

# The impact of telecommunication on rural areas in developing countries

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University of Technology  
Netherlands

Faculty of Electrical Engineering

# The Impact of Telecommunication on Rural Areas in Developing Countries

by

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## SUMMARY

This report deals with the economic and social impact of telecommunication in the developing countries. Attention has mainly been paid to the impact in rural areas.

The economic impact not only depends on the direct returns of the investment, like tariffs. Through the improved communication facilities, other sectors can indirectly make profit of the investments too. Especially, in areas with a very low telephone density, the indirect returns of a telecommunication investment will be enormous.

By the planning of a rural network, the following has to be taken into account: demand now and in the future, the wanted service quality, the geographical and climatological features of the area, the existing infrastructure and the use of the system by illiterates.

There are a number of different technical possibilities for building up transmission links in a rural network. Such as, coax cables, glass fibres, radio transmission or satellite communication. Often a combination of different possibilities will be the best solution. In thin populated rural areas, satellite communication with a single channel per carrier (SCPC) system will be a good solution. With a SCPC system little groundstations can be used. These stations are easy to maintain, and use not much power. As soon as a satellite channel and two groundstations are operational, transmission is possible. So, a SCPC system can be implemented rather fastly.

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## **Samenvatting**

In dit verslag wordt de economische en sociale betekenis van telecommunicatie in ontwikkelingslanden besproken. Er wordt vooral aandacht besteed aan deze invloed in rurale gebieden.

Voor de economische betekenis van een telecommunicatie investering, moet niet alleen gekeken worden naar de directe opbrengsten uit de tarieven. Door de verbeterde communicatie mogelijkheden, kunnen ook andere sectoren indirect mee profiteren van de investering. Vooral in gebieden met een zeer klein aantal telefoons per inwoner, zijn de indirecte bijdragen van een investering in telecommunicatie zeer groot. Door de telefoon kunnen afgelegen gebieden uit hun isolement gehaald worden.

Bij de planning van een ruraal netwerk moet o.a. rekening gehouden worden met de te verwachten vraag nu en in de toekomst, de gewenste servicekwaliteit, terreincondities, klimaat, de aanwezige energie voorziening, en de bruikbaarheid van het systeem voor analfabeten.

Er zijn verschillende technische mogelijkheden om transmissieverbindingen in een ruraal netwerk op te zetten. Er kan o.a. gedacht worden aan een systeem met coax kabels, een systeem met glasvezels, een systeem met radiotransmissie of een satellietverbinding. Vaak is een combinatie van systemen de beste oplossing.

In zeer dun bevolkte rurale gebieden is satellietcommunicatie m.b.v. een SCPC systeem een zeer goed bruikbare oplossing. Bij een SCPC systeem kunnen kleine grondstations gebruikt worden, die niet veel energie nodig hebben en weinig onderhoud vergen. Zo gauw er een satellietkanaal beschikbaar is en er twee grondstations operationeel zijn, kunnen er verbindingen tot stand gebracht worden. Een SCPC systeem kan dus vrij snel geïmplementeerd worden.

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**LIST OF ABBREVIATIONS AND SYMBOLS**

EIRP	effective isotropic radiated power
EUT	Eindhoven University of Technology
FDMA	frequency division multiple access
GNP	gross national product
IDA	International Development Association
ISDN	integrated switched digital network
ITU	International Telecommunication Union
LNA	low noise amplifiers
OECD	Organization for Economic Cooperation and Development
SCPC	single channel per carrier
SITE	Satellite Instructional Television Experiment
TDMA	time division multiple access
VOX	voice operated carrier
ERLANG	1 Erlang = 1 call of 1 hour duration per hour.
HF	3 - 30 Mhz
UHF	146 - 174 Mhz
EHF	1 - 30 Ghz

## 1. INTRODUCTION

In the developed countries enormous amounts of money are spent on building, and especially improving, of telecommunication networks. This demonstrates the economic and social importance of telecommunication in the industrialized countries.

In the developing countries, especially in the rural areas, telecommunication facilities like telephone, are at a very low level. However, it can be expected, that also in developing countries telecommunication facilities, as part of the infrastructure shall contribute to the social and economical developing of the country.

For the construction of a network, a choice has to be made between the possible systems. Every system has its advantages and disadvantages, depending on the area where it has to be used. In thin populated rural areas, satellite communication can be a good solution.

At the Eindhoven University of Technology (EUT) research has been carried out on the use of Single Channel Per Carrier (SCPC) systems for satellite communication in rural areas. The results of some parts of this research have been discussed in [1].

This report is a revision of the chapters one and two of [1]. Research has been done on new literature about the impact of telecommunication for developing countries after 1983. New points of view have been processed in this report. Parts of [1], discussing topics, on which no new points of view were found, have been copied directly from [1].

In chapter two some social and economical indicators of developing and developed countries have been discussed and compared. In chapter three some attention has been paid to the international development aid before 1960 and after 1960.

In chapter four the social and economical impact of telecommunication especially in the rural areas of developing countries, has been discussed. This chapter concludes with a view of financial agencies and banks, where developing countries can get financial aid.

In chapter five the advantages and disadvantages of the different telecommunication systems, which can be used in rural areas, have been discussed and compared. The information from this chapter can be used for the selection of a telecommunication system from a technical viewpoint.

Information technology is going to play an important role in the nearby future. For obtaining the advantages of this technology a modern telecommunication network is in need. Chapter six discuss some aspects of the impact of the information technology on the society.

## **2. CHARACTERISTICS OF THE DEVELOPING COUNTRIES**

### **2.1. Classification**

The countries of the world can be classified as follows [2]:

1. Developing countries: low income countries
2. Developing countries: middle income economies, oil exporters
3. Developing countries: middle income economies, oil importers
4. Capital surplus oil exporting countries
5. Industrialized countries
6. Countries with centrally planned economies

These classes are partly overlapping. Low income countries are countries with a Gross National Product (GNP) per person of less than \$400 (1983 U.S. Dollars).

The developing countries can also be divided in:

- major borrowers: countries with disbursed and outstanding foreign debt estimated at more than \$15 billion (1983 U.S. Dollars).
- The other developing countries.

From the tables I through IV can be concluded that:

- Through the rapid reduction of the oil price several middle income oil exporters (Indonesia, Mexico) are also major borrowers.
- Several major exporters are also major borrowers.
- In the group of major borrowers are also some more developed countries (Israel, Yugoslavia).

LOW-INCOME ECONOMIES	MIDDLE-INCOME ECONOMIES	UPPER MIDDLE-INCOME ECONOMIES	INDUSTRIAL MARKET ECONOMIES	EAST EUROPEAN NON-MARKET ECONOMIES
Ethiopia Bangladesh Mali Nepal Zaire Burkina Burma Malawi Uganda Burundi Niger Tanzania Somalia India Rwanda {Central African Republic} Togo Benin China Guinea Haiti Ghana Madagascar Sri Lanka Kenya Pakistan Sudan Afghanist. Bhutan Chad Kampuchea Lao PDR Mozambique Viet Nam	Senegal Lesotho Liberia Mauritania Bolivia Yemen PDR Yemen Arab. Indonesia Zambia Honduras Egypt El Salvador Ivory Coast Zimbabwe Morocco {Papua / New Guinea} Philippines Nigeria Cameroon Thailand Nicaragua Costa Rica Peru Guatemala Congo Turkey Tunesia Jamaica {Dominican Republic} Paraguay Ecuador Colombia Angola Cuba {Korea / Dem. Rep.} Lebanon Mongolia	Jordan Syria Malaysia Chile Brazil Rep. Korea Argentina Panama Portugal Mexico Algeria South Africa Uraguay Yugoslavia Venezuela Greece Israel Hong Kong Singapore Trinidad Tobago Iran Iraq	Spain Ireland Italy New Zealand Belgium United King. Austria Netherlands Japan France Finland Germany Australia Denmark Canada Sweden Norway United States Switzerland	Hungary Albania Bulgaria Czechoslovakia East Germany Poland Romania USSR
				HIGH-INCOME OIL EXP.
				Oman Libya Saudi Arabia Kuwait {United Arab Emirates}

Table I: Low, middle and high income countries. [2]  
In each group the countries have been selected in ascending order of their GNP [2].

Argentina	Israel
Brazil	Republic of Korea
Chile	Mexico
Egypt	Turkey
India	Venezuela
Indonesia	Yugoslavia

**Table II: The major borrowers [2]**

<u>Oil exporters</u>	<u>Oil importers</u>
Algeria	Argentina
Angola	Brazil
Cameron	Greece
Egypt	Israel
Gabon	Republic of Korea
Indonesia	Philippines
Iran	Portugal
Iraq	Singapore
Malaysia	South Africa
Mexico	Thailand
Nigeria	Yugoslavia
Peru	
Syria	
Tunisia	
Venezuela	

**Table III: Middle income oil exporters and importers [2]**

Argentina	Philippines
Brazil	Portugal
Greece	Singapore
Hong Kong	South Africa
Israel	Thailand
Republic of Korea	Yugoslavia

**Table IV: Major exporters of manufactures among the middle income oil importers [2]**

## 2.2. Social figures of developing countries

Attention will be focused on some social development indicators in the developing countries. Considered will be:

- Population
- Health, as expressed in life expectancy at birth in years
- Education.

These indicators will be compared with those of the industrialized countries and centrally planned economies. (The developed countries.)

### 2.2.1. Population

Table V shows the population in the developed and developing world in 1965, 1983 and the expected population for the year 2000.

Country Group	<u>1965</u>	<u>1983</u>	<u>2000</u>
low income economies	1530	2300	3100
middle income economies	760	830	1670
industrial economies	630	730	770
centrally planned economies	340	370	430

**Table V: Population in millions [2]**

When distinguishing between urban and rural areas, table VI can be compiled.

From Table VI can be seen that about half of the world population lives in rural areas of developing countries.



Country Group		1980	1990	2000
<u>Developed World:</u>	Urban (in 10 <sup>3</sup> )	857,009	991,153	1,113,242
	Rural (in 10 <sup>3</sup> )	323,993	286,243	247,003
	Rural (in %)	27.43	22.41	18.16
<u>Developing World:</u>	Urban (in 10 <sup>3</sup> )	943,041	1,389,471	1,979,134
	Rural (in 10 <sup>3</sup> )	2,250,067	2,613,150	2,914,999
	Rural (in %)	70.47	65.29	59.56
<u>Total:</u>	Urban (in 10 <sup>3</sup> )	1,800,050	2,380,624	3,092,376
	Rural (in 10 <sup>3</sup> )	2,574,060	2,899,393	3,162,002
	Total (in 10 <sup>3</sup> )	4,374,110	5,280,017	6,254,378
	Rural (in %)	58.85	54.91	50.56
Rural-Developing World (in %)		51.44	49.5	46.61

Table VI: Population growth in urban and rural areas in 1980 and the grow rate to be expected for the years 1990 and 2000 [2].

### 2.2.2. Population growth and GNP

Attention will be focused on the relation between population growth and GNP.

Country group	1984 population (millions)	Average annual growth (percent)				
		1965-73	1973-80	1980-84	1984-90	1990-2000
Developing countries	3.386	2.4	2.0	2.0	1.8	1.8
Low-income countries	2.263	2.4	1.8	1.8	1.8	1.7
Asia	2.040	2.4	1.7	1.7	1.6	1.4
India	749	2.3	2.3	2.2	2.0	1.7
China	1.032	2.4	1.2	1.3	1.0	0.9
Africa	223	2.6	2.8	3.1	3.3	3.4
Middle-income countries	1.123	2.4	2.4	2.4	2.2	2.1
Oil exporters	491	2.5	2.6	2.6	2.5	2.4
Oil importers	632	2.4	2.2	2.2	2.1	1.9
Major exporters of manufactures	413	2.3	2.1	2.0	1.9	1.7
High-income oil exporters	19	4.5	5.3	4.4	3.9	3.4
Industrial market economies	729	0.9	0.7	0.5	0.5	0.4
World, excluding nonmarket industrial economies	4.134	2.1	1.8	1.8	1.6	1.6
Nonmarket industrial economies	390	0.8	0.8	0.8	0.7	0.6

Table VII: Population growth, 1965 - 1985 and projected to 2000. [2]

From table VII can be seen that the average annual growth is decreased over the last few years (with exception of Africa). There is a big difference in average annual growth between developing countries and the industrial market economies.

Country group	1980 GNP (billions of dollars)	1980 population (millions)	1980 GNP per capita (dollars)	Average annual growth of GNP per capita (percent)					
				1965-73	1973-80	1981	1982	1983 <sup>a</sup>	1984 <sup>b</sup>
Developing countries	2,059	3,119	660	4.1	3.3	0.8	-0.7	-0.1	2.1
Low-income countries	547	2,098	260	3.0	3.1	2.0	2.8	5.2	4.7
Asia	495	1,901	260	3.2	3.5	2.5	3.4	6.0	5.3
China	284	980	290	4.9	4.5	1.6	5.8	7.6	7.7
India	162	687	240	1.7	1.9	3.5	0.4	4.2	2.0
Africa	52	197	270	1.3	0.0	-1.7	-2.6	-2.6	-1.5
Middle-income oil importers	962	579	1,660	4.6	3.1	-0.8	-2.0	-1.6	1.1
East Asia and Pacific	212	162	1,310	5.6	5.7	3.7	1.9	4.5	3.4
Middle East and North Africa	25	31	830	3.5	4.3	-2.5	2.6	0.5	-1.3
Sub-Saharan Africa	26	33	780	2.0	0.5	4.1	-4.8	-5.4	-5.4
Southern Europe	214	91	2,350	5.4	2.9	0.2	0.3	-0.5	0.2
Latin America and Caribbean	409	234	1,750	4.5	2.9	-4.1	-4.8	-4.5	1.1
Middle-income oil exporters	550	442	1,240	4.6	3.1	1.5	-2.3	-3.6	0.1
High-income oil exporters	229	36	14,050	4.1	6.2	-1.1	-7.8	-14.1	-6.4
Industrial market economies	7,477	714	10,480	3.7	2.1	0.7	-1.0	1.5	4.3

a. Estimated  
b. Projected

**Table VIII: Population and GNP per capita, and growth rates, 1965-84 [2]**

From table VIII can be seen that the projected average annual growth of GNP per capita for 1984, is positive for the developing countries all over. Only for Africa the growth is negative, but there can be seen an improvement against 1983.

Comparing the data of the oil exporters with the other countries, the influence of the oil price on the average annual growth over the years can be shown.

From table VII and VIII can be concluded that the countries in Africa with the highest average annual growth of population, have also the lowest average annual growth of GNP per capita.

### 2.2.3. State of health

To get an impression of the state of health in the middle- and low-income developing countries, and in the industrialized countries, the life expectancy is given in table IX.

Country Group	1965	1983	increase
low income economies	50	59	9
middle income economies	53	61	8
high income oil exporters	48	59	11
industrial market economies	71	76	5
centrally planned economies	69	70	1

**Table IX: Life expectancy at birth [2]**

From table IX can be seen that in the year 1983 the life expectancy in low income countries was significant lower then in the developed countries.

#### 2.2.4. Education

The level of education in developing countries is considered by looking at the illiteracy rates of adults in developing countries. This is shown in table X.

Education			
Country Group	Adult literacy rate (%)		
	1950	1960	1975
Industrialized countries	95	97	99
Middle-income countries	48	54	71
Low-income countries	22	29	38
Centrally planned economies	97	98	99

**Table X: Adult literacy rates (%) in 1950, 1960, 1975 [2]**

From table X can be seen that in the low income countries the adult literacy rate is still rather low (38%).

### 2.3. Economic figures of developing countries

Attention will be focused on some economic indicators as:

- income
- central government expenditure
- borrowings.

These figures will be compared with those of the developed countries.

#### 2.3.1. Income

Income differences between developing and developed countries are considered by looking at their GNP per capita ( In 1983 U.S. Dollars ) and by looking of the composition of that GNP.

Country group	1980 GDP (billions of dollars)	Average annual growth of GDP (percent)					
		1965-73	1973-80	1981	1982	1983 <sup>a</sup>	1984 <sup>b</sup>
Developing countries	2,085	6.6	5.5	3.3	1.9	2.0	4.1
Low-income countries	546	5.5	4.9	4.0	5.0	7.2	6.6
Asia	493	5.7	5.2	4.3	5.4	7.8	7.1
China	284	7.4	5.8	2.9	7.4	9.0	9.0
India	162	4.0	4.1	5.8	2.6	6.5	4.2
Africa	53	3.9	2.7	1.7	0.7	0.7	1.6
Middle-income oil importers	978	7.0	5.6	2.0	0.8	0.7	3.3
East Asia and Pacific	214	8.6	8.1	6.5	3.9	6.3	5.4
Middle East and North Africa	24	5.6	7.1	0.7	6.2	1.5	1.2
Sub-Saharan Africa	27	5.1	3.6	6.9	-1.0	-1.8	-2.1
Southern Europe	213	7.0	4.8	2.0	2.4	0.8	1.5
Latin America and Caribbean	420	7.1	5.4	-1.0	-1.5	-1.8	3.4
Middle-income oil exporters	561	7.1	5.8	4.6	0.9	-1.0	2.7
High-income oil exporters	230	9.2	7.7	0.1	-1.7	-7.0	0.6
Industrial market economies	7,440	4.7	2.8	1.4	-0.3	2.6	4.8

a. Estimated b. Projected.

Table XI: GNP ,1980, and growth rates,1965-84 [2]

Country group and indicator	1965	1975	1980	1981	1982	1983 <sup>a</sup>	1984 <sup>b</sup>
<b>Developing countries</b>							
GDP	327	736	2,085	2,210	2,126	2,046	2,111
Domestic absorption	331	743	2,132	2,282	2,179	2,063	2,099
Net exports <sup>d</sup>	-4	-7	-47	-72	-53	-17	12
Population (millions)	2,239	2,710	3,119	3,183	3,251	3,319	3,386
<b>Low-income countries</b>							
GDP	141	248	546	537	539	561	593
Domestic absorption	143	250	565	553	551	573	606
Net exports <sup>d</sup>	-2	-2	-19	-16	-12	-12	-13
Population (millions)	1,525	1,845	2,098	2,137	2,180	2,223	2,263
<b>Middle-income oil importers</b>							
GDP	128	333	978	1,034	1,027	940	963
Domestic absorption	130	340	1,018	1,079	1,059	953	954
Net exports <sup>d</sup>	-2	-7	-40	-45	-32	-13	9
Population (millions)	412	496	579	592	605	618	632
<b>Middle-income oil exporters</b>							
GDP	58	155	561	639	560	545	555
Domestic absorption	58	153	549	650	569	537	571
Net exports <sup>d</sup>	0	2	12	-11	-9	8	16
Population (millions)	302	369	442	454	466	478	491
<b>High-income oil exporters</b>							
GDP	7	28	230	266	255	219	...
Domestic absorption	5	16	148	174	193	...	...
Net exports <sup>d</sup>	2	12	82	92	62	...	...
Population (millions)	8	11	16	17	18	19	19
<b>Industrial market economies</b>							
GDP	1,369	3,240	7,440	7,498	7,418	7,672	8,417
Domestic absorption	1,363	3,231	7,505	7,526	7,433	7,671	8,417
Net exports <sup>d</sup>	6	9	-65	-28	-15	1	0
Population (millions)	632	680	714	719	723	726	729

a Estimated b Projected c Private consumption plus government consumption plus gross domestic investment.  
d Includes goods and nonfactor services

**Table XII: Population and composition of GNP ,  
1965-84 (billions \$ ) [2]**

From table XI can be seen that the increasing of the oil price in the period 1980-1983 had negative effects on the net exports of all countries with exception of the high income oil exporters. Through the stabilizing of the oil price over the last years, the estimated dates for 1984 are much better then the dates over the past few years.

From table XII can be seen that the GNP in 1965 as well as in 1984 in the industrial market economies had been four times higher then the GNP in the developing countries. From this data can be concluded that the economic gap between the developing and developed countries has not been decreased over this period.

Country group	1965		1973		1980		1981		1982	
	Agn-culture	Industry	Agn-culture	Industry	Agn-culture	Industry	Agn-culture	Industry	Agn-culture	Industry
Developing countries	31	29	26	33	20	38	19	37	19	36
Low-income countries	44	27	42	31	36	36	36	34	36	34
Asia	44	28	42	32	35	38	35	36	36	35
India	47	22	50	20	37	25	35	26	33	26
China	43	36	37	41	33	48	35	46	37	45
Africa	47	15	42	19	41	18	41	17	41	17
Middle-income countries	22	31	17	35	14	39	14	38	14	37
Oil exporters	22	26	18	33	14	42	13	40	14	40
Oil importers	21	33	17	35	14	37	14	36	13	36
Major exporters of manufactures	20	35	15	37	12	39	12	38	12	38
High-income oil exporters	5	65	2	72	1	77	1	76	1	74
Industrial market economies	5	40	5	39	4	38	3	37	3	36
World, excluding nonmarket industrial economies	10	38	9	38	7	39	7	38	7	37

**Table XIII: GNP structure of production ,1965-82 [2]**

From table XIII can be seen that the part of the agriculture in the GNP has been decreased in the period 1965-82 as well in the developing as in the developed countries.

Country group	Agriculture			Industry			Service		
	1965-73	1973-80	1980-82	1965-73	1973-80	1980-82	1965-73	1973-80	1980-82
Developing countries	3.4	2.0	3.2	7.9	6.5	0.7	7.7	6.4	4.0
Low-income countries	3.5	1.3	4.2	7.0	8.1	4.8	7.7	6.7	4.5
Asia	3.7	1.2	4.6	6.9	8.5	5.3	8.5	7.2	4.6
India	3.7	2.0	-0.4	3.7	5.0	4.6	4.5	5.7	8.3
China	3.8	0.2	7.7	9.0	10.0	5.3	21.4	8.9	0.3
Africa	2.2	2.2	1.4	7.8	1.0	-4.1	4.3	4.0	3.4
Middle-income countries	3.4	2.7	2.3	8.2	6.0	-0.6	7.7	6.4	3.8
Oil exporters	3.9	2.0	1.8	8.3	5.2	-0.2	7.4	7.9	5.8
Oil importers	3.1	3.1	2.5	8.2	6.5	-0.9	7.8	5.6	2.8
Major exporters of manufactures	3.0	2.9	3.1	8.8	7.2	-1.0	8.5	5.7	3.0
High-income oil exporters	..	..	..	..	2.3	-16.4	..	..	..
Industrial market economies	1.7	0.9	1.2	5.1	2.3	-1.0	4.6	3.3	1.5

**Table XIV: Sector growth rates, 1965-82 [2]**

From table XIV can be seen that the growth rates for agriculture, industry and service in the developing countries have been larger than in the developed countries, but the growth rates of industry and service have been decreased in the last few years.

Country Group	percentage of total expenditure							
	defense		education		health		economic services	
	72	82	72	82	72	82	72	82
low income	12	19	15	5	6	3	26	25
middle inc. imp	15	15	11	10	7	6	22	19
middle inc. exp	16	9	16	13	6	4	29	23
high inc. exp	13	25	14	8	6	6	18	20
industry market	23	14	4	5	10	12	12	10

Table XV: Central government expenditure, 1972,1982 [2]

The five major categories of economic services are:

1. Fuel and energy
2. Agriculture
3. Industry
4. Transportation
5. Communication

From table XV can be seen that the expenditures for education and health, as percentage of the GNP, in the developing countries have been decreased in the period 1972-1982. In the developed countries these expenditures have been increased in the same period. There also can be seen that the expenditures for defense in the low income economies in percentage of the GNP has become larger then in the industrial market economies.

TYPE	PERCENTAGES	
	1st WORLD	3rd WORLD
INFORMATION	40%	5%
INDUSTRY	40%	5%
SERVICES	15%	10%
AGRICULTURE	5%	80%

Figure I: Distribution of the working population [3]

In fig I is shown how the working population in low and middle income countries is distributed. Services include only the physical services such as chauffeurs, nurses, and waiters. Those who only write or talk, fit in the information category, such as a large sector of the government, the social workers and the bank employees. From fig I can be read that in places where no hunger exists, 5% of the population works in the agriculture. In the places where there is poverty and hunger, some 80% of the population works in the agriculture. However, farmers in the industrialized countries achieve great productivity, because they have a very large number of machines to carry out their tasks more efficiently [3].

### 3. INTERNATIONAL DEVELOPMENT

#### 3.1. The influence of foreign capital

Foreign finance can promote growth through higher investments and technology transfers. It can allow countries to adjust slowly to new circumstances in the world economy. The developing countries don't only need foreign capital for their development but also for:

- importing of energy
- importing of food
- importing of capital good
- importing of consumption products
- paying of interest on outstanding debts.

The developing countries obtain foreign capital by:

- exporting of raw materials
- exporting of food
- exporting of industrial goods and non factor services
- development aid
- borrowing money from commercial banks or governments.

Development aid and loans are the most important resources for development. In the next two sections attention will be paid to the developments in the international development aid and to the debt problem of the third world.

#### 3.2. International development until 1960

The development aid for low and middle income countries is first considered for the period until 1960. About this period it has been stated that:

1. "Up to two decades ago the development aid of the industrialized countries towards the low and middle income countries was motivated mainly by emotional reasons. The first world felt deeply sorry for the physical and inseparable mental misery of the people of the third world. Aid programs were only directed to the alleviation and malnutrition, illnesses and the disastrous effects of natural catastrophes"[5]
2. "The developed countries, with a rather conservative attitude as regards their financial assistance, viewed their position as one based upon their responsibility as former colonial ruler with no great impetus to provide in economic and technical needs"[6]
3. "The idea of giving development aid was closely related to the idea of changing the third world into a first world society"[5]
4. "The third world was in no real position to enforce an increase in the level of development aid; it had no political power and was fragmented for the greater part"[6]



### 3.3. International development 1960-1983

The development aid for low and middle income countries for the period of 1960-1983 is considered in the following. As during this period the industrial markets in the first world became saturated and the demand for raw materials, to be delivered from the low and middle income countries increased, the pre 1960 situation changed. About this period has been stated that:

1. "The low and middle income countries, rich in natural resources are now needed by the first world industries. In return for their raw materials, they receive the products of the latter as being a contribution to their development." Economists call this attitude "the New Economic Order".[6]
2. "The evolution and acceptance of this attitude has not changed the net balance between the developing countries and the industrialized countries, but the fact that the developing countries became a source of growth for the first world gave them some political power"[6]
3. "The developing countries think that the industrialized countries are obliged to help them with their development. In neglecting this, an already existing polarization between the industrialized countries and the developing countries will increase"[7]

### 3.4. Development aid wanted

The actual needs of the developing countries are reflected here. In case of malnutrition or natural disasters, direct aid, such as food and medical assistance is needed and given. But from this adhoc development aid no improvement in living standards can be expected in the long run. It has been stated that:

1. "In future the developing countries will not want the products of the industrialized countries, because, as they tend to selfreliance, they want to procure the financial and technical means in order to develop themselves"[6]

In short, these developing countries ask for the transfer of technology and the financial means in order to start exploiting themselves the know how, which they have gained.

3.5. Development aid, offered

Development aid, given, as expressed in financial terms is considered below.

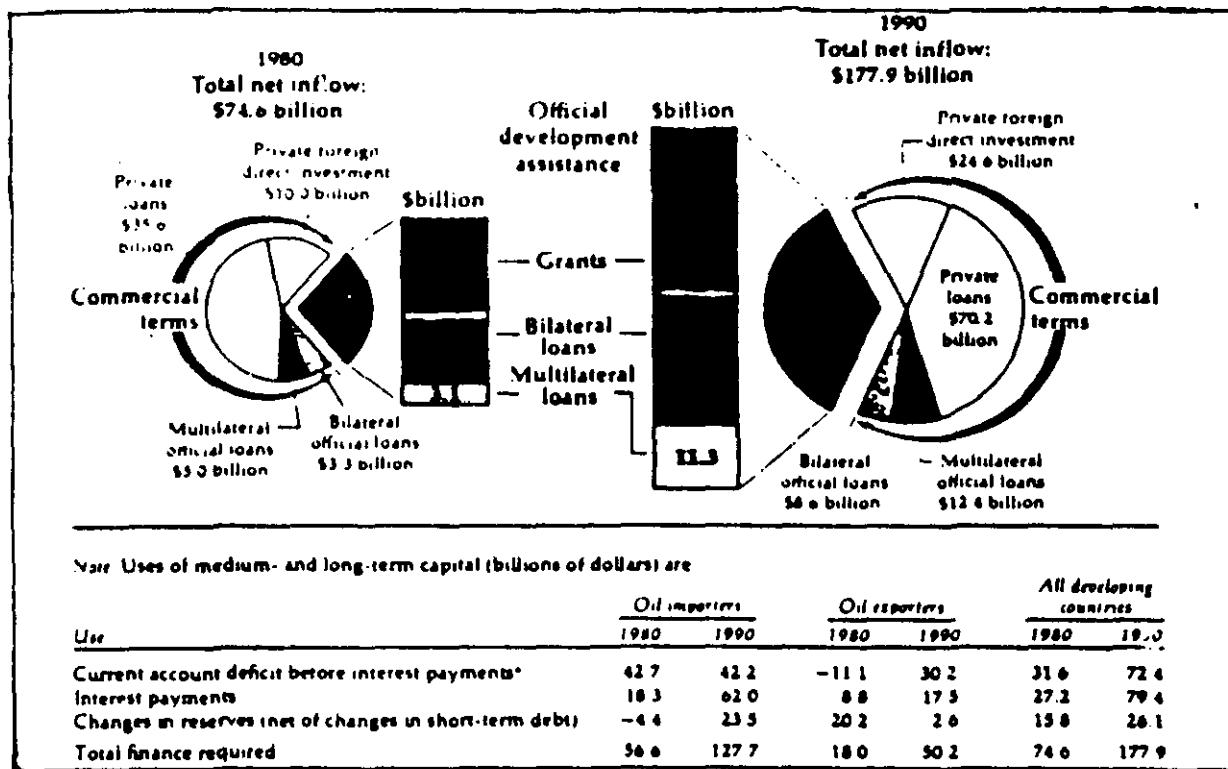


Figure II: Net flows of medium and long term capital to the Developing countries in 1980 and 1990 [4]

From fig II can be seen that in 1980 27% of the capital flow was official development assistance (20.7 billion dollars). The remainder capital flow (53.9 billion dollars) consist of investments and loans on commercial terms. This figure also shows that in 1980 all developing countries together paid an interest of 27.2 billion dollars.

### 3.6. The debt crisis

There can be seen a strong growth of the long-term debts of the developing countries in the period 1970-1980. During this period the interest that had been paid, was rather low. In 1981 can be seen a strong decreasing of the long-term debts because of a strong increasing of the interest.

A country must earn a return on its investments which is higher than the cost of the resources used. In the case of foreign finance, however, a country also has to generate enough foreign exchange to cover interest payments. In the period 1970-1980 when the interest was rather low, it was not difficult to satisfy this condition, but after 1981 these circumstances have been changed quickly.

Many African countries used the foreign finance partly for consumption and for investments in large public projects. Many of these projects contributed little to economic growth but only to increased exports needed to service the debt. With increasing of the interest, the economic problems of these countries have been increased too.

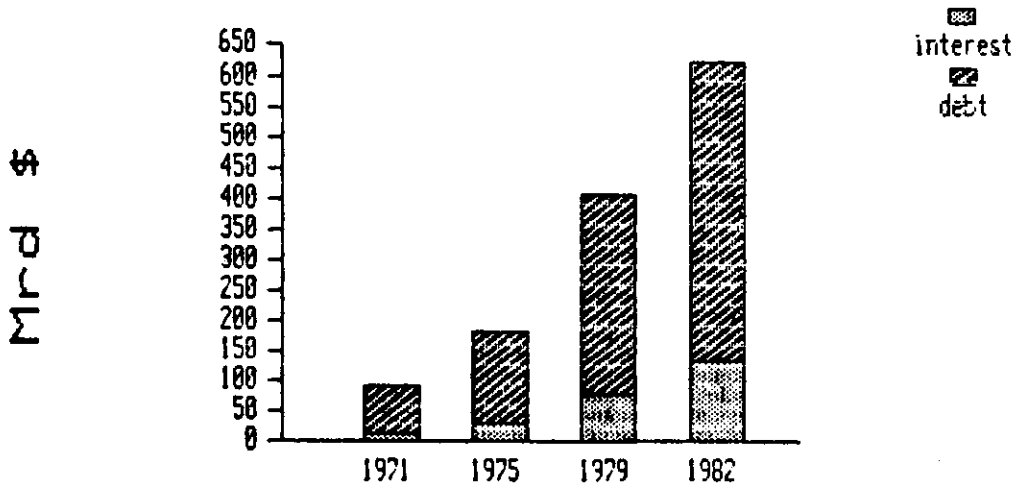


Figure III: Financial debts of the developing countries [8]

From table XVI can be seen that the countries with the highest total debt, do also have the highest percent commercial loans. The distribution of the net capital flow to the developing countries as shown in fig II is also shown in fig IV

Country	Total debt (Mrd \$)	commercial loans (%)	interest 1985-1987 (Mrd \$)
Argentina	50.8	86.8	20.4
Bolivia	4.0	39.3	1.6
Brasil	107.3	84.2	39.7
Chili	21.0	87.2	9.2
Colombia	11.3	57.5	6.4
Costa Rica	4.2	59.7	2.4
Ecuador	8.5	73.8	3.4
Ivory Coast	8.0	64.1	4.0
Jamaica	3.4	24.0	1.3
Mexico	99.0	89.1	44.4
Morocco	14.0	39.1	6.0
Nigeria	19.3	88.2	9.1
Peru	13.4	60.7	5.2
Philippines	24.8	67.8	9.5
Uruguay	3.6	82.1	1.4
Venezuela	33.6	99.5	17.8

Table XVI: Countries with the highest financial debts.  
Source: World Bank 1986.

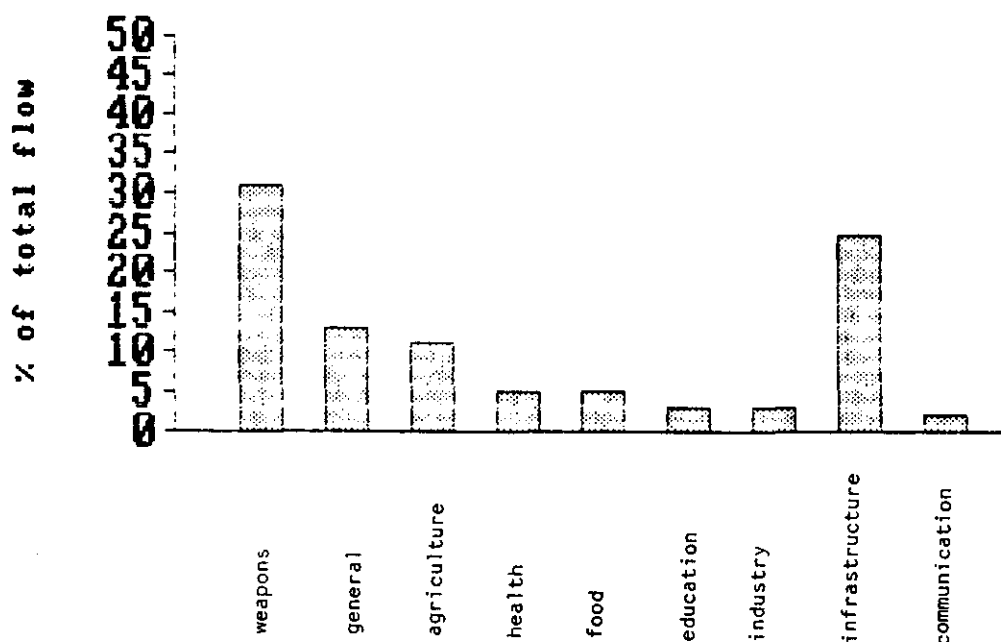


Figure IV: Distribution of the capital flow to the developing countries [3]

From fig IV can be read that most of the capital is used for the purchase of weapons. The agricultural and food sectors together represent 20% and are by far the most important recipients of civilian help, but still not more than half of what is given in military aid. Development in the sector communication as compared to the other sectors in fig IV is insignificant. It is possible to trace who the recipients of the aid are by determining for each sector which part affects the poor in the urban areas or the population in the rural areas. This is shown in fig V.



Figure V: Distribution of the money flow to the third world [3]

Table XVII is showing the distribution of development aid per person over the population when leaving weapons out of the picture. From table XVII can be read that, the development aid given, hardly affects the living standard of the rural population.

RURAL POPULATION	\$ 6.5 / YEAR
URBAN POOR	\$ 25 / YEAR
ELITE	\$ 125 / YEAR

Table XVII: Distribution of development aid per person over the population [3]

It has been stated that:

1. "The developing countries have no realistic prospect of bridging the gap between the industrialized countries and themselves, if dealing between them is conducted from the standpoint of a producer/consumer relationship"[7]
2. "The relationship between the industrialized countries and the developing countries can be characterized as one where at one end of the spectrum the industrialized countries continue to provide scientific solutions for the problems of the developing countries, manufacture goods and give financial aid on mainly commercial terms, while at the other end of the spectrum the developing countries continue to be a source of cheap raw materials and sometimes labor"[7].
3. "From the idea of producer/consumer relationship, the sale of the first world products is keenly felt as putting a strong pressure on the developing countries, trying to change the third world into a first world"[5].

### 3.7. Transfer of technology

It has been expected that transfer of technology will help the developing countries. But there are some restrictions:

- Technology should be placed in its proper perspective, especially because, in the absence of clearly defined development goals, technology itself has frequently defined development priorities and patterns, instead of being only one tool for meeting socio-economic development objectives. The question is not: 'What technology?', but: 'Technology for what?'. [9]
- About one billion jobs must be found by the year 2000 in the developing countries. The technology that must be transferred, has to create jobs. The developing countries needed technology for the industrialization of local raw materials and the manufacture of products by small size and spare business and capitalization resources. [10]
- The transfer of technology has to improve especially the live standards of the poor.
- The kind of technology that should be transferred depends upon the socio-economic characteristics of the potential users and the particular milieu in which the technology is used. [9]

### 3.7.1. The cost of technology transfer

Two kinds of issues are involved in technology transfer:

- The cost involved in either selling or acquiring technology
- The numerous impacts on the interest or objectives of the parties concerned.[11]

The cost can be in the form of pre acquisition costs, direct costs and indirect costs, while the various types of impact include economic effects and the social and political impact.

Less direct cost came from the technological dependence created by the transfer of sophisticated technology that requires continued import of spare parts and by the failure to build up technical skills to service imported technologies and to develop a domestic capacity for technological innovation.[11]

Through the years, experience has shown that technology transfer brings both cost and benefits to developing countries. Multina-

tionals can readily supply the technology, skill and capital that governments need for industrialization. But these benefits may come at the high price of:

- instances of overcharging for products and services
- restrictions on the use of transferred technology
- avoidance of taxes through the manipulation of financial flows.

### 3.7.2. Who should transfer the technology

There may be several channels for transferring technology. This is shown in fig VI. A major part in this concept is played by the industries of the industrialized countries, especially multinational corporations.

For example, the telecommunication market is completely controlled by a few multinational corporations of the industrialized countries. They control the know-how of the technology, the production processes of the technology and they possess the financial resources. However, industries in the first world fear the concept of transfer of technology, simply because it is contradictory to their 'making profit' principle. Bearing in mind the rapid development of the Japanese industries, they fear new competitors on the markets when the developing countries start producing technological products themselves [5].

Transfer to → From ↓	Governments	Institutions	Businesses	Individuals
Governments	Exchange of Scientists & Technical Cooperation Agreements	Funding of Equipment, Research, Etc.	Financing and Other Assistance	Sponsored Training Programs
Institutions	Consulting Contracts for Study of Specific Problems	Agreements to Cooperate; Exchange of Faculty and Students	Supply and Sale of Process Know-How	Training Programs
Businesses	Turn-Key Contracts for Construction of High Technology Plants	Supply of Research Equipment, Data, Etc.	Joint Ventures Licensing Agreements, Foreign Acquisitions, Etc.	Jobs and Training Programs for LDC Individuals
Individuals	Foreign Consultants Hired for Specific Projects	Faculty and Researchers From Foreign Countries	Foreign Workers, Managers and Researchers	Cooperative Research Projects

**Figure VI: Transfer of technology relations [12]**

The governments of the industrialized countries cannot really change this attitude, even if they want to, because they have no real grip on these multinational corporations. Especially, in a time of high unemployment they fear for their existence of their own industries, so that protectionism can be expected.

When multinational corporations cooperate with the developing countries, it is for their own benefit; to exploit new markets and to reduce export costs. Eventually products return to their country of origin at lower prices because of the cheap labor cost in the developing countries.

Multinational corporations keep the innovative processes in the industrialized world, while the idea of transfer of technology aims to start the innovative processes in the developing countries, and in doing so treating the developing world as an equal partner [5].



Moreover, the fact that the products of the industrialized countries are already at hand, can paralyze the innovative processes and initiatives of the developing countries to set up their own production lines. Universities, however and other non profit making institutions can contribute to the transfer of technology, but their contributions are rather small, as their financial resources are limited. They can however, really contribute to the transfer of technology within their limited financial capacity, in demonstrating to the industrialized world their responsibility for this type of development aid.

### 3.7.3. Which technology should be transferred ?

For a developing country it is difficult to choose the best solutions for expanding, e.g. their telecommunication network. The lowest cost and most appropriate telecommunication technology is likely to be based on the high technology of microprocessor and other silicon or gallium arsenide semiconductor chips.

Older technologies have:

- much higher costs
- higher power consumption
- more difficult maintenance
- less satisfactory technical performance.

Yet the economics of semiconductor manufacturing depends on the availability of global markets, which makes them uneconomic for

developing country manufacture on purely national scale. The choice for less appropriate local manufactured technology may lead to much higher costs and much longer implementation delays while waiting for local manufacturing capability.[13] The larger economic benefits of telecommunication serving all sectors of a society should exceed the specific benefits of local telecommunication manufacture [13].

The choice to be made between the two options has to be made by the developing countries. Two examples are given here. In expanding the telecommunication network into rural areas a country could decide upon a conventional HF radio system or might choose for satellite technology.

The first option was selected by Papua New Guinea. They stated that the HF radio system, despite of its well known disadvantages had the tremendous advantage of being a well known technology and completely controllable by their own people. Their greatest argument against the use of satellite technology was, that it was a foreign technology. It would not be possible for Papua New Guinea or any similar country to launch a satellite by their own. This meant that it would be necessary to "buy time" of some one else's satellite. Finally it was unacceptable that outside agencies, no matter what safeguards were written into agreements, would have ultimate control over their internal communications [14].

ADVANTAGE	DISADVANTAGE
<p>CONVENTIONAL TECHNOLOGY</p> <ol style="list-style-type: none"> <li>1. WELL KNOWN TECHN.</li> <li>2. RELATIVELY CHEAP IN FOREIGN VALUTA</li> <li>3. STIMULATING SELF-RELIANCE</li> <li>4. SELF MANUFACTURING AND MAINTENANCE POSSIBILITIES</li> </ol>	<ol style="list-style-type: none"> <li>1. RELATIVELY INFERIOR QUALITY</li> <li>2. RELATIVELY LONG IMPLEMENTATION TIME</li> </ol>
<p>LATEST TECHNOLOGY</p> <ol style="list-style-type: none"> <li>1. RELATIVELY SUPERIOR QUALITY</li> <li>2. RELATIVELY FAST IMPLEMENTATION TIME (TURN KEY PROJECTS)</li> </ol>	<ol style="list-style-type: none"> <li>1. UNKNOWN TECHNOLOGY</li> <li>2. EXPENSIVE IN FOREIGN VALUTA</li> <li>3. STRONG DEPENDENCY ON OTHERS</li> <li>4. NO SELF MANUFACTURING AND MAINTENANCE POSSIBILITIES</li> </ol>

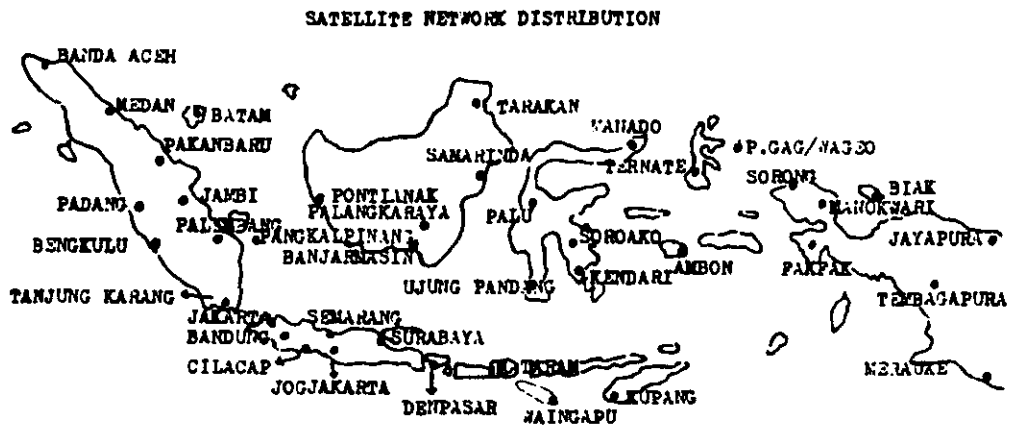
Figure VII: The conventional against the latest technology. [1]

India however chose for satellite technology and this foreign technology was introduced into India (SITE experiment). But their policy was to transform this foreign technology into a home technology, in which they have succeeded. Today, India has a launcher of its own and has put already some satellites in operation [12].

Indonesia chose also for satellite technology. As can be seen from table III, Indonesia is an oil exporter today. In the early seventies, when the oil price was rising, only Java, where most of the local and international organizations have headquarters, was served with a rather adequate telecommunication service. But the eastern and the northern part of Indonesia, where exploitation and exploration activities of the oil industries should be intensified, reliable and good quality telecommunications are missing.

It was obvious that without good communication with Java and among the centres of industrial activities, the development of the nation's natural resources would be slow or even non-existent. The economic and social cost of this bottleneck, measured in terms of lost foreign currency earnings opportunity and forgone expansion in the productive base of the economy, was much higher than the cost of extending the telecommunication system. But to expand the telecommunication system with the conventional technology, it would require more than ten year to obtain the desired telecommunication service. [35]

Therefore, Indonesia chose a satellite system, with a fast implementation time. The system is called PALAPA. In August 1976, the first satellite PALAPA/A1 was launched. The original 40 station network is shown in the next figure.



**Figure VIII: Overview of PALAPA in August 1976 [36]**

The system has grown from the initial forty earth stations to 228 operating earth stations and two operational satellites in 1984. [36]

At the moment, while the cost of satellite and launch vehicles soar, and the reliability of the launch vehicles has become questionable, a new technology, using glass fibre cables is dropping in cost. Therefore, and because glass fibre marine cables become common, Indonesia chose in 1987 for a glass fibre system on Java.

#### 4. THE IMPACT OF TELECOMMUNICATION

##### 4.1. Introduction

Telecommunication expansions can play an important role in the social and economic development of developing countries. However, that condition in itself does not necessarily mean that telecommunication projects should receive top priority in the allocation of investment resources. This is because projects in other sectors (e.g. nutrition, education, industry, agriculture, etc.) can also make strong claims to be crucial for development [15].

Because of the enormous social problems like high population growth, mass migration to the cities, insufficient agriculture production, high unemployment, and a rapidly growing demand for education, national investments policies tend to favor sectors other than telecommunication [16].

This trend is further reinforced by the feeling, widely shared by the community of economic planners and foreign aid experts, that telephone facilities (which today still account for some 90% of all investments in two-way telecommunication) are of interest mainly to the urbanized and affluent segments of society and don't contribute in any way (unlike education) to raising the standards of living of the great mass of people, notably in the rural areas .

In the next sections will be shown, that the influence of telecommunication investments on other sectors of the society is much greater than expected.

##### 4.2. Global telephone density

The telephone density in the world is shown in fig IX

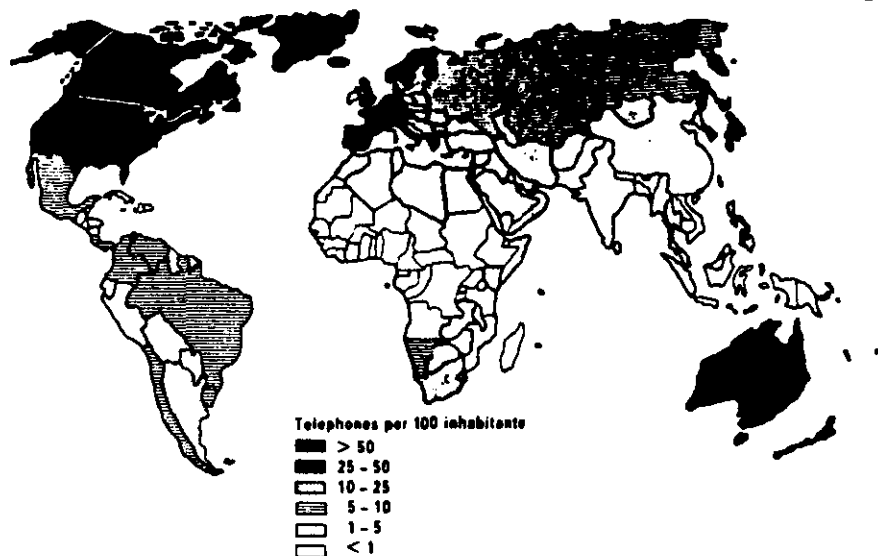


Figure IX: Telephone density in 1982 [16]

From fig IX can be concluded that the telephone density, as expressed in the number of telephones per 100 inhabitants of a country, is extremely low in Africa and Asia. (viz < 1 ). The telephone density in North America, Europe and Australia is high ( > 50 ).

Region	1982	1983	1984	1985	1982-1985 Growth Rate (%/year)
Europe	39.2	37.2	40.0	43.0	3.1
North America	25.9	21.8	22.0	22.6	4.4
Asia	28.7	27.9	30.3	33.0	4.8
Latin America	4.4	4.9	4.9	5.4	7.1
Oceania	1.5	1.6	1.7	1.7	4.3
Africa	1.1	1.1	1.2	1.3	5.7
Total	100.8	95.5	100.1	107.0	2.0

**Table XVIII: Estimated GNP expenditures for public telecommunication, by region, 1982-1985.**  
(In billions of 1982 US Dollars) [17]

Region	1982	1985	1982-1985 Growth Rate (%/year)
Europe	130.6	160.2	7.0
North America	111.8	123.1	3.3
Asia	92.7	115.6	7.6
Latin America	16.0	19.8	7.4
Oceania	6.6	7.8	5.7
Africa	4.1	5.0	6.8
Total	361.7	431.4	6.1

**Table XIX: Estimated number of telephone main stations installed worldwide, by region 1982-1985.**  
(In millions) [17].

From table XVIII can be seen, that as expected, there is a great difference in capital expenditures for telecommunication between developed and developing countries.

From table XIX can be seen, that the estimated growth rate for the number of telephone stations is around 6% for all countries with exception of North America. That country has a fairly well saturated telephone network and therefore achieves slower average growth.

% of population and telephones in principal cities per country.					
Industrialized countries	% of population in main cities	% of telephones in main cities	Developing countries	% of population in main cities	% of telephones in main cities
USA	48.9	51.9	Venezuela	39.5	75.5
Canada	40.0	49.6	Upper Volta	7.3	97.6
FR Germany	27.4	39.5	Indonesia	11.0	70.4
UK	31.3	40.1	Chad	10.8	40.2
France	31.4	53.9	Kenya	9.8	78.9
Italy	37.8	50.0	Malaysia	10.2	58.6
Japan	52.6	59.5	Pakistan	14.7	68.7
Australia	68.6	77.3	Thailand	14.8	82.8
Switzerland	34.9	45.9	India	6.8	55.0
Sweden	36.0	43.1	Fiji	1.4	46.9
Belgium	41.9	56.2	Costa Rica	43.1	85.2
Spain	26.6	47.3	Papua/NG	8.8	85.7
<b>Averages</b>	<b>39.8</b>	<b>51.2</b>		<b>14.9</b>	<b>70.4</b>

Source:  
The figures are taken from *The World's Telephones*, August 1980 edition. Population figures for FR Germany were based on estimated figures, as those in *The World's Telephones* were obviously in error.

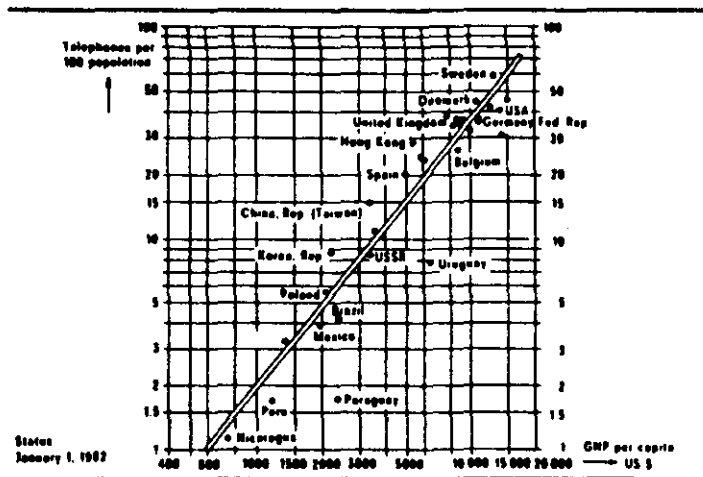
Note:  
The same countries were selected as those for text Table 1 but with the following exceptions: (a) Indonesia was substituted for Burma, as figures were not available for the latter.  
(b) Papua New Guinea was substituted for Singapore in view of the totally urban nature of the latter network.

**Table XX: Urban and rural telephone distribution [18]**

From table XX can be seen that there is a difference in telephone density between urban and rural areas in the whole world. Because of the fact that most economic and social activities, like trade and administration have been carried out in the cities, a little difference in telephone density can be expected. But in developing countries this difference is much higher than that what can be expected.

**4.3. Telecommunication and GNP**

Like all the other components of an infrastructure of a country, its communication facilities are closely linked to the GNP.



**Figure X: Telephone density and GNP [16].**

From fig IX can be seen that the telephones are concentrated in the developed countries. At this moment, 84% of the population of the world has to manage with only 15% of all the telephones in the world [16].

From fig X can be concluded, that there exists a correlation between the telephone density and the GNP. The question, however, is ; "What is the driving factor ?" [17].

"Experience in many countries has been that causality applies in both directions. On one hand, telecommunication provides an important infrastructure for the operations of an industrialized, diversified economy that relies on interchange of information among mutually dependent participants. Telecommunication is needed for efficient administration of government and business. On the other hand, an advanced stage of industrial development provides an economic base for telecommunication growth in terms of capital, technical expertise and demand. Unfortunately, for many developing countries these statements are more appropriate in the negative sense, in that:

1. The lack of telecommunication infrastructure hampers industrial development, while
2. a less advanced stage of industrial development produces a serious shortage of capital and trained manpower which inhibits expansion of telecommunication facilities." [19]

Often, there is a great unsatisfied demand for telecommunication services in less industrially developed countries, a sure sign that telecommunication growth has not kept pace with industrial development. [19]

#### **4.4. The impact of telecommunication on rural areas**

For the developing of a low income country, it is important to pay attention to the developing of the rural areas because: [20]

- About 90 % of the country's population lives in rural areas.
- Most of this population is composed of poor peasants living below subsistence level.
- Most of these are related to the bulk of poor living in the derelict areas of the urban centers.
- The major source of foreign exchange and raw materials comes from agriculture.
- The bulk of the food, produced locally, is done by the peasants in the rural areas.
- The main source of income for most of the developing countries is and will remain agriculture and agricultural based processing and manufacturing industries.
- The balance of political and social power is increasingly being determined by rural residents.
- The solution of the biggest urban problem (That of rural to urban migration) is in solving the economic and social problems of the rural areas, through the improvement of the quality of the live within the rural areas.

In the past, little attention had been paid to rural telecommunication and its contribution to rural development because:  
[21]

- There is a lack of an historical model from the industrialized countries, which can demonstrate the role that telecommunication can play in the development of a subsistence based economy to that of a modern society along "Western" lines. A modern telephone system in a rural setting is felt to be an anachronism, being associated with modern business and "Western" lifestyles.
- The benefits from telecommunication manifest themselves externally to the investment itself. So other investments, which show direct returns are at a distinct advantage when competing for scarce development funds.

The external contributions of telecommunication to the society have been demonstrated in two case studies in India and Egypt. The expected external social and economical contributions of telecommunication (especially telephone) and the results of the case studies will be discussed in next sections.

#### 4.4.1. The economic impact

The financial revenues of telecommunication projects in urban areas can be expected higher because in rural areas: [17]

- The telephone density is much lower,
- thus, the average distance between subscribers is longer.
- The distances to other main areas are longer.
- The traffic per subscriber is lower.

Although the direct financial revenues of telecommunication are higher in urban areas, it can be expected that telecommunication projects in rural areas will have to generate unexpected indirect economical contributions:

- A detailed analysis of 35 countries, industrialized and developing, has shown that one percent rise in the number of telephones per 100 population over a period of five years contributed in the seven following years to a rise in the GNP of 3 percent. This contribution to national income is particularly high in the countries or areas with the lowest telephone density, thus in the rural areas of the developing countries. [22]
- Telecommunication expansions can be expected to increase employment in developing countries. The high capital-labor coefficient typical of telecommunication projects means that relatively few people are directly employed in such projects. However, the greater availability of product and factor markets output and investment are likely to increase in response to new opportunities and diminished uncertainties. This higher output and capital formation usually generate higher employment. [23]



- The poor rural farmer can by telephone be informed over the market prices of his products. Without this information, the price he will be paid, depends upon the price that the (powerful) merchant wishes to pay. In that situation, it can be expected that the merchant should make the most profit.
- Increased availability of telecommunication is likely to accelerate the rate at which new and more productive techniques are diffused among rural farmers. This improved

production technology lowers the relative price of food, which is a large weight in the low income budgets of the poor.[23]

There can be concluded that the indirect returns of rural telecommunication are higher than expected. There has been developed a technique named: Social Benefit cost Analysis, which uses shadow prices. These prices are applied to a project's output. The value is defined as the contribution that the new output makes towards attaining the basic socio-economic objectives of a country. Such a shadow price consists of two elements: [15]

1. The consumer surplus; This is the amount above the actual price that a consumer would be willing to pay in order to obtain the output of the project.
2. The indirect benefits that an investment provides to society but which the project can not appropriate. The economical advantages of information technology, can only be obtained by a telecommunication network, that can be used for collecting the data.

#### 4.4.2. The social impact

Beside the economic benefits, telecommunication generates also some social benefits for the society.

- Telecommunication gives people the means of access to centers of information and the means to respond to it. People can communicate with each other, without travelling, saving time, energy and money, thereby enlarging the area in which they are living and working.
- Teaching programs and audiovisual aid can be broadcast and in this way raise the level of education and health of a country.

- Remote medical assistance can be given to rural hospitals. It is possible to warn people against natural disasters such as floods, hurricanes etc.
- The possibility of conveying messages more cheaply may increase the amount of false information transmitted with socially pernicious effects. Some observers have suggested that radio and television have facilitated the transmission of messages that mislead rural poor peasants into thinking that all is well in the city. Such mis-information may help stimulate excessive rural urban migration. This possibility of increased mis-information applies more to one-way communication media (like radio and television) than two-way media (like telephone).
- If telecommunication is expanded all over the country, the administrative control, police and law enforcement can be handled more effectively. Election programs discussions and social programs, which are broadcast all over the country, tend to unify the people. Everybody is aware of what is going on. National discrepancies between African tribes for instance can be bridged.
- Telecommunication can be used by minority groups to manipulate the people. In many attempts to overthrow the government, the radio and television stations were seized first. On the other hand governments and political parties can also use television for manipulating the people. This are mainly disadvantages of one-way communication. With a good telephone network a rural inhabitant is able to control the information that he has received by television or radio.
- All the people in a country may be unified by telecommunication. When this is the fact, regional cultures and traditions may be lost because the people and especially young people do not think it is necessary any more to adhere to these cultures and traditions.

#### 4.5. The ITU-OECD study

There have been carried out some studies on measuring the economic and social profitability of investments in rural telecommunication. Several approaches can be envisaged. The one used in the ITU-OECD study, was to look in great detail at the patterns of the use of telecommunication services in a few rural areas, to identify who used the telephone and why, and to measure the economic value of this service to the individual users. Two countries, India and Egypt, were selected for this micro economic analysis of the benefits of rural telecommunication. [24]

India : The Kaul study [24]

This study, carried out by S. N. Kaul of the Economic Cell of the Indian ministry of Communication, focused on two types of telephone service available in rural India:

1. The privately owned telephone of individual village subscribers.
2. The public village telephone.

The distinction in this two types of telephone is important for an economic and social point of view:

- The trade off between private and public service. Should a national telecommunication authority, which has only limited investment resources at the disposal, put most of its money into the potentially profitable private service for individual subscribers, or should it invest more heavily, into the financially less profitable public telephone service.

The study in India provides an answer to a number of widely held assumptions about the role and importance of telecommunication in rural areas.

1. "People in remote rural areas do not really need a telephone." In fact, the research shows, when a village telephone is available, it is used primarily for long-distance calls and services as a vitally important substitute for personal travel. This substitution function is all the more important given the relative isolation of rural settlements and the long distances which have to be traveled

on poor roads. Figure XI shows the consumer surplus which shall be earned, when a travel has been substituted by a telephone call.

2. "The telephone is used primarily by the more affluent segments of the population and does not benefit the poorest people". This view of telephone service is not of course entirely incorrect: clearly, the only people who can afford to have a telephone at home, are those with comparatively high level of income. Kaul's analysis of the utilization pattern of public village telephones shows that even the poorest people make use of the public telephone, when there is one. They are in fact prepared to devote a substantial part of their monthly income to pay for vitally important long-distance call.

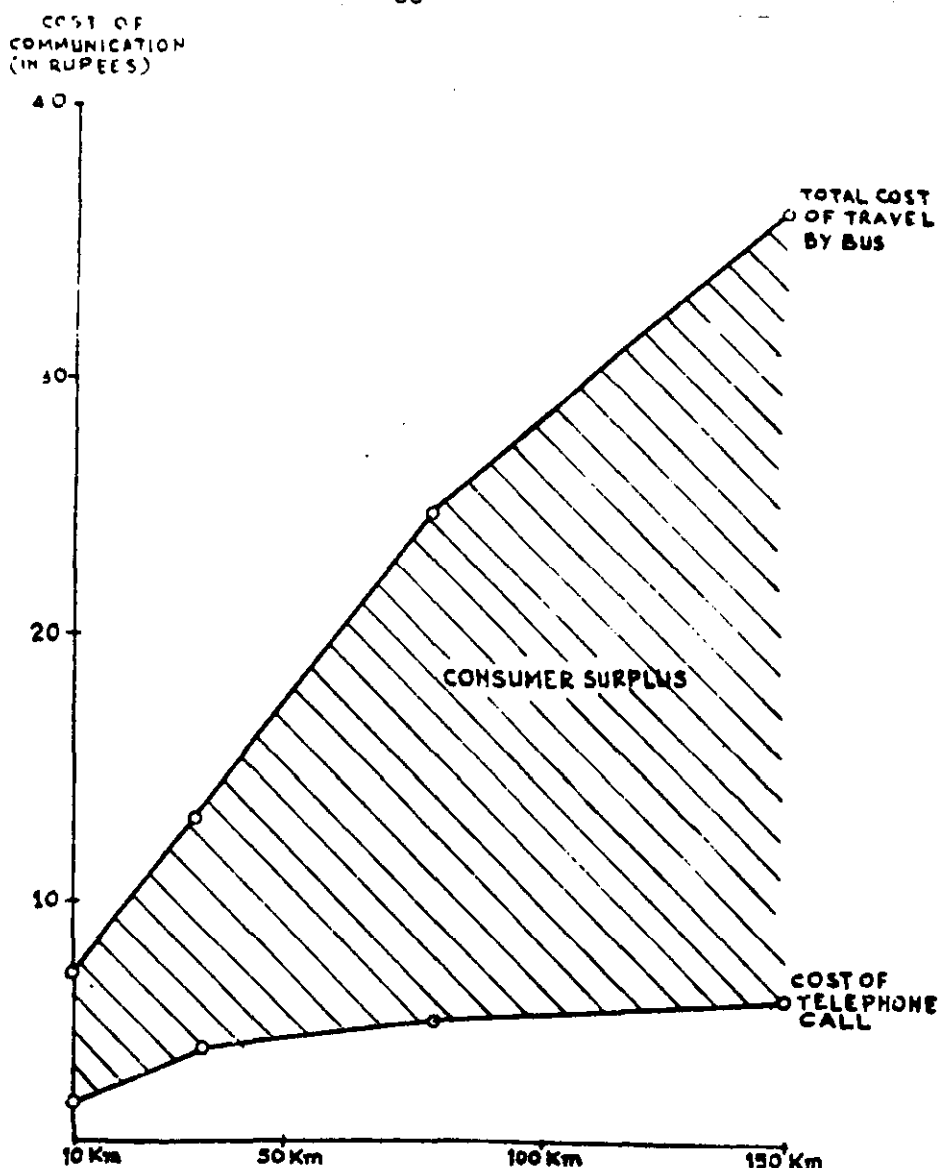


Figure XI: The cost of long-distance communications by telephone and bus. [24]

The interviews of rural telephone users carried out by Kaul brought to a light number of critical problems concerning rural telephone services:

- The ease of access to a public village telephone; This telephone, usually located in the local post office, is seldom accessible for more than three to five hours a day. The inconvenience to the user is obvious, but this limited access time also means that the revenues accruing to the telecommunication authority are much lower than they could be, and this in turn makes investments in such facilities even less attractive from the telecommunication authority's point of view.

- The reliability of the service;  
Kaul's study shows that nearly 55 percent of the users were dissatisfied with the quality of the service. By far the most important cause of dissatisfaction was the sheer inability to make a call, because the telephone network was overstrained during all of the day. This is an important problem, given the fact that many users have to travel considerable distances to get the nearest public telephone.

Research has been done to the cost of service to the user. Most of the village public telephones are used for long-distance calls, the price of which is proportional to the duration and the distance of the call. Although the price of a long-distance call is relatively high, given the level of income of the most users, only less than half of the users (43%) felt that the tariff charged was high. Thus people, living in the rural areas, are prepared to pay for telephone services, contrary to what is often assumed. What is more, this willingness to pay does not seem to be correlated with income levels. Those who find telephone expensive are generally not the poor farmers, but the more affluent professionals.

#### Egypt: The Kamal study [24]

In Egypt a study has also been carried out to the benefits of rural telephone. In this study, research has been done to the substitutability of telephone service by other services like transport, and to the degree of substitutability between telecommunication and other factors of production. In both cases the benefits are presumed to be equivalent to the potential losses resulting from the absence of telephone service. This approach has a few limitations:

- It is based on a non existing scenario whereby telephone service is withheld while other things remain the same.
- It ignores the integrative nature of the various modes of communication, the telephone can serve as a substitute for face to face communication, but its availability also tends to increase the amount of social interaction and generates a new demand for communication.

In Egypt less emphasis has been given to village public telephones, which can be used by everyone, and in particular by the poor farmer and landless labourer. In this study attention has been paid to the rather more affluent segments of the local community and the professional classes like traders and public officials. They own a private telephone.

Four broad categories of telephone users were identified:

- The service organizations.
- The trade sector.
- The owners of capital equipment, land owners and members of the liberal professions.
- The artisans.

The study has paid attention to four groups of issues:

1. The business oriented communications behavior of selected key individuals.
2. Alternative communication behavior in hypothetical cases in which telephone service is either withheld in a village where it already exists or introduced into a village where it does not yet exist.
3. Communication behavior in emergency cases.
4. The value of the benefits accruing from telephone use.

The substitutability between the telephone and other modes of communication depends on a number of factors. In some cases substitution is possible, while in others it is a non choice situation.

The procedure used in this study was fairly straight forward. In situations where it is possible to replace the telephone by some other mode without too great inconvenience, the benefit of telephone use are equivalent to the difference in cost between the possible modes, and the difference in the monetary value of the time spent on each of the possible modes. In many cases, however, the time factor is important, and the communication which takes place instantaneously ( i.e. by telephone ) has a much greater value to the user than a more time consuming mode of communication. ( Going to the nearest town by bus. ) Typical of such situation is the ordering of spare parts for agricultural machinery for example. In such a case, one must add to the benefits the cost of idle time of expensive capital equipment, which can be minimized as a result of instant communication by telephone. In emergency, it is almost impossible to replace the telephone by an other communication mode. Calculating these benefits have been shown that the measurable benefits of telephone turn out to be approximately 85 times higher than the cost. If benefits are calculated in a very conservative way, ( i.e by considering only the time saving element and not other benefits like higher productivity of capital equipment ) , they still turn out to be approximately 36 times higher than the cost.

The Kamal study has also shown that:

- The size of the benefits accruing from telephone is closely linked with the distance to the big urban centers.
- The benefit of the telephone is closely related to the density of the network: The greater the number of subscribers in the province, the greater the benefit of the service to individual users.
- The level of benefits from the telephone tends to vary according to each socio-economic category and type of activity. The group which appears to profit rather less from the telephone, is the artisans class, and which derives the greatest benefits is that formed by the owners of capital equipment. These differences in the level of benefits are, however, rather marginal and do not lend much support to the view, that the telephone benefits primarily the most affluent segments of the population. In fact, the Kamal study has strongly suggests that all the four social groups, covered in this analyses, benefit enormously from the availability of telephone service.

These two studies raise two important issues of rather general nature.

1. The rather large difference in the scale of benefits, they are much larger than anticipated, and would most probably be even larger if the quality of the telephone service were better. There has also been shown an unexpected difference between regions. This difference suggests rather clearly that telecommunication planners need a much better and more finely tuned appreciation of regional characteristics in allocation of their investments funds.
2. What is the relevance of these findings to other developing countries? Would a similar study using the same methodology in another country yield the same type of results? These questions cannot of course be answered at present. Nevertheless both studies suggest very clearly that rural telecommunication are an extraordinarily important and potentially very profitable investment from a social and economic standpoint.

#### **4.6. Financing of telecommunication**

When expanding a telecommunication network in developing countries technical and financial aid is required. A part of the financial needs (for the equipment) must be composed of foreign exchange. World Bank studies have indicated that currency costs of telecommunication projects can be split, with 40 percent being local and 60 percent requiring foreign exchange. [18] Governments of developing countries have a number of possibilities to obtain foreign financing: [18]

- The use of various forms of barter or "buyback" arrangements. In such purchasing, the vendor agrees to "buy back" a certain amount of the buyer's export, often approximating the cost of the telecommunication equipment. For example: an exporter of coffee may demand that in financing for its buying a microwave system from country x, that country must buy back an amount of coffee, over a certain number of years, equal to the cost of the system. This possibility obviously reduces the foreign financing constraint considerably, while also guaranteeing a future market for the commodity. There is, however, a disadvantage, the willingness of a selling country to make the barter or buyback arrangement, takes precedence over the technical judgment about the equipment.

- The use of various forms of loans, depending on the country's economic condition:

- A. Short-to-mid-term commercial loans. (under 10 year)
- B. Long-term commercial loans. (about 20 year)
- C. Long-term loans at less than market interest.
- D. Outright grants.

Short-term loans are often provided through supplier credits and are often relatively easy to arrange through a bank. Long-term loans can be arranged through the sale of bonds or by borrowing from one of the multilateral banks, such as the World Bank. In view of the long lifetime of most telecommunication equipment, the consequent low depreciation and the usually rapid increase in net fixed assets, its important that a major part of the external financing should have long-term maturities, if cash flow problems are to be avoided. Especially, in rural telecommunication investments, where the revenue contribution from the service will be relatively small, long-term maturities, offered by agencies like the World Bank, are to be preferred.

The following kind of banks and other financing agencies can be distinguished: [18]

- Private banks;
- Multilateral banks like:
  - African Development Bank
  - Asian Development Bank
  - European Investment Bank
  - Inter-American Development Bank
  - The World Bank /  
International Development Association (IDA)

Private banks provide commercial loans. These are the easiest types of loans to negotiate, assuming the borrower is creditworthy, and the most expensive. Commercial lending is generally non-restrictive and passive. The borrower is not constrained to show development impact, or undertake any other activity than to ensure that it will repay the loan.

The World Bank and its sister organization the IDA, have been the principal sources of multilateral funding for the telecommunication sector. In addition, telecommunication financing is often included in loans from other sectors of the bank, such as education or agriculture.

The World Bank handles requests for loans and assistance from developing countries of low and middle income. The bank is a non profit development promotion agency, thus the loans are offered at favorable interest rates. The interest that must be paid, is 0.5% higher than the interest that the bank must pay for the loan in the international capital market.



The IDA is responsible for loans and credits to the poorest developing countries. (GNP less \$400 US per capita). IDA credits carry no interest charge and are subject only to an annual service charge of 0.75% of the loans value over the 50 year repayment period.

The criteria used by the World Bank and IDA in considering financing a telecommunication project include the following:

- The required finding is not available from other sources.
- The loan will provide a level of investment, that will help to attain broad national development goals and support individual development projects that depend on adequate communications infrastructure.
- The loan will promote efficiency and social equity, such as the extension of service to rural areas.
- The loan will promote rational institution building and policy improvements within the telecommunication sector.
  
- The loan will promote rational long-term technical and financial planning and assists in achieving a least cost solution to providing service.

Normally, the World Bank finances between one-quarter and one-third of the total cost of the telecommunication projects it supports.

## **5. TECHNICAL CHOICE OF TELECOMMUNICATION SYSTEM**

### **5.1. Network planning**

#### **5.1.1. General**

When implementing a telecommunication network in an arbitrary area research has to be done in the following sectors:

#### **1. Research into the typical features of the area concerned**

These studies must contain the following aspects [25]:

- Typical geographical and climatological features of the area.
- The situation of the towns, villages and small settlements in the area.
- Population density and distribution in the area.
- Activities in the area, for example agriculture or industrial activities.
- Existing infrastructure in the area (availability of water, electricity and roads).
- Existing telecommunication networks.
- Economic potential of the area (what amount of revenue can be expected).

#### **2. Research into the telecommunication services that are required**

These studies must contain the following aspects:

- Expected traffic loss (from where to where can traffic be expected).
- What kind of telecommunication is required (telephony, datatransmission, etc.).
- Reliability (what grade of service is required).
- Technical quality of the network (bandwidth, signal to noise ratio, bit error rate, etc.).
- Expansion capabilities for the future.

As a result of these studies, typical network parameters can be selected. These parameters are:

- Network structure.
- The number and the position of the nodes in the network.
- The transmission capacity between the exchanges.
- Choice of the transmission system.

These aspects reflect networks in general. We shall now focus our attention on rural areas.

#### **5.1.1.1. The features of the rural areas**

In the following geographical features of a rural area are considered.

- The area will be very large. (For example up to 250 by 250 km.)
- It can contain large deserts, jungles, forests, lakes, mountains, hills, swamps and snow or ice covered areas.
- Except for some towns (more than 10.000 inhabitants) the people in this area live in villages (less than 1000 inhabitants), in small settlements (up to 300 inhabitants), or completely scattered or even nomadic.
- Agriculture is the main activity, although in some towns some industrial activities can also be expected.
- Roads connect the towns, small roads lead to the villages and settlements.
- There is hardly any primary power or power generation, although electricity will be present in the towns and most of the villages.
- The economical potential of the rural area will be low, climatic conditions may be severe.
- If any telecommunication network exists, it is to connect the towns with an insufficient capacity.

#### **5.1.1.2. The required services**

Despite the rapid growth of data transmission, facsimile and other services in the Western industrialized world, most of the telecommunication traffic still originates from the telephone. Therefore, we shall concentrate on implementing a telephone network, eventually extended with telegraph and telex. Other services can also be implemented when not requiring additional financial means.

There should be made a choice between manual operated or automatic exchange.

The most important factors favoring automatic exchanges are [29]:

- 24-hour service
  - fast connections
  - privacy
  - equality of service for all subscribers
  - very low personnel cost
- straightforward link-up to the national subscriber trunk dialling system.

The most important factors favoring manual operated exchanges are [29]:

- low first cost
- fast and easy installation
- easy maintenance
- acceptance of connections of very long and insulated lines.

In rural areas with a limited number of long distance lines, it will be possible to make full use of the expensive long-distance lines if a manual switchboard delay operation is used. The operator will also be able to give more flexible service to the subscriber, especially given the fact that most of the rural public telephone users will be illiterate.

At an existing telecommunication network three kinds of service enhancement can be distinguished [27]:

- quality improvements
- convenience improvements
- supplementary services and facilities.

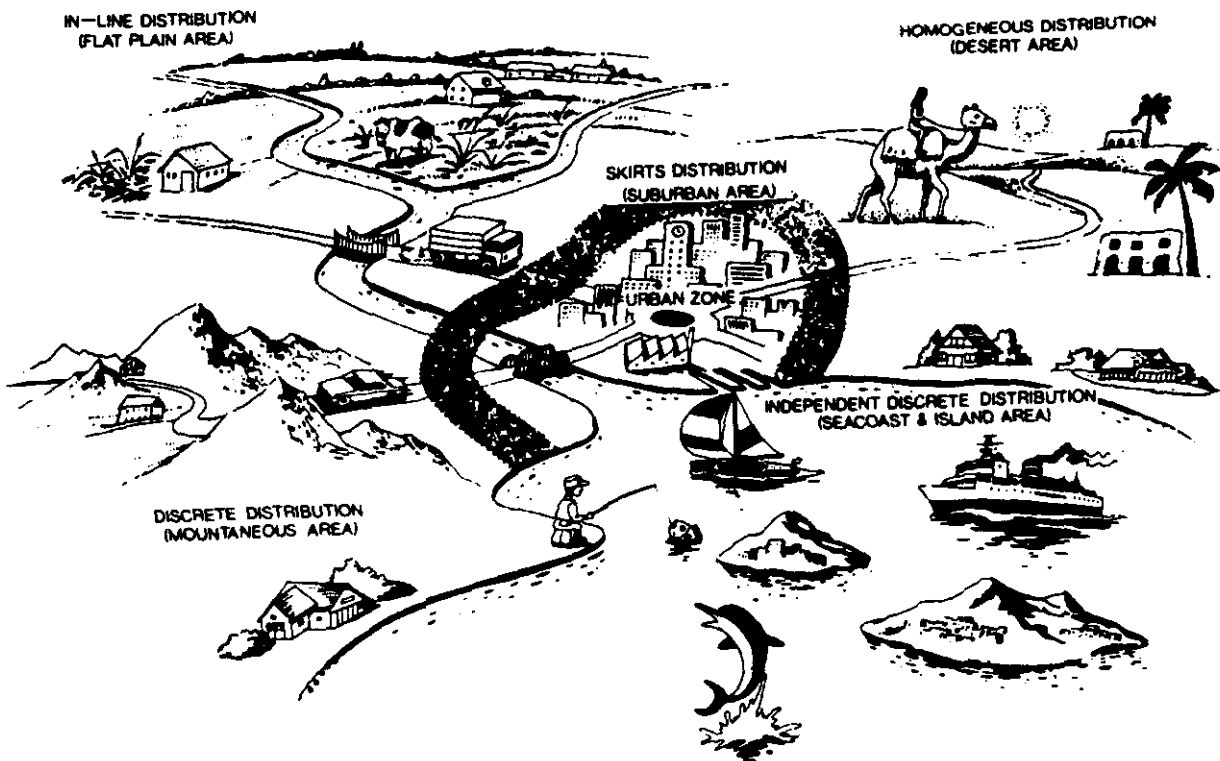


Figure XII: Typical rural area model [26]

Type of Enhancement	Example	Type of Benefit
Quality Improvements	Improved signal-to-noise ratio (reduced end-to-end loss)	Increased subscriber satisfaction: in extreme cases fewer calls abandoned due to poor audibility
	Improved grade of service (GOS) (reduced probability of call failure due to "system buoy")	Increased subscriber satisfaction Converts non-revenue-earning call attempts into revenue-earning calls
Convenience Improvements	Multi-frequency (push-button) dialing with reduced call set-up times	
Supplementary Services and Facilities	Call waiting indication	Converts non-revenue-earning calls into revenue-earning calls
	Automatic call forwarding	Economises time of people with scarce skills As above

**Figure XIII: Examples of service enhancements [27]**

**5.1.2. ITU's basic need planning concept [28]**

This concept defines an approach to the provision of rural telecommunication. According to this concept, rural community telephones should be installed in each community with a population of about 10.000 inhabitants. For companies or government agencies, individual telephones could be installed, if the operating company receives a guarantee, that a minimum of amount of call charges can be collected each month. With this in mind a fundamental development plan can be made.

The fundamental development planning process provides data about the possible number of telephone and telex extensions needed in the future and the amount of traffic which can be expected. A separate process is necessary to produce an area plan, which specifies the type and the number of the network components. A preliminary cost estimation completes the fundamental development plan.

Figure XIV shows an overview of the total planning process. Three parts of the flow chart are discussed now.

Number of subscribers.

The assessment of present and future demand is the first purpose of this part of the fundamental planning process. In a low income region the demand from private persons can be neglected. The supply of public telephones should initially be kept at a low level and could start in the more remote areas, where the benefits of a telephone service are obvious. The proper locations of public telephones to fulfill immediate demand are:

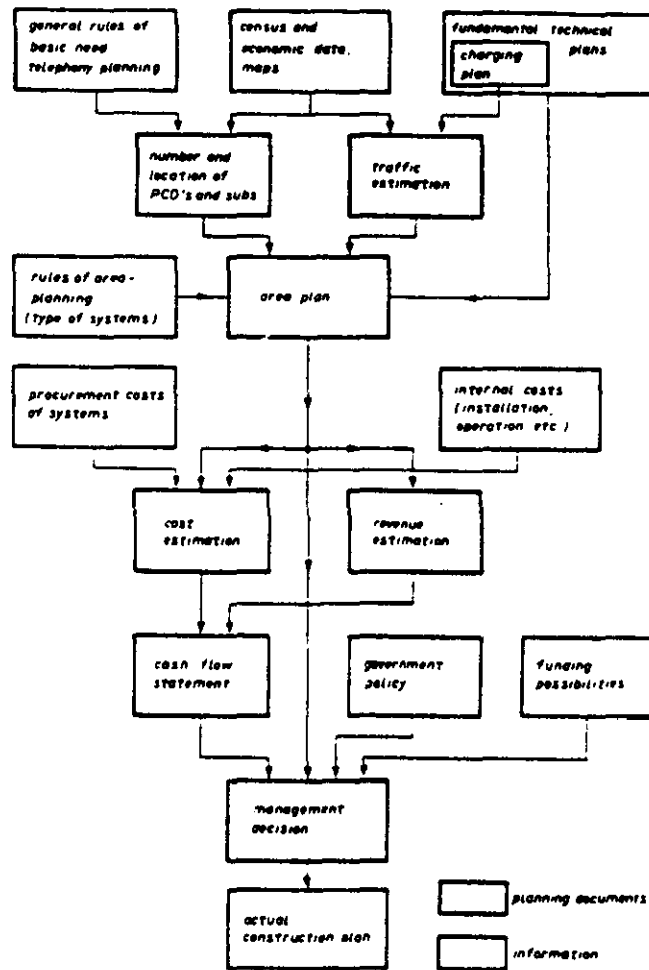


Figure XIV: Flow chart of the planning process for a rural telecommunication network [28].

- concentrated settlements with a population of 5000 or more and an average yearly GNP of \$200 per capita (1983 US dollars) or more. Settlements with a lower GNP have to cover a greater population.
- market centers in which shops are operated and where the population of the surrounding areas gathers regularly on the market place. Such centers would also normally house schools, health dispensaries, etc.

### Traffic estimation

This part of the fundamental planning process should generate preliminary traffic figures. Experience in some countries shows that traffic figures in rural areas can vary greatly. Where roads are bad and distances are great, it may be expected that the average daily traffic generated by public telephone users, would be 8 average calls to other communities in the neighborhood or the district center, and 8 average calls to capital or other major towns. An average call has been defined as lasting three minutes. By raising the tariffs during business hours, the telephone traffic will be spread over 12 hours or more.

The terminating traffic at a public telephone will be very low compared with the originating traffic. It can be recommended to assume a busy hour traffic in the order of 0.033 erlangs for the average public telephone, and 0.066 erlangs for the busy public telephone. Traffic originating from business and officials can easily be higher. For planning purpose an average of 0.5 erlangs could be assumed.

When all calls are charged at long-distance level, precautions should be made that all call charges are the same for originating and terminating traffic between two subscribers to avoid abnormal subscriber practices. Traffic values are influenced strongly by tariff structures and by the way call charges are paid for. Direct payment, as if necessary of course by a public telephone, reduces traffic. It has been observed in various countries that charges for the use of official governmental telephones are not made or cannot be collected easily by the telecommunication authority. This may seem logical from the viewpoint of government financing. It does, however, introduce a serious danger to the proper operation of rural communications, especially in countries where official use is a substantial part of the total use. If the telephone service is made free of charge, the installed systems will be easily overloaded.

#### **5.1.3. Rural network parameters.**

As a result of studies, previously described, the network can be established. First the positions of the exchanges have to be determined. The best position for a local exchange, is in a rural town or village, which act as a center for the region. CCITT indicates that in rural areas a subscriber density can be expected of 1 per 50 km<sup>2</sup>., when people live scattered in the area, or, in the case of isolated settlements, a maximum of 1000 subscribers. The ITU gives in [29] a broad classification as to the relationship between the subscriber density and the size of the exchange, based on economic considerations. These are given in fig XV.

TYPE	NUMBER OF SUBSCRIBERS /KM2	RURAL AREA (HA)	EXCHANGE AREA	EXCHANGE SIZE	MOST DISTANT SUBSCRIBER (KM)
A	> 1.5	65	50—130	80-200	5 - 8
B	0.1 - 1.5	65-1000	100-140	40-160	7 - 13
C	< 0.1	1000-10000	> 1000	< 40	65-1000

Figure XV: Rural exchanges sizes. [29]

Seen from an economic point, public exchanges with less than 30 subscribers are not attractive. In these situations, when occurring in rural networks, other solutions exist:

1. Line collection
2. Drop and insert possibilities.

These are described below.

1. Line collection

Next to the functions of distributing and trunking, known from the normal networks (see fig XVI), the rural networks also posses the function of transfer (see fig XVII).

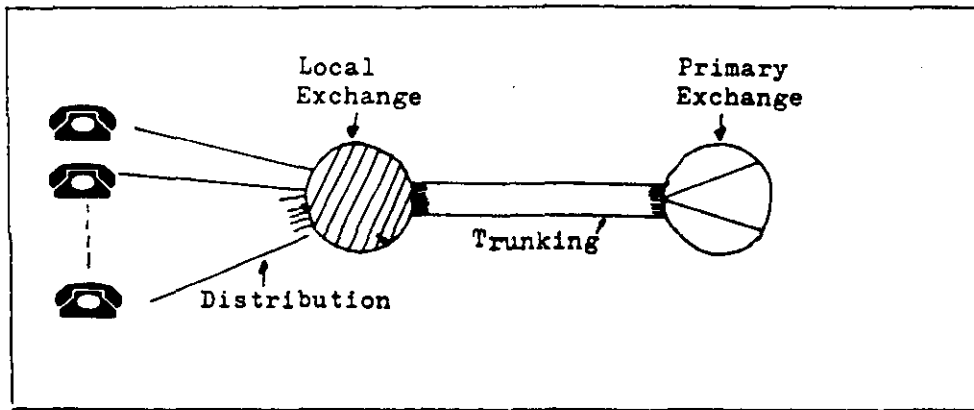


Figure XVI: General network layout [1]



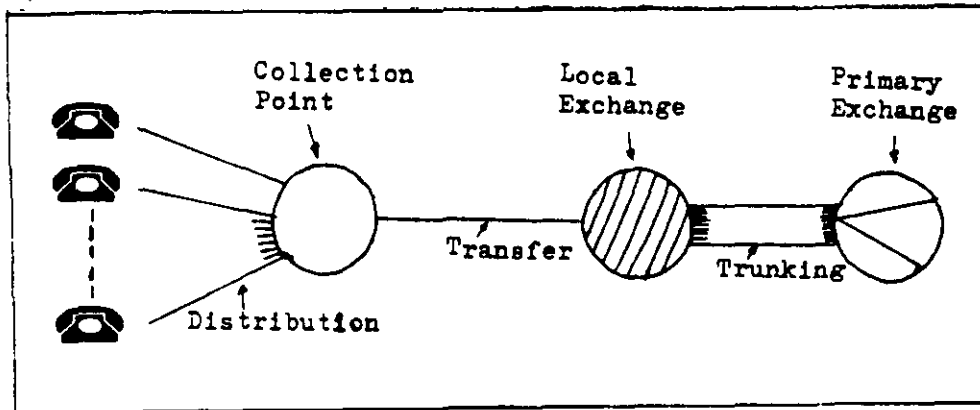


Figure XVII: Rural network layout [1]

## 2. Drop and insert possibilities.

When a trunk link passes through a rural area, it can be made possible to connect this link with a local network. This is shown in fig XVIII.

According to [29] the number of lines in a typical rural network lies between 100 and 1000. Completely automatic exchanges with less than 100 lines are rare (for example private or business exchanges such as the PABX). For determining the size of the exchanges it must be estimated how many people must be provided in the next few years with telephone. These studies have to take into account the growth of economic activity and the expected growth of subscribers in the area. The size of the exchange has to be planned for a period up to the next planning period. As far as telephony is concerned, it appears that the demand for telephony rapidly increases after automatic exchanges have been installed and put into operation.

Next, transmission capacity has to be determined. This capacity is dependent on the amount of traffic and the grade of service, according to the Erlang B formula [29]. This relationship is shown in fig XIX, where the grade of service is expressed as traffic loss. In fig XIX, a subscriber traffic of 0.05 Erlang is assumed.

Normally the traffic to and from one single subscriber varies from 0.01 to 0.1 Erlang. Sometimes however, the amount of traffic can be much higher (for example when there is only one public telephone in a village serving all villagers). Typical figures on rural traffic are 4-8 Erlang/100 subscribers. As far as the desired grade of service is concerned, typical figures for rural areas are given in fig XX.

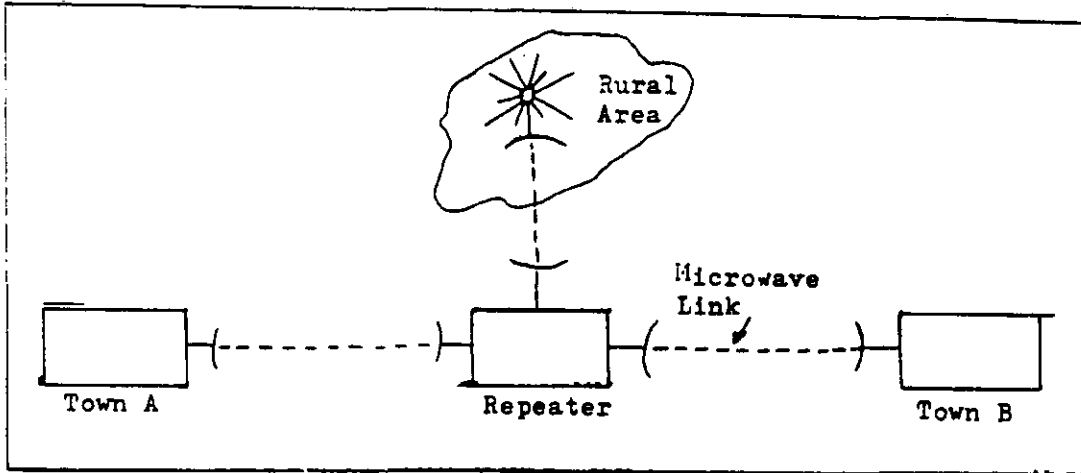
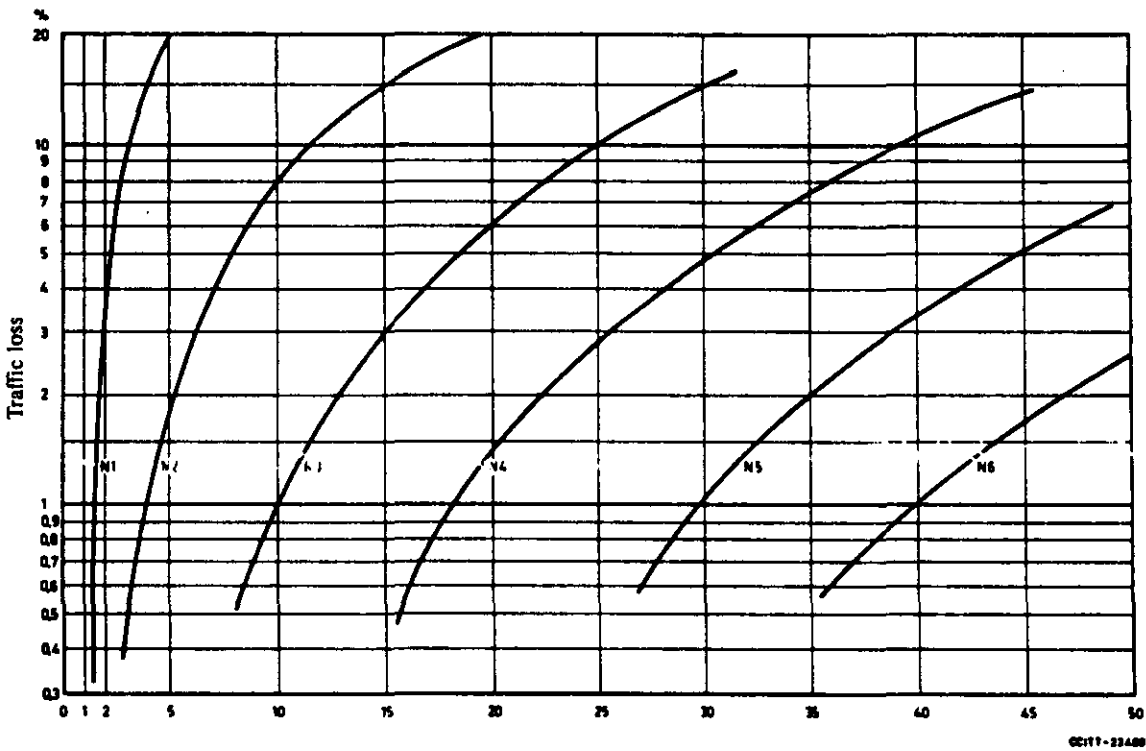


Figure XVIII: Drop and insert in trunk links



GC117-23488

Figure XIX: Traffic loss versus the number of subscribers, with N channels available [29]

TYPE OF CONNECTION	ACCEPTED TRAFFIC LOSS
INTRA EXCHANGE CONNECTION	0.01-0.02
OUTGOING INTEREXCHANGE CONNECTION	0.005 (without trunks)
INCOMING INTEREXCHANGE CONNECTION	0.005 (without trunks)
TRUNK GROUPS	0.005

**Figure XX: Traffic loss for different connection types [29]**

Transmission capacity has to be selected in such a way that future expansion is possible. Some aspects playing a role when determining transmission capacity for a number of years are:

- Economic activity of the area.
- Population increase
- Government policies.

When choosing the type of transmission system, topographic aspects and climatological conditions play an important role. The main topographic aspects are according to [26]:

- existing infrastructure
- soil conditions
- swamps
- hills and mountains
- forest
- jungle
- cultivated land
- the accessibility of the area
- the existence of urban areas.

The main climatological aspects are:

- extreme temperature
- typical season weathers
- thunderstorms
- earthquakes
- snow and ice
- lightning
- humidity
- dust
- avalanches
- forest fires
- increased solar activity.

Finally also the influence of man and animal on the transmission systems must be taken into account, such as theft, sabotage, destruction, maintenance rates, etc.. What remains now is the selection of the transmission system and the transmission medium (radio or cable system). A first selection of equipment most suitable and economic for a rural area can be made with the following rules of thumb [28].

Distance		Short (less than about 50 km) -	Medium (about 50 km to 250 or 300 km)	Long (more than about 250 or 300 km)
Capacity of the route				
Small (less than about 100 channels)	Line	Loaded VF cable. Open-wire line link. Symmetric-pair line link (FDM or PCM).	Open-wire line link. Symmetric-pair line link (FDM or PCM).	Open-wire line link. Symmetric-pair line link (FDM or PCM).
	Radio	VHF UHF	VHF UHF	HF Tropospheric scatter system. Diffraction system. Satellite.
Medium (about 60 channels to about 1000 channels)	Line	Loaded VF cable. Open-wire line link. Symmetric-pair line link (FDM or PCM).	Open-wire line link. Symmetric-pair line link (FDM or PCM). Coaxial cable (FDM or PCM).	Open-wire line link. Symmetric-pair line link (FDM or PCM). Coaxial cable (FDM or PCM).
	Radio	Microwave (FDM or PCM).	Microwave (FDM or PCM).	Microwave (FDM or PCM). Satellite.
Large (More than about 600 channels/ television)	Line	Loaded VF cable. Coaxial cable (FDM or PCM).	Symmetric-pair line link (FDM or PCM). Coaxial cable (FDM or PCM).	Coaxial cable (FDM or PCM).
	Radio	Microwave (FDM or PCM).	Microwave (FDM or PCM).	Microwave (FDM or PCM). Satellite.

Figure XXI: Classification of transmission systems [30]

1. A single telephone extension located more than 100 km away from any other existing or planned extension, can be connected with an HF single-side band radio telephone.
2. A single group of at least ten telephone extensions, located more than 200 km away from any other existing or planned extension, can be connected via a small satellite earth station, with the condition that more such installations exist in the country.
3. A single telephone extension located 10-100 km from an existing or planned telephone exchange, remote concentrator, satellite earth station or long-distance transmission facility, can be connected with a single channel VHF-UHF radio telephone.
4. A number of groups of telephone extensions (3 or more extensions in a group) 10-100 km from each other and 50-300 km from an existing or planned local exchange, can be connected with a multiple-access radio system with concentration.
5. In many cases a combination of the various types of equipment will be necessary to meet actual requirements.

Another broad classification of how the transmission system can be selected, seen from an economical point of view, is given in fig XXI. The typical features of these systems will be considered in the next sections.

## **5.2. Transmission systems**

### **5.2.1. Introduction**

For implementing transmission systems in rural areas, the best suitable options has to be selected from a number of appropriate systems. Factors that influence this choice are:

- Terrain aspects of the area;  
Terrain aspects can already give an indication whether landline systems are preferable or not.
  - Distance that has to be bridged
  - Capacity of the system;  
When expansion must be taken into account for the rural area, those systems must be chosen which require a minimum of pre-investment.
  - Reliability of the system
  - Cost of the system
  - Quality of the system
  - Expansion possibilities
  - analogue or digital transmission
- At the moment, the industrial countries are moving from analogue to digital transmission techniques. With a digital network, there are possibilities of integrated services of telephone, television and computer communication. A network with these possibilities is called an Integrated Switched Digital Network (ISDN).

The systems that will be considered are:

1. Open wire carrier systems
2. Cable carrier systems
3. Optical fiber cable systems (glass fiber)
4. Radio systems: HF, UHF/VHF and SHF systems
5. Satellite systems.

Finally a comparison of the different systems will be made and a rural network model will be presented.

### **5.2.2. Open wire carrier systems**

These multi-channel carrier systems play an important role in the trunk networks of sparsely populated areas. They are generally used for distances up to a few hundred kilometers. Open wire lines are parallel bare conductors suspended above the ground. The individual conductors are held by electrical insulators on cross arms. This is shown in fig XXII.

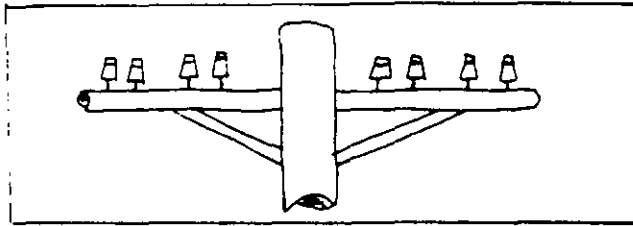


Figure XXII: Pole used in open wire carrier systems [1]

Advantages of these systems are:

- 1.The system is very good suitable for areas where a limit on radio frequency bands exists.
- 2.The repeater section can be made very long.
- 3.Relatively cheaper than other carrier systems when needed for light to moderate traffic.
- 4.The system can be brought into operation in stages until the maximum number of channels to be provided is reached.
- 5.The system offers drop and insert possibilities.

Disadvantages of these systems are:

- 1.The capacity is limited.
- 2.The quality of the system depends on climatic and geographic conditions.
- 3.High maintenance is required.
- 4.Low reliability.

This is further discussed in [26]. As a conclusion of this section it may be said that for trunking of a light to a moderate amount of telephone traffic over relatively long distances, the open wire carrier system is suited. However, the open wire carrier system may be the most cost effective system for this purpose, it is clearly not the best solution when reliability is at stake.

### 5.2.3. Cable systems

In all cable systems we can distinguish:

- Cables for distribution
- Subscriber drop wire
- Cables for transfer and trunking

### 5.2.3.1. Coax cable systems.

For subscriber cables copper covered steel conductors are mostly used. Normally the maximum length of subscriber cables is 5 km but can be extended to 25 km. In these cables loading or negative impedance repeaters must be inserted. The cable can be buried or suspended in the air. As to the symmetrical pair cables, systems of 24, 60 and 120 channels are most widely used. Symmetric pair cable systems can be used for short (less 50 km ), medium (50-300 km) and long (more 300 km) distances. When the number of channels increase, the repeater section length will increase too. This is shown in fig XXIII.

SYSTEM (channels)	REPEATER SECTION LENGTH (kms)
24	24
60	14
120	8

**Figure XXIII: Repeater section length versus system capacity [1]**

Coaxial pair carrier cable systems are used when systems of high or medium capacity are required. The capacity of a coaxial pair may range from 120 - 2700 channels, a cable may contain up to 12 coaxial pairs. Coaxial pair cable systems can be used for all distances, the repeater section length is about 3-4 km. Because of the large capacity of the system it can also be used for sound channels (3 telephone channels = 1 radio channel) or video programs transmission (1260 channels for 625 line TV)

Advantages of the symmetric pair and coaxial pair cables are:

1. Large capacity
2. Reduced crosstalk
3. Independent of temperature and humidity
4. Less possibilities for theft

Disadvantages of the cable systems for rural areas are:

1. Cable laying may be very expensive
2. Fault location may be very expensive
3. Repeater section length is shorter
4. Large capacity

#### 5.2.3.2. Glass fibre systems

Instead of coaxial pair carrier cable systems optical fiber cable systems can be used.

The advantages of such system above coaxial cable systems are:

- Larger capacity (more than 10.000 telephone channels)
- Immunity to electromagnetic interference
- Larger repeater distance (about 10 km)

The disadvantages are:

- The optical cables and equipment are more expensive.
- The system is more sophisticated (digital) and therefor more difficult to maintenance.

As a conclusion it may be stated that, just as in urban areas, the subscriber dropwire may be used to connect the subscriber to the local exchange for distances up to 25 km. As to the carrier cable systems and the optical systems, they are not very suitable for rural areas because of their large capacity and the assumed terrain roughness. These systems are more suitable for large trunks over relative short distances (less 50 km), for instance in connecting suburban local exchanges to the first order exchange.

#### 5.2.4. Radio systems: classification

Frequency bands which can be used for radio transmission systems can be found in the range from 3 MHz - 10 GHz. The band 3 - 30 MHz is generally called the HF-band. The band 146 - 174 MHz is located in the so called UHF-band. Frequencies between 1 GHz and 30 GHz are generally called EHF frequencies. These frequencies, mostly used in terrestrial high capacity microwave links, are also used in satellite links.

##### 5.2.4.1. HF Radio systems

At frequencies in the 3 - 30 MHz band, the propagation mechanism is ground propagation and ionospheric reflection.

Advantages of HF radio systems are:

- Very long distances can be covered
- Relatively cheap and simple technology

Disadvantages of these systems are:

- Voice quality is poor
- capacity is low
- antennas are large



#### 5.2.4.2. VHF/UHF Radio systems

The propagation mechanism of a VHF/UHF radio link is mainly line of sight, which determines the lower limit of this band, where frequencies above 1000 MHz are used for wideband microwave transmission.

The advantages of the VHF/UHF radio systems are:

- Good quality compared to HF systems
- VHF/UHF systems are used for distribution, transfer and trunking
- Antennas are small and simple.

Disadvantages are:

- Limited coverage
- Limited capacity

It can be concluded that when the number of subscribers in the area is low and there are no problems on the availability of radio frequencies, the VHF/UHF systems may be used in the dedicated channel mode, otherwise the multiple access mode must be chosen. The system can be used for distribution, transfer and trunking of light traffic.

If well designed, the capacity can be enlarged by frequency reuse. For this purpose the area has to be divided into cells. Each cell is given its own frequencies and its output power is reduced to a level at which good reception is possible with a minimum of cochannel interference to other cells.

#### 5.2.4.3. EHF Radio systems

These systems, working at frequencies above 1 GHz have a large capacity (up to 1800 channels) and are used for trunking purpose of heavy traffic, for example between towns. When the multiplexing is FDM, in the stackable channel mode, drop and insert possibilities exist.

Because of the low density of subscribers in the rural area, microwave systems will in general not be designed for rural areas, unless a significant growth of the traffic amount is foreseen. However, when an existing microwave system, connecting two urban areas, passes through a rural area, efficient use of the system can be made by means of these drop and insert possibilities.

### 5.2.5. Satellite systems

Satellites can be used to provide trunk links and also access links between isolated subscribers and the national network.

Advantages of satellite systems are:[31]

- 1.Total satellite system can be installed relatively rapidly. The needed installation time is about 3 years from decision to proceed.
- 2.Service to additional remote sites can be provided in a very short time once a satellite system has been installed.
- 3.Satellite earth stations can easily be moved to new sites, when a site has been connected via terrestrial links and the earth station is no longer required.
- 4.The installation of an earth station does not freeze the network configuration, but preserves the option to interconnect that site to the terrestrial network at an appropriate time.
- 5.Satellite systems are particularly adaptable to operate under circumstances when traffic data or projections are inadequate, because traffic handling capacity at a site can easily be increased by adding modems.
- 6.Satellite circuit costs are independent of distances. Therefore, rural stations which are economically unfeasible by using other systems may be economically served by satellite.
- 7.Because a station can reach any other station in the network by the satellite connection, reliable interconnections depend only on the two stations involved.

Disadvantages of satellite systems are:

- 1.Satellite communication systems are still expensive.
- 2.For application in the tropical zone more power or larger antennae in the earth stations are required.
- 3.For developing countries these systems contain a lot of "foreign technology".
- 4.When a country does not own a satellite, then it will be necessary to expend significant foreign exchange (for space segment usage), on what are mostly purely internal national calls. It is not sure, that the expected increased rural production will have to be generated enough foreign exchange to pay the purely internal national calls.[21]
- 5.National security is lessened because it is both easy to monitor satellite communication and to jam such communication.[21]
- 6.A satellite solution requires an international Pan African agreement and thus a limitation of national autonomy and self-reliance at national level.

Table XXI gives a overview of the possible multiple access satellite systems.

Multiple access method	Signal processing	Multiplex	Modulation	Control
FDMA	---	FDM	FM	PA
SCPC	Companding	FDM	FM	PA
	Companding	---	FM	PA or DA
	Delta modulation	---	QPSK	PA or DA
TDMA	Pulse code modulation	---	QPSK	PA or DA
	Pulse code modulation TDM	TDM	QPSK	PA or DA

**Table XXI: Multiple access systems.[31]**

### 5.2.5.1. SCPC satellite systems

SCPC satellite systems generally operate in frequency bands above 1 GHz and can be used for distribution and trunking of light to moderate traffic. As traffic from and to rural areas will be light, these systems will be particularly interesting.

The design of the SCPC satellite system should be chosen in such a way that the earth stations can be kept small, simple and cheap. The system can operate in a pre-assigned channel mode when a constant traffic flow exists, or in a demand-assigned channel mode, when the number of subscribers is very large and their individual amount of traffic is low, as is the case in rural traffic. The system can operate in a Frequency Division Multiple Access (FDMA) mode or in a Time Division Multiple Access (TDMA) mode. In the latter case no output backoff of the satellite's traveling wavelube is required to keep the intermodulation losses low since the number of carriers never exceeds one. Those stations can have small antennae or simple Low Noise Amplifiers (LNA). However, equipment for synchronisation as required for TDMA will be complex and expensive. Therefore FDMA is at the moment the most economic for SCPC use. As far as these SCPC systems are concerned, there are two suitable modulation types for SCPC systems:

1. Delta-modulated SCPC
2. FM-Companded SCPC

In fig XXIV a comparison is made between the two modulation types.

	DELTA MODULATION	COMPANDED FM
CHANNEL SPACING	22.5 KHz (32kb/s)	22.5 KHz
CAPACITY ( in 36 MHz transp.)	1600 Channels	1600 Channels
OPERATIONAL C/No	56 dBHz (BER=10 <sup>-4</sup> )	57dBHz (S/N=33dB)
VOICE QUALITY AT THRESHOLD	GOOD	MODERATE
INSERT POSSIBILITIES FOR TELEGRAPHY TECHNOLOGY	NOT POSSIBLE COMPLEX	POSSIBLE SIMPLE

**Figure XXIV: Features of DM and companded FM [29]**

When companded FM is considered, to improve the quality and to save satellite power, pre- and de-emphasis can be implemented, and the carrier can be "voice operated" (VOX). This means that the carrier is switched off during pauses in the speech.

From fig XXIV can be concluded that companded FM is slightly inferior but much simpler. Companded FM is very flexible. Enlarging the channel spacing and thereby reducing the system capacity, the quality can be increased, the antenna diameter can be decreased or cheaper LNA's can be used.

The satellite systems can have centralized control or decentralized control. A comparison is made in fig XXV.

CENTRALIZED CONTROL	DECENTRALIZED CONTROL
1. SIMPLE EARTH STATION (Except Master station)	EQUAL, COMPLEX EARTH STATIONS
2. SLOWER	FASTER
3. FAILURE OF MASTER STATION CAUSES COMPLETE FAILURE	FAILURE OF A STATION CAUSES NO PROBLEMS FOR THE SYSTEM

**Figure XXV: Characteristics of centralized and decentralized control. [1]**

It can clearly be seen that if one aims at simple earth stations, centralized control should be considered. As an additional advantage of centralized control for new telecommunication networks, traffic measurement can be done very easily to control the grade of service. Also billing of users can be handled in the master station.

Today many countries lease transponders or parts of transponders

from Intelsat for domestic use. These satellites are not originally designed for domestic use because they are equipped with global beam antennae. When satellites are designed for domestic use, their antennae should be designed in such a way that a maximum of Effective Isotropic Radiated Power (EIRP) is obtained within the coverage area and a minimum of EIRP is radiated outside this coverage area.

As conclusion, FDMA/FM SCPC systems may be a very good solution for rural communications, especially when the area to be covered is rough and inaccessible. For small towns and villages, or isolated subscribers, who are in the need of a good quality link (for example rural hospitals), the SCPC systems may be suitable for connection to other rural earth stations and urban exchanges, as concluded from a technological standpoint. Seen from a political or economical view, one may choose differently.

SYSTEM	OPEN WIRE	CABLE	GLASS-FIBRE	HF RADIO	VHF/UHF	SCPC
DESIGN CAPACITY	ANY	ANY	ANY	LOW	LOW	MOD
QUALITY	FAIR	FAIR	GOOD	POOR	GOOD	GOOD
INSTAL. SPEED	LOW	LOW	LOW	HIGH	HIGH	HIGH
MAINTENANCE	HIGH	MOD 3)	MOD 3)	LOW	LOW	LOW
DISRUPTION POSSIBILITIES	LOW	MOD 3)	LOW	HIGH	LOW	LOW
FLEXIBILITY	LOW	LOW	LOW	LOW	MOD 3)	HIGH
RELATIVE COST	LOW	HIGH	HIGH	LOW	MOD 3)	HIGH
EXPANSION POSSIBILITIES	LIMITED	LIMITED	HIGH	LOW	LIMITED	HIGH
SUITED <50KM	+	+	+	-	+	-
FOR 50-200KM	+	-	+	-	+	+
DIST. >200KM	+	-	-	+	-	+
SUITED FOR DISTRIBUTION	-	+	-	+	+	+
TRANSFER	-	+	+	-	+	+
TRUNKING	-	+	+	-	+	+
DIGITAL TRANS	-	+/-	+	-	+/-	+
LEVEL OF FOREIGN TECHNOLOGY	LOW 2)	MOD 3)	HIGH	LOW	LOW	HIGH

1)= with satellite available  
2)= multiplex equipment not involved.  
3)= MODERATE

Table XXII: Comparison of the systems mentioned.

### 5.3. Comparison of the systems mentioned

Finally, comparing the transmission systems, as previously considered, some conclusions can be made. These are summarized in table XXII. From this table can be concluded that SCPC satellite systems score high, despite costs, and would be a good solution for a rural telecommunication network. However for other than technical reasons developing countries may decide differently. From table XXII a typical rural network may be suggested. This is shown in fig XXVI.

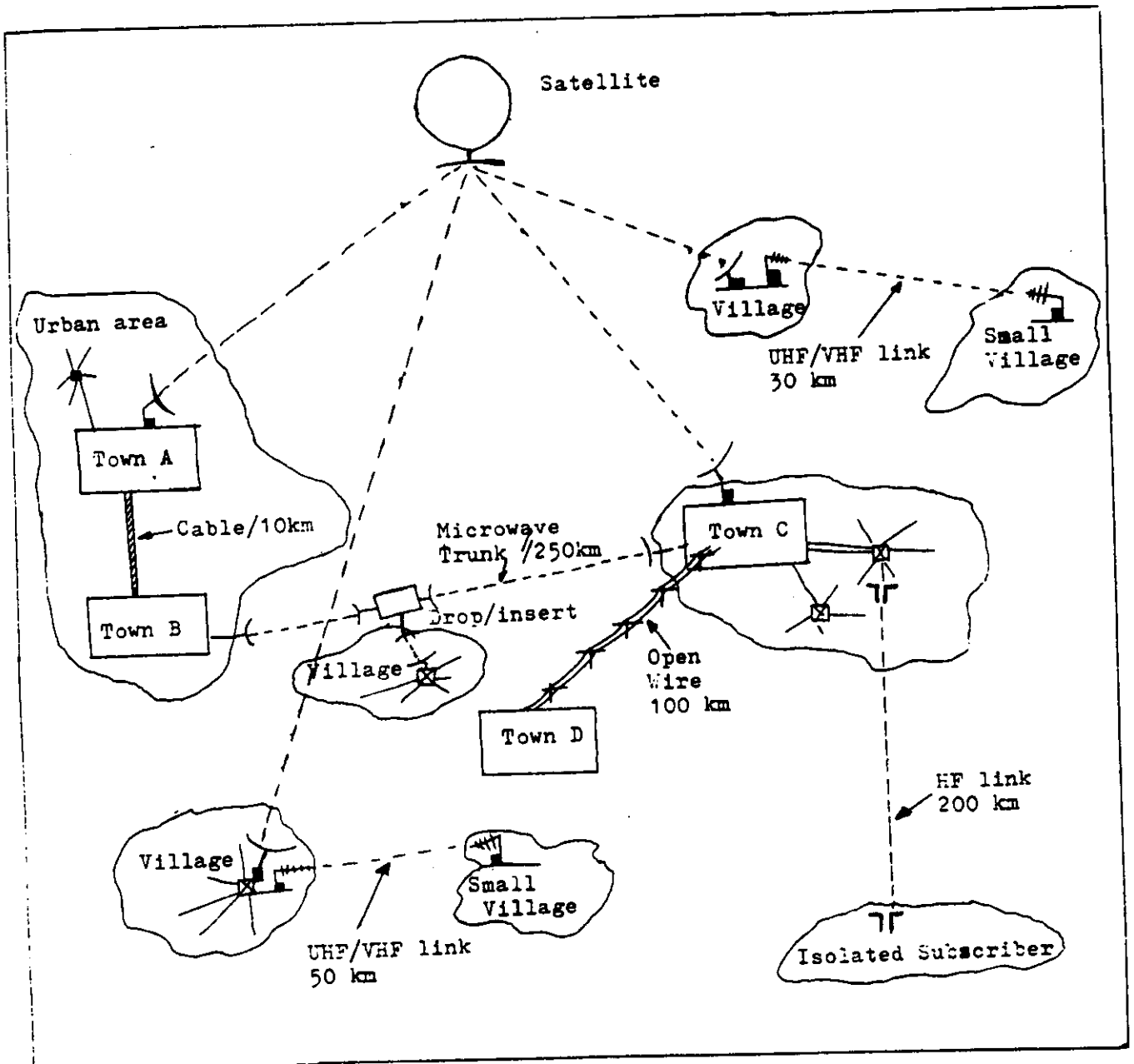


Figure XXVI: Typical rural area model. [1]

## 6. THE IMPACT OF INFORMATION TECHNOLOGY ON SOCIETY

Advances in computer hardware and software have allowed information technology to penetrate into, and firmly establish itself within our society. It is believed that the use of information technology would cause widespread unemployment. But, as history has shown, the technological advances cut product costs enough to create new demand, which required more, rather than less, employment. Information technology presents new ways to save labor that may result in increasing economic development. In the industrialized countries more and more unskilled dirty work is carried out by robots, while other jobs mainly in the service sector are created. During the early 1800's roughly 70% of the US labor force was employed in agriculture; today roughly 75% of the labor force is employed in services. It is estimated that 55 percent of the labor force will be employed in information industries [32].

By means of computers and telecommunication the industrial organizations and the government can easier be managed. Especially in the developing countries, information technologies offer new opportunities for improved resource management. Demographic data are often inadequate in developing countries, and government policy makers are often forced to make decisions in an information vacuum. The abilities to gather information more effectively (particularly from remote areas), analyze data in a variety of ways, and produce accurate reports in a number of different reports can all contribute to an enhanced decision making process [33].

It can be expected too that advances in informatics in the industrialized countries are widening the gap between them and the developing countries.[33]

There can be concluded, that information technology can contribute to the developing of a country, but:

- Without a well functioning telecommunication network, the information technology can hardly be used. The collection and dissemination of data is without telecommunication very difficult.
- The telecommunication system that will be selected, has to be suited for the transmission of digital information.

└

## **7. CONCLUSIONS AND RECOMMENDATIONS**

### **7.1. Conclusions**

1. In 1983 more than 75% of the population of the world lived in low and middle income developing countries. More than half of this population lived in the rural areas.
2. The countries with the highest average annual growth of population, have also the lowest average annual growth of GNP per capita.
3. The life expectancy of low income countries was significantly lower than in the industrialized countries (59 versus 76).
4. The adult literacy rate in low income countries was low from 1950-1980 (38%).
5. The increasing of the oil price in the period 1980-1983, had negative effects on the net exports of all countries, of course with exception of the high income oil exporters.
6. Through the stabilizing of the oil price over the last years, and the decreasing of the price in 1985, figures from the World Bank for the nearby future are much better.
7. The percentage of the agriculture in the GNP, is decreased in the period 1965-1982, as well in the developing as in the developed countries.
8. Until 1960, the idea of giving development aid, was closely related to the idea of changing the Third World into a First World.
9. During the last ten years, the foreign debts of developing countries have increased greatly.
10. The countries with the highest total debt, are also the countries with the highest percent commercial loans.
11. Commercial loans are easier to obtain than loans from non commercial agencies, but these loans are also more expensive.
12. Of the capital, flowing to the developing countries, much more money is used for the purchase of weapons, than for goods in any other sector.



13. According to the developing countries, there is no realistic prospect of bridging the gap between the industrialized countries and the developing countries, if dealings between them are conducted from the standpoint of a producer/consumer relationship.

14. The developing countries tend to self-reliance.

15. The transfer of technology, is believed to be the solution for the developing countries, to develop themselves.

16. It is questionable whether transfer of technology, executed by multinational cooperations, will give the offset in the development, as is desired by the developing countries.

17. The number of telephones, radio and television sets in the developing countries, is significant lower than in the industrialized world.

18. Economic activity, expressed in GNP/capita, is linked with the variables of infrastructure, and thus with telecommunication.

19. There is a great unsatisfied demand for telecommunication services in developing countries. There can be concluded, that telecommunication growth did not keep pace with industrial development.

20. The contribution to national income of telecommunication investments, is particularly high in the countries or areas with the lowest telephone density, thus in the developing countries rural areas.

21. The indirect return of rural telecommunication is higher than expected.

22. Even the poorest people make use of the public telephone. They are prepared to devote a substantial part of their monthly income, to pay for vitally important long-distance calls.

23. On the subject of revenues of telecommunication, there is a disparity of views, between the development banks and the developing countries. In contrast to development banks, the developing countries find, that the nonfinancial revenues, which can be earned by telecommunication projects, should also be taken into account, when making investment calculations.

24. In a rural area, a subscriber density of 1 per 50km<sup>2</sup> can be expected when people live scattered. In the case of isolated settlements a maximum of 1000 subscribers can be expected.

25. Seen from an economical standpoint, telephone exchanges with less than 30 subscribers are not attractive.

26. For trunking purpose of a light to a moderate amount of traffic over relative long distances, the open wire carrier system, may be the most cost effective system. When reliability is at stake, the open wire carrier system is clearly not the best solution.

27. Cable systems may be used for subscriber lines for distances up to 25 km. The carrier cable systems are not very suited for rural areas, because of their large capacity and assumed terrain roughness. For trunking purpose, connecting suburban exchanges over short distances, these systems are not suited.

28. HF radio systems may be suitable for a few isolated subscribers in a large area. Half-wave dipole antennas may be the most cost effective antennas, because of easy installation and maintenance.

29. VHF/UHF radio systems may be suited for a light to moderate amount of traffic. If necessary the capacity can be enlarged by introducing cellular systems (frequency re-use). The maximum distance, that can be covered by these systems, is circa 50 km, depending on the size of the antennas.

30. Terrestrial SHF radio systems are not suited, for application in rural areas, in so far as they are used for trunking of a large amount of traffic. However, if an already existing system is passing through a rural area, efficient use of these systems can be made by means of "drop and insert".

31. SCPC satellite systems are a good solution for rural communications, when the area to be covered is rough, inaccessible or thinly populated.

## 7.2. Recommendations

1. The kind of technology to be transferred, should be chosen by the developing countries. Their policy should be to make these foreign technologies "home" technologies as soon as possible.

2. Economic activity should be stimulated, but not the migration to urban areas. Therefore, in order to stop this migration from rural areas, and to start a remigration to increase the agriculture production, the rural infrastructure, including telecommunication facilities, should be expanded.

**Appendix A: A MODEL FOR THIN ROUTE SATELLITE SERVICES.**

This appendix is an edited version of [34].

It would be useful for national planners to be able to predict the benefits of investments in rural satellite communications. A model has been developed to estimate the benefits of providing thin route satellite services in a rural region .

The technique uses a multiple regression model, which provides a coefficient to estimate the impact of telephones on GNP. Inputs to the model are the initial level of GNP, initial number of telephones, rates of telephone growth, and values for the impact of telephone investments on GNP. The original model was developed using data for 52 developed and developing countries over 13 years. To estimate the impact of telecommunications in rural or isolated areas within developing countries, the following approach was used. The 30 developing countries were selected from the total of 52 nations, and were divided into three groups of ten nations according to telephone densities. Average telephone density (in telephones per 100 population) was 7.6 for group 1, 1.0 for group 2, and 0.2 for group 3.

However, even group 3 had much higher telephone densities than would likely be found in many rural areas of developing countries. Thus a hypothetical fourth group was created, which would be more nearly approximate these conditions. Group 4 has a telephone density of 0.01, a population of 10 million, and a GNP per capita of \$100. An average growth rate of telephone installations of 8% per year was used. The inputs for the analysis are summarized in table XXIII. To provide comparative data on the aggregate and per telephone impact of accelerated telephone installation, rates of five times and ten times average growth on telephones were also used in the original study.

Nations	GNP(\$ million)	ATD(per 100 pop.) )=1	AINT )=2	ATGR % )=3
group 1	46.560	7.6	2.100.000	8
group 2	22.110	1.0	410.000	8
group 3	13.256	0.2	79.000	8
group 4	1.000	0.01	1.000	8

)1= Average Telephone Density  
 )2= Average Initial Number of telephones  
 )3= Assumed Average Telephone Growth rate

**Table XXIII: Inputs for analysis [34]**

In many rural and remote areas without existing telecommunications infrastructure, the most cost effective means of providing

basic telecommunications may be by satellite, using small (e.g. 4.5 meter or less in diameter) earth stations, operating with a satellite optimized for thin route service. It is assumed that 10 telephones would be connected to each earth station. These might be public call offices and telephones located in government offices, clinics, stores, or businesses in one community, and linked to the earth station by VHF or UHF radio. The design life of the satellite is specified as 10 years.

The data are organized to show:

- impact on GNP of all telephones installed over a 10 year period.
- average impact on GNP per telephone.

These data are purely illustrative. The planner could choose to vary:

- the number of telephones installed.
- the period over which to estimated impact on GNP.
- the number of telephones linked to each earth station.

The results of the analysis show the impact of installation of thin route satellite earth stations for three groups of developing countries and a hypothetical rural region. Table XXIV shows the average contribution to the GNP per earth station. A range of low, medium, and high estimates is given for each group, to indicate the use of the upper 95% confidence value. The medium estimated is used for comparison.

Nations	low estimate	medium estimate	high estimate
group 1	\$ 4.000	\$ 10.000	\$ 17.000
group 2	\$ 10.000	\$ 22.000	\$ 39.000
group 3	\$ 30.000	\$ 66.000	\$108.000
group 4	\$185.000	\$367.000	\$550.000

Note:  
One thin route earthstation is asumed to provide service for ten telephones.

**Table XXIV: Impact on GNP per thin route earth station, installed over ten year satellite life (average growth rate). [34]**

It should be noted that the impact on GNP per earth station increased dramatically as telephone density increases. Thus for group 2 with a telephone density of 1.0, each earth station contributes an average of \$22.000 to the national GNP over 10 year satellite live. However, for group 4 with a telephone density of 0.1, each earth station contributes \$367.000 in the same period.

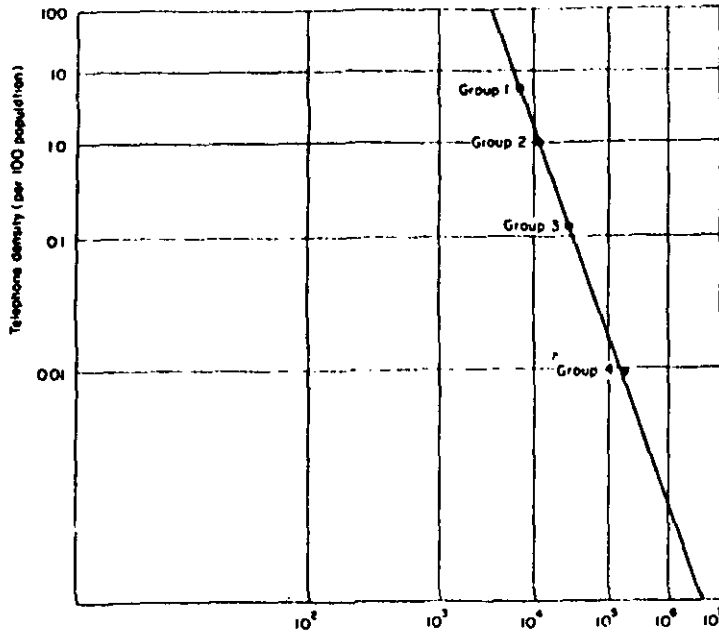


Figure XXVII: Increase in GNP per earth station (\$) [34]

Year	GNP (\$)	Increase GNP due to telephones (\$)	number of Telephones
Initial	1.000.000.000	0	1.000
1	1.103.711.000	515.000	1.080
2	1.107.586.000	1.031.000	1.160
3	1.111.627.000	1.579.000	1.240
4	1.115.839.000	2.075.000	1.320
5	1.120.228.000	2.609.000	1.400
6	1.124.799.000	3.115.000	1.480
7	1.129.557.000	3.715.000	1.560
8	1.134.509.000	4.290.000	1.640
9	1.139.659.000	4.882.000	1.720
10	1.145.015.000	5.493.000	1.800
Total (rounded)		29.300.000	
increase in GNP per telephone		= \$ 37.000	
per earth station		= \$370.000	

Table XXV: Example of benefits accrued over ten years for hypothetical rural region. [34]

## Appendix B: AN SATELLITE SYSTEM FOR AFRICA

This appendix is an edited version of [37].

### 1. INTRODUCTION

This appendix discusses an optimum satellite system for regional and domestic applications in Africa.[37]

At the moment, many countries are entering the world of domestic satellite communications, either by implementing their own satellite system or by leasing the space segment capacity from foreign or international organizations.

Due to the very large capacity, which can be offered and the relatively high costs of the space segment, regional approaches are the most appropriate in the case of developing countries, such as in Africa.

Traffic requirement studies show that a satellite system could be used for the transmission of over 25.000 half-telephone circuits and several television channels by the end of the next decade.

These studies indicate that the following services could be required in this instance:

- interstate telephone, data and television transmission.
- domestic interurban and rural telephone and data communications.
- domestic interurban and rural television and radio distribution.

This appendix proposes an optimized approach to implement such services in the framework of a regional African satellite system.

### 2. SYSTEM OPTIMIZATION

#### 2.1. Specific constraints [39]

The first specific constraint in designing an African satellite system, is related to propagation effects. A number of African countries are suffering from ones of the most adverse propagation conditions in the world. This situation precludes the use of the 14/11 GHz bands if the quality criteria ( including 99.99 % of the year-quality objectives ) are to be met in all countries. The use of the 6/4 GHz bands has therefore been preferred.

The second type of constraints encountered in Africa is related to the local environment: in most places, reliable electric power is not available. This calls for very low power earth stations

and preclude the use of air conditioning in most cases. In general no technical support is available, which means that earth stations located in rural areas should not require auto-track system nor technical personal. Similarly, urban stations should be small enough to be accommodated in town and not require auto-track system.

Finally, the difficulties of the climatic and technical environment require that solid state equipment be used as much as possible and, along this line, that maintenance activities be reduced to their simplest expressions.

## 2.2. Service requirements

The analysis of traffic requirements [38], [39] has indicated that 3 types of earth stations will be required to accommodate the desired services :

- rural earth stations,  
for TV and radio community reception and transmission of up to 12 telephone ( or telex ) channels.
- urban earth stations,  
for TV and radio reception intended for regional broadcast, and transmission of up to one hundred telephone ( or telex ) channels.
- national earth stations,  
acting as the master station of a domestic satellite network and as a gateway for regional ( inter-state ) communications. These stations are also large urban stations and transmit TV and radio channels to the domestic network, together with several hundred of telephone ( or telex ) channels.

## 2.3. System optimization

Based on the considerations from above, the system has been optimized for urban stations in the case of trunk routes and for rural stations in the case of thin routes.

The basic objective of this optimization was to:

- maximize the satellite transmission capacity.
- use the same transponder characteristics for TV and telephone transmissions, to improve flexibility in meeting traffic requirements.
- satisfy the constraints and requirements listed in the sections above.
- use available and demonstrated technologies for satellite and earth stations to be operated from 1988 on.

## 2.4. System characteristics

the traffic requirement analysis and time frame have shown that the most appropriate means of system access and modulation techniques would be:

FDMA/FDM/CFM for trunk route telephony,  
FDMA/CPC/CFM with demand assignment for thin route  
telephony.  
FDMA/FM for TV transmission.

The main system characteristics have been determined to be as follows:

### Satellite payload

Transponder bandwidth : 40 MHz  
Saturated EIRP : 37 dBW  
G/T : -3 dB/K  
Saturated PFD : -80 to -90 dB(W/m<sup>2</sup>)

2-fold frequency re-use by linear polarization discrimination and beam separation (for domestic services).

### Earth stations

#### National stations (Standard 1)

11 m antenna diameter, with step-track system  
uncooled parametric amplifier (60 Kelvin)  
G/T : 31.7 dB/K  
EIRP : up to 76 dBW (for TV transmission)

#### Urban earth stations (Standard 2)

8 m antenna diameter, no tracking system  
FET LNA (75 Kelvin)  
G/T : 27.5 dB/K  
EIRP : up to 58 dBW (for a 96 channel FDM  
carrier)

#### Rural earth station (Standard 3)

4.5 m antenna diameter, no tracking system  
FET LNA (75 Kelvin)  
G/T : 22.5 dB/K



EIRP : up to 55 dBW (for 12 SCPC channels).

SCPC/CFM characteristics

Companding improvement factor : 13dB

Channel spacing : 30 kHz

Operating C/N : 11.1

Quality criteria

The following quality objectives are met in all African regions, with the above mentioned transmission parameters:

Telephony (for all earth stations) : CCIR rec. 353

Radio reception (for all earth stations) : CCIR rec. 505

TV reception (with sound) : weighted S/N ratio (measured as CCIR rec 567, SECAM standard)

rural earth stations : 44 dB

urban earth stations : 47 dB

national stations : 49 dB

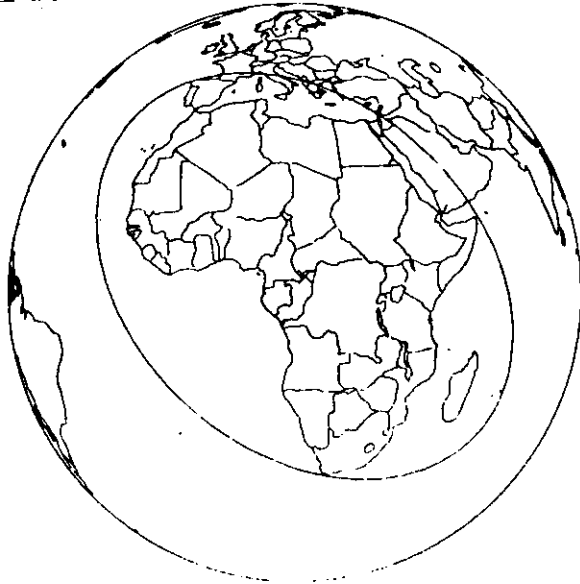
These features allow for the transmission of two TV channels per transponder, thus maximizing TV transmission capacity. The average capacity of a satellite transponder is 1000 voice channels when operated in FDM/CFM and 1330 when operated in SCPC/CFM.

**3. TELECOMMUNICATION PAYLOAD**

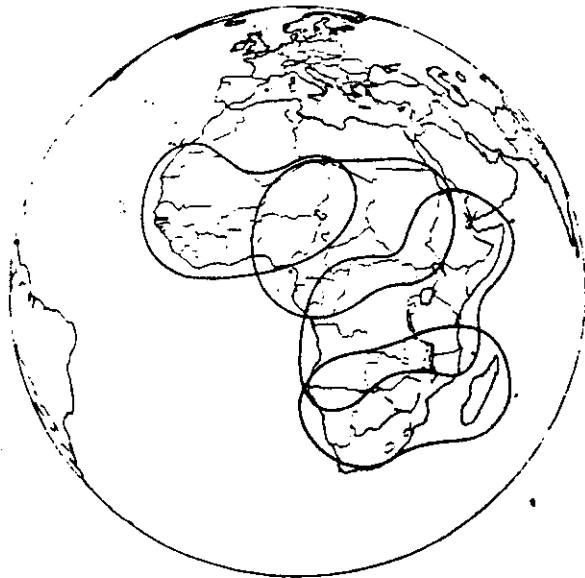
3.1. Coverage areas

Two types of coverages are proposed both for transmit and receive:

1. An African coverage with encompassing all the countries of the African continent. ( Fig. XXIX ).
2. four spotbeam coverages which cover the whole subsaharian Africa. This choice is justified by the fact that the requirement for the north saharian countries are met by the ARABSAT system. Each country is fully covered by at least one of the four spotbeams. ( Fig XXX ).



**Figure XXVIII: African regional coverage [37].**



**Figure XXIX: Spot-beam coverages for domestic applications [37]**

### 3.2. Transponders

The payload makes use of a C-band frequency plan with 24 transponders of 40 Mhz usable bandwidth. Each transponder is equipped with a 16 watt traveling wave tube amplifier.

Figure XXX shows a typical structure with low noise MOSFET receivers, input multiplexers and output multiplexers.

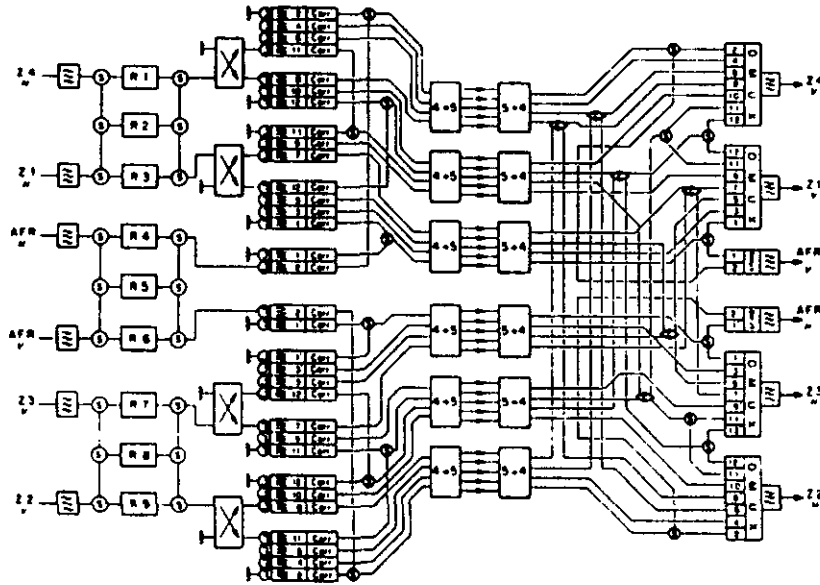


Figure XXX: Possible payload structure for an African satellite [37].

Table XXVI gives a potential assignment for the 24 transponders : 7 are assigned to each of the spotbeam zones and 4 are assigned to the African zone (AFR). In the spotbeam zones, there is no frequency reuse on the same coverage area by means of orthogonal polarizations. This reduces the complexity of the antenna subsystem and the number of receivers in the transponder subsystem : only six receivers are used, one for each zone and one for the african zone.

Coverage areas	Transponders	Polarization	
		Up	Down
zone 1	1,3,5,7,9,11,12	H	V
zone 2	2',4',6',8',10',11',12'	V	H
zone 3	2,3,6,8,10,11,12	H	V
zone 4	1',3',5',7',9',11',12'	V	H
AFR	1,2/1',2'	H/V	V/H

Table XXVI: An assignment for the 24 transponders.[37]

### 3.3. Antennas

There are three antennas on this communication payload. Two are dedicated to the African coverage and the other to the spotbeam coverages.

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