support in the form of capital or operating cost contributions, low interest loans, or fiscal and tax incentives. It is recommended that such operations be identified and, as far as possible, separated from the commercially viable operations in order to qualify for government support and external concessionary finance.

Monopoly or Competition?

Conventional wisdom argues that a high cost and marginally profitable service such as rural telecommunications needs to be supplied as a monopoly, even though there may be competition for territorial licenses. Most countries seem to agree with this, the