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Information Infrastructure in Developing Countries: Bridging the Urban - Rural Divide

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ABSTRACT

Developing countries need to stimulate economic and social development in their rural areas to minimize the gap some call the "Digital Divide." However, they are often unable to deliver basic telecommunications infrastructure services to remote communities due to the high costs and other barriers. In this paper, we examine approaches that could be used to deploy simple and practical information infrastructure leveraging technologies such as portable computers, wireless telecommunications, and alternative energy sources like solar power as a means of delivering basic Internet access to remote areas at comparatively low cost. We examine some of the key challenges likely to be encountered in implementing such an initiative and possible solutions to meet those challenges.

1. INTRODUCTION

Developing countries have long faced profound and systemic problems caused by inadequate information and telecommunications infrastructures that have constrained their ability to deliver services that would promote equitable social and economic growth to the residents of their rural areas. These infrastructure gaps, often referred to as the "Digital Divide", have emerged over the years in developing countries between urban and rural areas, exacerbating problems caused by the migration of rural populations to urban areas in search of better education, health care and economic opportunities.

In this paper we identify and examine key infrastructure barriers to rural social and economic progress in developing countries and describe how current technologies can be deployed to provide a simple, practical and affordable solution to overcome these barriers.

We consider the following questions:

- What are the challenges that governments of developing countries are likely to encounter as they implement large-scale deployment of information and communication infrastructure services to their rural populations?
- How can current technologies be deployed to help developing countries overcome their infrastructure barriers and thus deliver basic information and communication infrastructure and services to their rural populations?
- What currently available technology solutions could be employed to address and overcome these challenges in a practical and affordable manner?
- What technical and social challenges will be associated with the implementation of the proposed solution?

How can converging technologies could be deployed to help developing countries overcome their infrastructure barriers and thus deliver basic their information and communication infrastructure and basic services to their rural populations? What challenges are governments likely to face as they seek to engage in large scale deployment of converging technologies, and what solutions might be available to overcome the same?

The rest of the paper consists of a survey of academic and practitioner literature. Based on the literature, some conclusions and suggestions have been put forward, regarding the possibility of use of converging technologies in developing countries. Finally, the technical and social challenges associated with such efforts have also been highlighted.

We examine technology applications in India and other countries in Asia, Latin America and Africa in order to gain a better understanding of how converging technologies can be used to overcome infrastructure barriers and the challenges of implementing these technologies.

2. LITERATURE REVIEW

To better understand these questions, we examined academic and practitioner literature related to the applications of information technology applications in India and other developing countries in Asia, Latin America, and Africa to gain a better understanding of how these technologies can be used to overcome existing infrastructure barriers. We also studied some of the challenges related to the implementation these technologies.

Various studies have addressed the need for addressing the information and infrastructural needs of developing countries. Fakeeh (2001) observes that even though in developed countries there are significant trends that are bringing together computing and communications technologies, the economic and social benefits of information technology for developing countries have been lacking **(1)**. Fleming (2001) suggests that factors such as low literacy and technical skills, and inadequate transportation infrastructure are partly the cause of this inequity **(2)**. However, there is general agreement (Fleming 2001, Cavanaugh 1998, Hudson 1995), that information and telecommunications infrastructure is one of the most crucial links in the development process **(3), (4)**. In this context, the large-scale deployment of information technologies in developing countries could provide significant benefits by promoting economic opportunities and enabling the delivery of basic services in the areas of health, education, and commercial services into remote and rural areas.

According to Rischard (1996), these technologies have also been used to provide distance learning, surveillance and control of epidemics and contagious diseases, and the dissemination of information on best healthcare practices to doctors, nurses, health agents, and community leaders **(5).**

One of the key challenges and opportunities faced in progressive developing countries such as India is the re-engineering of the several existing government processes towards effectively supporting the rural sector. There are multiple agencies involved with multiple decision-makers and often conflicting priorities and objectives. Simply providing greater information availability through information technology may not be enough. Architectures for supporting the re-engineering of group decision processes should be explored.

We conduced a study of the academic and practitioner literature in this area and examined such technology applications in India and other countries in Asia, Latin America and Africa in order to gain a better understanding of how converging technologies can be used to overcome infrastructure barriers. We also studied some of the challenges of implementing these technologies.

2.1. Trends

Communication and information technology have always been important enablers for creating prosperity for countries. The degree of a country's prosperity can also be related to its willingness and capability to adopt new technologies.

India's 1991 economic liberalization radically transformed the urban landscape in terms of productivity, efficiency. It promoted the development of a communication and educational infrastructure that was radically different from the past. However, India's rural areas lag far behind, and still lack many of the most fundamental infrastructure services. With 70% of the countries population residing in these rural areas and an equal percentage of its gross domestic product being derived from those areas, it is critical that India include the rural areas in its efforts to create a more prosperous future.

To a large degree, most developing countries face similar disparities in growth and demographics of their rural and urban areas. Rural to urban migration in developing countries has forced governments to focus their scarce resources on developing the infrastructure within cities. Hence, it is common within developing nations to find highly developed and well-connected urban centers existing in the midst of rural communities that possess little or no information infrastructure. Consequently, the urban areas have become overcrowded and rural areas have been decimated as their most productive citizens migrate to the urban areas. This phenomenon has caused a host of social and economic problems besides imposing many indirect costs in terms of grinding poverty, lost productivity, and squandered opportunities. This "Digital Divide" also offers a stark contrast in developing countries between urban and rural centers in terms of education, healthcare, sanitation, communications power, and transportation services. Developing robust and sustainable rural networks in each of these areas is crucial for the success of any long-term development plans.

Radio and television have played increasingly important roles throughout the twentieth century. These broadcast technologies have been used by both governments and Non Government Organizations (NGO) to bring about much needed development in rural parts of the world by using them to disseminate agriculture and health-related information.

The greatest stimulant to India's economy during the 1960's was the Green Revolution that transformed rural activity and productivity. Renowned agricultural scientist, Dr. M S Swaminathan, and his colleagues had achieved a breakthrough in creating a hybrid variety of rice and wheat that produced much higher yields. To generate awareness and acceptance among the agricultural community, the institute he headed setup 2,000 model farms in and around New Delhi that promoted the use of hybrid grains. Radio offered all that an under-developed country required to implement this farming technology. It could cover a large area at a very low cost, maintaining the infrastructure was relatively inexpensive, it could integrate well with the governments communication and information structure, and the unit cost per radio was inexpensive when converted to a cost per person.

Likewise, NGO's have employed radio as a tool to deliver much needed information to rural parts of the world. "Developing Countries Farm Radio Network", an NGO based in Canada has, since 1979, used the radio to achieve their goal "to promote practices, in food production and processing, in health, in small-scale rural enterprises and in natural resource management, that lead to sustainable rural livelihoods in developing countries." Their approach has been to "link almost 500 rural radio stations so that they can share expertise and experience. Working together, they can greatly enhance their capacity to provide relevant development programming for millions of people who depend on agriculture for their livelihood."

The advent of television further strengthened this fabric of communication. However, broadcast television is still a one-way medium and while it provides a powerful visual medium, the benefits of interactivity are not possible.

Limitations on access and the ability of people to interact with credible sources of information resulted in new inefficiencies. If the flow of information to a remote area can be controlled or restricted, that control can be used to artificially manipulate local economic conditions. In one case, for example, a local trader provided villagers with price quotes for their produce that were roughly half the actual prevailing market prices. In another case, farmers needing to acquire legal records in order to arrange bank loans, needed to pay bribes and kickbacks to local officials **(9)** Over the years, such examples of corruption and inefficiency have become institutionalized in developing countries and has severely inhibited rural development efforts.

2.2. Wireless Internet as the Next Medium

Freling (2001) describes the Internet, as the next medium in communications and its potential benefits for rural communities, "Using a combination of solar energy and wireless communications technology, rural and remote parts of the world have the opportunity to leapfrog sustainably into the 21st century. Once compelled to migrate to over-crowded towns and cities in search of economic opportunity, rural villagers may now choose to stay close to home ... where they are more closely connected to each other and to nature." **(10)**

Some of the limitations to development of such large scale and hybrid sequences are imposed by:

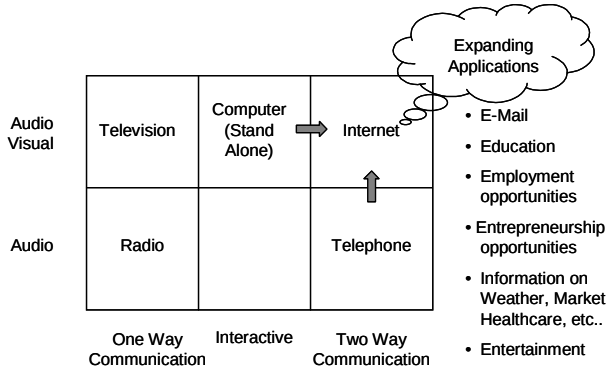
lack of faster and reliable communication
need for real time information
lack of proper educational facilities and educational related information
lack of information on employment and entrepreneurial opportunities
lack of proper health related information

These are obstacles that can be overcome by the introduction of the Internet to rural areas. Internet expands the scope of the existing communication systems as a more effective means of development as shown in Figure 1.

It is evident that the large-scale deployment of Internet access into rural areas of developing countries such as India could provide significant socio-economic benefits. By providing more equitable access to increasingly important infrastructure services such as the Internet, governments can allow a higher proportion of their populations to remain residents of rural areas while still enabling them to participate in the benefits that are now only available by emigration to urban centers.

Infrastructure: Implementing this initiative will require, every village to be provided with a computer, phone line/wireless connection, a location to house the two in proper conditions, person to operate and train the villagers, so they become self sufficient over time, and a connection to the Internet. Though

Figure 1 : Expanding Applications of Internet



this might sound ambitious, the costs when considered are in fact quite realistic if done in a phased manner. A rough arithmetic as follows puts the total cost of implementation at around $ 1.2 Billion in India's case without the telecom infrastructure costs.

On a 3 year implementation plan this translates to roughly $ 400 million per year but the challenge however is going to be in estimating the ongoing costs of communication and in establishing the costs of getting Internet access to these areas.

Not withstanding the financial implications, central to the eventual consideration and implementation of such a proposal rests is on the ability to deliver at least three supportive resources, viz. telecommunications, power, and a skilled workforce to implement the initiative.

2.3. Telecommunications Infrastructure

An key factor for future economic development is the establishment of a sustainable and scalable telecommunication infrastructure. Frank Tipton state in the ASEAN Economic Bulletin that "in the developed world, on average, there are nearly 50 phone lines per 100 people whereas in low income countries, there are only 1.4 phone lines per 100 people" **(11)**. India, which has over 600,000 villages, still has 225,000 villages to be covered by some form of communication **.** As of 1998, China had covered less than 300,000 villages of the 740,000 villages that span its vast region with a telecommunication link. The same pattern is repeated in other developing countries, hampering growth prospects of these economies. Compounding these coverage issues are complex technology-related challenges that governments often face. Rapid changes in technology has made it difficult for governments and companies to deploy systems without fear of building in obsolescence. The telecommunications industry is strewn with technologies that once looked promising only to be discarded within a relatively short period of time. This poses immense risks on governments as they consider adopting new technologies.

India has, over the past 50 years, been able to install only 26.8 million lines. In the next 3 years the country's Telecommunications Department plans to invest $10 billion to lay an additional 13 million phone wires **(13).** Comforting as it may seem to grow coverage by 50%, it still falls far short of real demand. Furthermore, inadequate infrastructure in most developing countries exacts a high cost for maintaining these antiquated "landlines", quite disproportionate to the services they offer. This requires governments to heavily subsidize these facilities, given their inability to extract sufficient revenues from the population being served.

Rural areas present other issues as well. Villages are usually isolated clusters and are located in remote and sometimes inaccessible areas due to terrain effects. Mountains and jungles create significant barriers to deploying landlines to reach these remote areas. This demands highly innovative solutions in not just establishing the communication system, but in also integrating them with existing systems and ensuring compatibility with broad-based infrastructure upgrades that will occur in the future.

The economic challenges of reaching rural communities can thus be summarized into the following core issues:

- Low telephone demand
- Low utilization
- Dispersed subscribers
- Difficult terrain
- Isolation from the national network
- Lower levels of potential short-term revenues **(14)**

The biggest need in any rural infrastructure project is the staying power of the project through a length of time needed to achieve economies of scale. Given the sparse and dispersed population in these areas, there is a need for several forces to interplay. To be profitable, low installation and operating costs coupled are critical. Initial subscribers, typically people in business or government who have a real need for telecommunication services, will look for other ways to serve their needs, if the service is too expensive or of poor quality **(14)**. On the other hand, if an adequate service is provided at a high cost, the necessary revenues are difficult to generate, and due to a consequent lack of demand, services cannot be provided in a profitable manner. Therefore, either initial installation costs and subsequent maintenance cost for any communication system has to be low enough so that it can be sustained within a low population base, or funding should be sufficient to cover a period of time that is required to achieve profitability through economies of scale.

2.4. Closing the Gap: Wireless Solutions

Considering the economic constraints imposed by remote, low density communities and the socioeconomic benefits that could be realized, a practical, low cost solution should be considered as a starting point. A wireless infrastructure may be the only viable solution that can deliver the required coverage in a cost-effective manner.

The installation costs of a basic wireless infrastructure for delivering basic telecommunications services are becoming increasingly affordable. Operation and maintenance costs of wireless infrastructure can also be significantly lower than conventional landlines because the physical assets are concentrated within manageable areas, unlike land lines, where a fault in the line can occur anywhere along their paths.

The benefits of wireless solutions are evident in their ability to deliver coverage at comparably lower costs compared to running landlines to individual subscribers. Moreover, given that wireless allows the user to be mobile, it offers an ideal solution for the poor regions of the world. Here, villages could share their resources and bring accessibility to a wider area unlike permanently installed landlines. For example, mobile phones are being promoted in rural Bangladesh with Grameen Telecom, offering cellular phones to Bangladeshi village women as part of its micro credit program, which makes small loans to entrepreneurs. The women sell minutes to locals who speak to their relatives in other villages or towns, and the women get much-needed financial independence **(13)**.

Current mobile telecommunications systems such as the GSM are gradually incorporating data communications technologies such as General Packet Radio Service (GPRS) or Cellular Data Packet Data (CDPD). If these services are available, voice and data telecommunications can easily be provided to the rural communities. Handset manufacturers such as Nokia and Ericsson are introducing handheld mobile devices which can make use of solar power and remain in operation for several hours.

2.5 Alternative Energy Sources

Providing a reliable source of energy is a crucial requirement for the deployment of any telecommunications infrastructure. Sixty percent of rural India is not connected to the central power grid; a situation not uncommon in most developing countries **(15)**. Today, the power requirements for provisioning basic wireless Internet services in a rural community can be achieved by using a variety of alternative energy sources such as solar energy, wind power, hydroelectric, biomass conversion, and a variety of other techniques.

Solar photovoltaic systems provide the simplest and most direct technique for creating the electrical power needed to meet the relatively low energy requirements of a personal computer and a wireless access device.

Companies such as Solardyne Corporation offer low-cost, portable solar photovoltaic systems capable of powering a computer for the same length of time. These systems are easy to transport and install. They are stand-alone devices that require little or no maintenance and have proven their ability to enable untethered computing capabilities. Because of their relatively low cost, ability to operate independently, and rugged design, these systems are ideal for applications that require a computer to be operated in a remote location.

They can also be linked to a solar powered wireless device that in turn gets connected to the Internet and delivers instant two way communication capability. Testimony to such a design lies in Provenir, a remote village in the Amazon forest with a population of 600. Today, due to a joint initiative of Solarquest, the US Department of Energy and American Electric Power, this village is connected to the Internet. There is a "The 2,500-watt solar power system and 16 storage batteries that provides electricity for lighting for adult and children's classes, three computers, a satellite receiver/sender for broadband Internet access, a refrigerator/freezer for medicine and vaccines and AEP's Datapult energy monitor which will show how the solar panels are performing and the electricity is being used on AEP's web site". (17)

2.6. Skilled Resources

Low cost labor continues to be the resource in greatest abundance in most developing countries and it is readily available to assist in the deployment and maintenance of the proposed communication solution. While each economic landscape will require a creative approach in terms of how it taps into its labor pool, labor availability offers countries an opportunity to use the deployment initiative as an economic stimulus.

An example of how a creative solution can be found is available by studying the labor pool in India. To channel the deployment initiative the government could use its force of 300,000 to facilitate the setting up of Internet and e-mail facilities at village communication centers. This would bring some of the benefits of information technology to the rural areas. This could be a feasible solution specially because as courier services and e-mail have mushroomed, especially in urban areas, the quantity of mail passing through post offices has been almost halved **(16)**.

2.7. The Role of the Government

The role of the government cannot be minimized in supporting and laying down the foundations for such an endeavor. This role can extend from laying out the broad national framework for rural access of the Internet, to identifying areas of services of the government that can be brought directly to the villagers. It is government that will need to support the initial investment required to assure implementation of such an initiative.

Needless to say, the role of the government cannot be minimized in laying down the foundations for such an endeavor. This role can extend from laying out the broad national framework for rural access of the Internet, to identifying areas of services of the government that can be brought directly to the villagers. Bypassing intermediaries in the system, the issue of graft and corruption to provide basic services can be overcome. Middlemen, who use their availability of commodity prices, or lack thereof at the farmers end, will be forced to provide fair prices to avoid being relegated to the margins of the market.

3. EXAMPLES

The following examples provide illustrations of some of the initiatives that are currently underway in India and other developing countries, for using converging technologies to set up the information and communication infrastructure, confirming that some of the opportunities and challenges are currently being reflected in the corridors of these countries. We're presently going through a period of experimentation and it might be safe to assume that like most experiments, we might stumble upon success and not realize it till later when the luxuries of today have become necessities of tomorrow.

Freling (2001) reports that with the introduction of wireless telephony, many rural villages are further empowered economically. Up-to-date knowledge of farming techniques and market prices helps farmers to obtain higher value for their produce. By taking digital photographs of locally made arts and crafts, and uploading these images onto a website, village artisans can make their goods directly available to a worldwide audience. Cultural products such as music are especially well-suited to village-based ecommerce since they can be transmitted electronically without having to deal with the cost, logistics, and delay of physical transportation. Solar-powered connectivity provides a conduit through which information as well as trade and commerce may flow to and from rural parts of the world previously isolated and cut off **(10)**.

Another example of the power of the Internet can be seen in Warana, where the cooperative movement and information technology has come together. The project involves a cluster of 70 villages in Warana in the western Indian state of Maharashtra. There are 25 cooperatives with a total turnover of Rs. 600 Crores (US$ 127 Million). The main hub of the Rs. 2.5 Crore (US$ 500,000) project set up by the National Informatics Center and the Maharashtra government is at the Warana Engineering College and the second hub is at the sugar cooperatives administrative building. Both have VSAT's. Information kiosks have been set up at six or seven business centers in the villages. Here and elsewhere, farmers check rates at different Mandis (markets) and choose the days when they can get a better price. They have learned to access veterinarian advice on e-mail. With computerization of land records, farmers have been set free from the clutches of the local village landlord **(17)**.

In a joint initiative between Solarquest, American Electric Power, and the U.S. Department of Energy, a remote village known as Provinir was connected to the Internet. Provinir, located in the Amazon forest has a population of 600 people. The system used a 2,500-watt solar photovoltaic power system to provide the electricity needed to power lighting for two classrooms, three computers, a satellite receiver/sender, and a refrigerator/freezer used for medicine and vaccines **(18)**.

These examples demonstrate the feasibility of employing these systems in India and other developing countries. Such technologies can be used very fruitfully, for progress and development in the information infrastructure for many of the rural lands in developing countries.

Table 1 : Estimated installation costs per site

Basic Personal Computer with peripherals	$ 600.00
Solar Photovoltaic Power system	$ 600.00 **(19)**
Mobile phone or wireless transceiver	$ 100.00
Furnishing and accessories	$ 200.00
Transportation, installation, and training	$ 500.00
Cost per site	$2,000.00

4.0 A PROPOSED SOLUTION

We propose a basic solution for reaching remote rural villages using a personal computer, wireless telecommunications services, powered by an alternative energy source. The initial configuration would require each site to be provided with at least one computer, a wireless connection to an Internet service provider, and a solar photovoltaic energy system. The wireless connection could be provided using mobile data communications such as GPRS or CDPD, or using a Wireless Local Loop connection to a regional central office. The village would need to provide a proper location to house the system. It is essential that resources be provided to operate and administer the system and to educate and train the local residents so that they become self-sufficient over time.

While the typical costs per site are modest, the aggregate costs are significant. The estimated fixed costs of implementing wireless Internet capabilities in remote villages are shown in Table 1. This figure does not include the associated telecommunications infrastructure costs that may be incurred by the Internet Service Provider.

In a country like India with an estimated 600,000 potential sites in remote villages, the initial investment could cost nearly US$1.2 Billion. In addition to these fixed costs, there would be additional variable costs of providing Internet access and maintaining the system over its useful life. To ensure that the investment is well utilized, it is essential to ensure that adequate effort is devoted to educating the residents on proper maintenance, administration, and utilization of the system.

5. CONCLUSIONS

As suggested by Rischard (1996), "New low-cost and converging technologies offer developing countries unprecedented opportunities for rapid development…. Yet these technologies also raise the threshold of competitiveness" **(5)**. The digital divide between developed countries and developing countries is a serious one and is constantly increasing. This requires developing countries to receive a significant lift in their pace of development which cannot be achieved without developing their rural landscape.

This significant lift can be provided only by using appropriate converging technologies which have at their heart the Internet as the delivery vehicle of health, education and socio-economic services to rural areas.

The concepts and examples discussed in this paper, point to certain ways in which these technologies can be used in a generic manner. It would be worthwhile to conduct case studies in specific countries in order to explore solutions appropriate and specific to the social and cultural framework of individual countries and societies.

We recommend that further research be conducted with a specific developing country as a case study, in order to understand the true cost of such a large-scale deployment of converging technologies and challenges that might exist not uncovered in this paper.

REFERENCES

1) Fakeeh, K. A., "Recent Developments in Information technology and its Impact on Global Economy", Issues and Trends of IT Management in Contemporary organizations, Proceedings of the IRMA International Conference, 2001, pp. 212-215.

2) Fleming, S. T., “Information Needs for a developing Country”, Issues and Trends of IT Management in Contemporary organizations, Proceedings of the IRMA International Conference, 2001, pp. 223-225.

3) Cavanaugh, K., “Bandwidth’s New Bargainers”, Technology Review, November-December 1998, pp. 62-65.

Fleming, S. T., “Information Needs for a developing Country”, Issues and Trends.

4) Hudson, H., “World Bank Report on Economic and Social Benefits of Rural Telecommunications.”

5) Rischard, Jean-Francois, “Connecting Developing Countries to the Information Technology Revolution”, SAIS Review 16.1 (1996) 93-107, Copyright © 1996 The Johns Hopkins University Press.

6) Wadhwa, S., Bhattacharya, S., “Re-engineering the Group Decision Process”, Vision, MDI, Journal, December 2000.

7) Ganguly, Meenakshi, “Dr. Swaminathan – A Profile”, TIME Magazine, TIME 100: August 23-30, 1999 VOL. 154 NO. 7/8

8) Developing Countries Farm Radio Network, “Local Radio for Sustainable Rural Livelihood, Programs Goals and Objectives”, http://www.farmradio.org/english/program.html#goals

9) “Village Voices”; The Times of India dated 01/31/2000

10) Freling, Robert .A, “Solar Vision”, , International Journal of Humanities and Peace, Annual 2001 v17 il p67(2)

11) Tipton . F, “Bridging the digital divide in Southeast Asia”, ASEAN Economic Bulletin, April 2002 v19 il p83(17)

12) “USO Funds for rural telephony” ; Business Line Internet Edition dt. 11/08/2000. Copyright The Hindu Business Line & Trebica Internet Initiatives Inc.

13) Kriplani, Manjeet, “Taking the isolation out of poverty India, Bangladesh and Sri Lanka go cellular” , Business Week dt. 05/03/1999

14) “Rural Telephony Market Analysis”, White Paper by STMI.com http://www.stmi.com/whitepaper.html

15) Mehta, V. S., “Solar Energy: Imperative for Rural India”, The Economic Times, 7) India, March 25, 2000.

16) “Please Mr. Postman”; The Times of India dt. 12/07/20003

17) “India at grassrootlevel.com” ; The Economic Times dt. 04/09/2000

18) “Solar Powered Internet Connection for Remote Bolivian Village”; © 1997-2001Xantrex Technology, Inc. @ www.traceoffgrid.com/readingrooms/stories/6.html

19) Morgan Babetter, “Solar Power to Light SW Bell Pay Phones” St. Louis Post-Dispatch dt. 12/15/92

BIBLIOGRAPHY

Cavanaugh, K., “Bandwidth’s New Bargainers”, Technology Review, November-December 1998, pp. 62-65.

Developing Countries Farm Radio Network, “Local Radio for Sustainable Rural Livelihood, Programs Goals and Objectives”, http://www.farmradio.org/english/program.html#goals

Fakeeh, K. A., “Recent Developments in Information technology and its Impact on Global Economy”, Issues and Trends of IT Management in Contemporary organizations, Proceedings of the IRMA International Conference, 2001, pp. 212-215.

Fleming, S. T., “Information Needs for a developing Country”, Issues and Trends of IT Management in Contemporary organizations, Proceedings of the IRMA International Conference, 2001, pp. 223-225.

Freling, Robert .A, “Solar Vision”, , International Journal of Humanities and Peace, Annual 2001 v17 il p67(2)

Ganguly, Meenakshi, “Dr. Swaminathan – A Profile”, TIME Magazine, TIME 100: August 23-30, 1999 VOL. 154 NO. 7/8

Hudson, H., “World Bank Report on Economic and Social Benefits of Rural Telecommunications.”

“India at grassrootlevel.com” ; The Economic Times dt. 04/09/2000

Kriplani, Manjeet, “Taking the isolation out of poverty India, Bangladesh and Sri Lanka go cellular” , Business Week dt. 05/03/1999

Mehta, V. S., “Solar Energy: Imperative for Rural India”, The Economic Times, India, March 25, 2000.

Morgan Babetter, “Solar Power to Light SW Bell Pay Phones” St. Louis Post-Dispatch dt. 12/15/92

“Please Mr. Postman”; The Times of India dt. 12/07/20003

Rischard, Jean-Francois, “Connecting Developing Countries to the Information Technology Revolution”, SAIS Review 16.1 (1996) 93-107, Copyright © 1996 The Johns Hopkins University Press.

“Rural Telephony Market Analysis”, White Paper by STMI.com. http://www.stmi.com/whitepaper.html

“Solar Powered Internet Connection for Remote Bolivian Village”; Ó 1997-2001Xantrex Technology, Inc. @ www.traceoffgrid.com/readingrooms/stories/6.html

Tipton . F, “Bridging the digital divide in Southeast Asia”, ASEAN Economic Bulletin, April 2002 v19 il p83(17)

“Village Voices”; The Times of India dated 01/31/2000

“USO Funds for rural telephony” ; Business Line Internet Edition dt. 11/08/2000. Copyright The Hindu Business Line & Trebica Internet Initiatives Inc.

Wadhwa, S., Bhattacharya, S., “Re-engineering the Group Decision Process”, Vision, MDI, Journal, December 2000.