APPROPRIATE TELECOMMUNICATIONS TECHNOLOGY FOR RURAL DEVELOPMENT IN AFRICA

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Abstract. Development in Africa is very much linked to development of its rural areas, where about 80% of the population live and where a similar percentage of national products is generated. To develop and realise the potential of rural areas requires a basic infrastructure, of which telecommunications must be an integral part. Difficulty of access, scarcity of qualified staff, non-availability of electricity and adverse climatic conditions are major obstacles to the supply of the necessary telecommunications services. Properly applied modern technologies can overcome or significantly ease many of those problems. In many cases this means taking advantage of satellite telecommunication technology. The impact of telecommunication service supply - within the frame of a balanced infrastructure - on the overall socio-economy is more important than the internal rate of return on telecommunications investments, which may even be negative. Appreciation of this fact is necessary to secure financing.

Keywords. Appropriate technology for developing countries; power generation; satellites, artificial; role of telecommunications in development; telecommunication benefits.

INTRODUCTION

For many decades rural Africa has lagged well behind the rest of the continent in its standard of living, level of infrastructural development and rate of economic growth. This state of affairs shows little sign of changing.

The seriousness of the situation becomes very clear if seen against the background of about 80 percent of the population of Developing Countries living in rural areas and nearly all export goods (foreign currency earners) coming from the rural areas.

The neglect of the rural areas has led to widespread discontent one of the manifestations of which is a phenomenon of very grave concern to many African Governments - the migration from rural areas to the cities creating menacing social and other problems.

Evidently, more attention must be given to rural development, and it must be a primary target to overcome the imbalance in its infrastructure. This is why the German Ministry of Economic Cooperation via its executing agency, the German Agency for Technical Cooperation, has entrusted the International Telecommunication Union to undertake a study on the application of modern technology for the provision of telecommunication services to rural areas in Africa. This paper presents the major study results.

The problems of rural telecommunications in Africa or elsewhere cannot be dealt with in isolation. There are many interrelated aspects, which encompass much more than technical and operational features of concern to telecommunications entities - they involve, for instance, issues of financing, overall economic considerations and planning.

It was therefore quite natural that the study approach develop around three major questions:

- What is the role and value of communications in the context of a rural African environment?
- What are the technical and operational obstacles to rural telecommunication service supply and their potential solutions?
- What are the costs involved and what possibilities exist for financing the necessary investments in rural telecommunications?

VALUE AND ROLE OF RURAL TELECOMMUNICATIONS

The first question deals with fundamental aspects of the value of rural telecommunications and, in particular, its impact on overall economic and social development.

A purely internal rate of return approach, limited to the level of the telecommunication service supplier only, will most likely not lead to an optimal level of investment in rural telecommunications. In fact, this turns out to be a major reason for the present problematic situation. A more comprehensive view on the effects of telecommunications in the overall socio-economic context of a country, on the other hand, reveals significant factors favouring investment in telecommunication.

Overall benefits of telecommunications have therefore been considered in two parts: the direct and indirect benefits.

The direct benefits of telecommunications have been defined in the study as those referring to "the net financial returns to service suppliers which are attributable to specific projects or programmes." Indirect benefits were referred to as "net returns other than direct financial returns on investments derived by the supplier authority, viz. returns over and above the price paid for services."

Investment expenditures normally yield to investors only direct benefits as defined above. As such, investment decisions are normally based exclusively on these direct benefits or, in slightly different language, the private rate of return yielded by the investment project.

Indirect benefits, however, represent benefits which are realised because an investment or expenditure has taken place but which are not captured by, or reflected in, the direct benefits of the expenditure, i.e. are not considered in the private rate of return calculation. Where such indirect benefits are of significant magnitude, their exclusion from the rate of return calculation could produce investment decisions which are contrary to the best interests of the society affected by them.

Reliable, cost-efficient rural telecommunications can enhance levels of output, employment and foreign exchange earnings (in export sectors) by enabling a higher capacity utilisation of resources.

The efficiency gains at the enterprise and worker productivity level can be significant and immediate. Higher long-term growth rates can also be realised and a better use made of all installed infrastructure - roads, power, water and other basic inputs into the productive process.

Economies can be readily realised in the deployment of skilled personnel and additional savings effected in the use of other scarce resources - e.g. imported petroleum and transport capacity - by the use of a basic telecommunication network to coordinate decision-making and the different stages of production, distribution and exchange.

Information flow and business transactions can be speeded up and better use made of machinery and expensive capital goods.

Rural telecommunications can also help reduce costs in all sectors and in particular can facilitate and improve the supply and delivery of public services, e.g. in the fields of health, education, agricultural information and veterinary services.

The range of sectors which can benefit in rural areas is extensive and covers agriculture (arable and pastoral), forestry and fishing, mining, manufacturing, infrastructure (e.g. power, meteorology, civil aviation and public works), banking and financial services, transport in all its aspects, commerce, tourism, administration, health, education and others.

It is self-evident that the economic and social benefits of investment in rural telecommunication do not accrue only to rural areas or to users of the services alone. Non-users will also gain from spill-over and multiplier effects and there also benefits in urban areas; the impact on overall development and its contribution to a more balanced infrastructure also help in improving the quality of life.

The difficulties which may exist in the quantification of indirect economic benefits should not obscure their existence. The fact that indirect benefits are certainly not negative and are often highly significant, together with the unique role of rural telecommunications as a broadly interconnecting element in infrastructure, and

productive and social activity, provides sound justification for their being accorded considerable importance in planning evaluations.

In order to arrive at sound investment decisions it is necessary that:

a) consideration be given to both direct and indirect benefits in assessing the viability of a telecommunication investment, and

b) planning of telecommunication investments is coordinated with other sectors.

This requires such Government involvement as may be necessary to ensure that the socially desirable level of investment is realised.

It may be worthwhile at this point to comment on the meaning of "basic telecommunication services". The understanding put forward in the study is that access will be given to a widely-spread telephone network. This implies an important role for Public Call Offices, but does not eliminate the need for telephone stations for administrative, business and private use.

The system concept should be such that it allows growth towards maturity and profitability. It is thought that other requirements like telegram, telex and possibly data and facsimile services would, if needed, be met using telephone circuits together with additional peripherals.

Because of its beneficial socio-economic impact, sound broadcast service is considered a basic telecommunication service for rural areas in developing Africa. It can provide information and education to a large public by relatively simple and cost-efficient means.

Television, however, is not considered at present as qualifying as a basic service in the context of a balanced rural infrastructural development. In addition, TV would need an infrastructural basis which at present in rural Africa generally does not exist.

TECHNICAL/OPERATIONAL ASPECTS

After review of the very fundamental issues concerning the role and benefits of rural telecommunications - the acceptance of it being crucial for any significant progress in this area - a second question arises:

> What are the technical and operational obstables to rural telecommunication service supply and their potential solutions?

The unawareness of the effects of telecommunications (for development) has been identified as one reason for insufficient service supply. Other reasons are based in the character of the rural environmental itself, which poses very specific conditions in technical and operational areas.

The major ones are relatively well known - remoteness or difficult access, scarcity of qualified staff, non-availability of electricity and adverse climatic conditions. But there are also major deficiencies in the organisational structure influencing volume and quality of services and while the improvement of managerial capabilities remains of paramount importance, a number of problems could now be overcome or significantly eased by applying appropriate new technologies.

Whether this actually happens will, to a large extent, depend on by the willingness of developing countries and financing institutions to promote rural telecommunications. Otherwise equipment manufacturers may consider the market as too insignificant for the efforts required toproduce equipment suited for specific rural applications.

The technical solutions adopted must especially take into account the already mentioned deficiencies related to operation and maintenance, lack of electricity, difficulties in access, shortage of skilled labour, and so on.

The principal requirements for elements to be incorporated into a rural telecommunication system are thus:

- Low power consumption;
- Local power generation or long-term storage;
- High reliability, stand-by systems and a certain degree of redundancy;
- Unattended operation, no periodic maintenance, self-diagnosis, remote supervision and local fault indication and/or signalling, thereby allowing the

employment of relatively low level maintenance staff;

- Modular design (plug-in modules) and easy access to test and measuring points to provide better and faster maintenance and fault clearing;
- Fast and simple installation;
- Operation without airconditioning (for power reasons);
- Small dimensions, to be easily containerised and transported to any site location, even if no access roads are available;
- Compatibility of old and new equipment;
- Minimum sensitivity to climatic influences and other unfavourable environmental conditions including high temperature, humidity, dust, lightning, direct sunlight, insects and rodents.

The importance of low power consumption equipment may be underlined by the fact that cost for power generation in rural areas may amount to as much as 30 percent of the total investment.

The variety of rural scenarios in Africa means that rural telecommunication service cannot be satisfied by a single approach. A rural telecommunication system should, therefore, be made up of individual modules selected and arranged in a way that best fits any given situation.

Appropriate rural telecommunication technology will therefore comprise both conventional and new terrestrial and satellite technology.

In the following a satellite telecommunication system is discussed which may serve as an example of what is understood by appropriate design for rural applications:

The dominant characteristic of the rural environment which influences system design is the non-availability of electrical power. This imposes a design of low power consumption for the earth stations and all co-located equipment, e.g. subscriber collecting systems and (sound) broadcast transmitters.

If investment, maintenance, life cycles and consumables are taken into account, for consumption levels up to 400 Watts, a solar energy power system is at present the best choice under rural African conditions. At higher power requirements, intermittently operated diesel generators with storage batteries are preferred. It should be noted here that solar energy still is not cheap. It is only recommended below approx. 400 Watts, where other alternatives cannot be operated efficiently at present.

For the earth stations, this leads immediately to a fully transistorised solution avoiding airconditioning or forced air cooling (the same, of course, applies to all co-located equipment using electrical energy).

Considering these limitations and available solid state power amplifier technology, it follows that RF output power per SCPC channel for a rural application must be somewhere between 0.2 and 1 Watt. This requires a specially designed satellite with an e.i.r.p. in the order of 38 dBW and a saturation flux density in the order of -90 dBW/m^2. (As an indication: sensitivity of present generation Intelsat satellites falls 15-20 dB short of the latter figure.)

For reasons of rain attenuation, other propagation losses, satellite power, earth station antenna pointing error losses and technological, reliability and cost considerations, the 4/6 GHz bands are clearly to be preferred and even a necessity for this type of application.

A rural telecommunication network typically exhibits a thin-route low density traffic pattern. This requires some sort of demand assignment multiple access (DAMA) system to be employed in order to make efficient use of the space segment capacity.

An appropriate solution would therefore be a dedicated satellite system designed around the above indicated major performance requirements.

For an earth station to be deployed in a rural environment, special attention must be given to ease of installation, unattended operation, simple and in general only corrective maintenance, possibly remote supervision and adaptability to changing traffic requirements by modular design.

It is implied in the above example that the comparison of the appropriateness of

different solutions is not a matter of comparing costs only since a number of parameters enter the evaluation which cannot be easily or even roughly expressed in monetary terms, e.g. service quality, security, skill requirements, equipment diversification, local production options, and many more. Again, there are no ready made solutions proposed. But the potential of different options has been evaluated and there is much scope for judicious selection within the boundaries of presently available technology.

The Feasibility stage of the project will, of course, deal in detail with individual country cases; and solutions will be sought to adapt best to the specific needs.

FINANCIAL CONSIDERATIONS

The third major question was:

> What are the costs involved and what possibilities exist for financing the necessary investments in rural telecommunications?

The order of magnitude cost estimate which has been put forward for the provision of basic rural telecommunication service supply in Sub-Saharan Africa is US$ 1,000 million.

This amount does not concern the acquisition of hardware alone. It implies also significant requirements to be served with respect to the strengthening of the operational/managerial capacities of national telecommunications administrations. Indeed, this is often a necessity which would arise even without the proposed project.

For hardware components unit prices have been advanced in order to establish some reference for quantitative comparisons between alternative options.

The study team is aware of the range of variance involved in unit price determination. Considerable differences exist in equipment prices, and real cost much depends on source and supplier, financing conditions, inflation rates, market and project size, risk assessment, procurement and delivery delays, technological comparability, technology support services and guarantees, to name just a few.

Even when all this is taken into account, however, it is still believed that the study results have broad validity. The alternative of avoiding price quotations would have prohibited derivation of a basic solution and precluded a first-round estimate of choice in technical options.

On the other hand, viable technical options (e.g. in the field of equipment design) still need to be developed for the rural African environment. This process will itself absorb investment funds and will only be of interest to manufacturers provided there is a market of adequate size.

Some solutions utilising modern technologies, e.g. satellite systems, have been shown as likely to be very cost-efficient when properly applied in certain areas. But the economies of scale involved in this case require that assets and capacity utilisation should be shared.

Common asset utilisation and joint problem-solving could also permit modalities to be developed in the spheres of coordinated funding and financial acquisition, leading possibly to more sizeable commitments and better terms being obtained for resources deployed.

Various potential sources of finance exist for the integrated rural telecommunication system (terrestrial and satellite elements). These could include:

- Revenue surpluses from telecommunications entities;
- Revenue from rural services provided (installation, rental and call charges);
- Government contributions via capital and loan funding, tax rebates and revenue subsidy;
- Private capital market loans (local and/or international);
- Supplier credits;
- Multilateral financial institutions (e.g. ADB, IBRD, EDF, etc.);
- International development assistance (from bilateral sources), and so on.

Fortunately, there have already been positive indications in this respect, and bilateral and multilateral donor and financing bodies

are engaged in discussions to enter the Feasibility stage.

The financial costs of the project may seem daunting at first glance, but they will become understandable when viewed in the context of the area and size of population to be served, the share of these investments related to the total effort deployed for rural development, and the potential benefits which could result.

CONCLUDING REMARKS

The Pre-Feasibility study carried out on the Application of Appropriate Modern Telecommunications Technology for Integrated Rural Development concludes that the development of telecommunications services is essential for the rural population and the whole of African countries and that the proposed integrated rural system is technically and economically viable.

Major results may be summarised as follows:

- The provision of at least a basic rural telecommunication service to alleviate the existing urban/rural infrastructural imbalance would significantly improve the efficiency and profitability in practically all other sectors and so yield a high return for the country's overall economy. There is evidence that investments in rural telecommunications are beneficial even if the rural element, taken alone, exhibits a negative rate of return;

- The gap between the skills required to operate and maintain existing and future telecommunication facilities and the expertise actually available has to be narrowed and finally closed. External assistance would be incomplete if not all aspects related to the provision of telecommunication services are taken into account, e.g. manpower, training, O/M activities, organisational and managerial aspects, documentation, planning, and so on;

- The technology, which can provide rural telecommunication services more cost efficiently and ease operation and maintenance significantly, is available. This technology needs to be applied to build appropriate equipment for application in rural Africa;

- Because of the variety of rural scenarios in Africa - e.g. the differences in topography, climate, population density and socio-economy - it is necessary to choose specific solutions for individual cases. Models and planning aids have been developed to facilitate the definition of an optimal system;

- In special cases - for reasons of remoteness, difficult access, security, low traffic values, etc. - conventional, terrestrial technologies are inappropriate, whereas satellite technologies can be efficiently used. Requirements however dictate the use of a dedicated satellite system, so that cheap earth stations can be deployed and efficient use can be made of space capacity with the aid of DAMA equipment;

- The implementation of the proposed project would need substantial external assistance.

In summary, there are strong socio-economic reasons favouring the continuation of the project. The project is also in line with established development aid policies of major donor countries and institutions. The necessary technology to implement the project is available.

REFERENCES

ITU (1981). Pre-Feasibility Study on Appropriate Modern Telecommunications Technology for Integrated Rural Development in Africa. Geneva.

Clarke, D.G., and Laufenberg,W. (1981). The Role of Telecommunications in Economic Development with Special Reference to Rural Sub-Saharan Africa. ITU, Geneva.

Lesser, B. (1982). Rural Development in Sub-Saharan Africa: The Case of Telecommunications Infrastructure. Dalhousie University, Halifax, Canada.