

FD-101-105
2017

SECTOR BRIEFING:
ENERGY AND PHYSICAL INFRASTRUCTURE

ENERGY AND PHYSICAL INFRASTRUCTURE IN CENTRAL AMERICA

I. ENERGY

A. Overview

Until recently, virtually all primary energy used in the Central American isthmus has been derived from imported petroleum, firewood, and agricultural residues. In 1970, oil represented 50% of the primary energy used; by 1978 this had dropped to 42%, and for 1983 will show further declines. Despite the decreasing relationship of petroleum to total energy supply, however, the absolute amounts of imported oil have increased regularly over the past twenty years. Relative dependence on firewood as a source of primary energy supply has increased. Fuelwood and biomass accounted for 51% of the energy used in 1978, versus 44% in 1970 (see Table 1). Hydro energy has been a predominant source of electrical generation in the region, and is projected to grow substantially over the next decade as several major hydroelectric dams now under construction begin production.

Overall energy consumption in the region in the 1970s increased at an annual rate of approximately 5%. Diesel fuel and electricity are the commercial sources of energy experiencing the most rapid growth. There was considerable variation between countries, however, in energy consumption during this decade. Between 1970 and 1979, per capita primary energy consumption increased 64.3% in El Salvador and 44.4% in Guatemala, but only 2.8% in Nicaragua and 28% in Honduras and Panama (see Figure 1). Total energy consumed per dollar of Gross National Product actually declined in all countries except Nicaragua and El Salvador during this period (see Figure 2).

The structure of energy consumption changed significantly during the 1970s. In 1970, residential, commercial, and public consumption of energy accounted for over 68% of total consumption; in 1978 this share had declined to just under 54%. Consumption by the transportation sector grew from 16% to 20% during the decade, and industrial consumption increased from 20% to nearly 24% (see Table 1).

Four major problems affect the ability of the countries of the Central American region to satisfy their energy requirements: (1) the continuing dependency on imported oil; (2) the substantial share of energy supplied by firewood, and the resulting environmental concerns caused by the resulting depletion of forest resources; (3) the large investments required to tap and sustain the region's hydroelectric potential; and (4) the inefficient use of energy. These problems are discussed in more detail below.

Table 1

Central America
1. Supply Sector Energy Supply and Demand

1.1. Primary Energy Supply

SOURCE	1970		1974		1978	
	TOEx10 ³	o/o	TOEx10 ³	o/o	TOEx10 ³	o/o
PETROLEUM	6,183	50.0	6,747	51.2	5,495	42.3
. Production	—	—	—	—	31	0.2
. Imp. (Exp.)	6,183	50.0	6,747	51.2	5,464	42.0
FIREWOOD	4,948	40.1	5,330	40.4	5,691	43.8
. Production	4,948	40.1	5,330	40.4	5,691	43.8
. Imp. (Exp.)	—	—	—	—	—	—
HYDROENERGY	756	6.1	429	3.3	510	3.9
. Production	756	6.1	429	3.3	510	3.9
. Imp. (Exp.)	—	—	—	—	—	—
OTHER PLANT ANIMAL FUELS	466	3.8	678	5.1	912	7.0
. Production	466	3.8	678	5.1	912	7.0
. Imp. (Exp.)	—	—	—	—	—	—
OTHERS	1	0.0	4	0.0	390	3.0
. Production	—	—	—	—	390	3.0
. Imp. (Exp.)	1	0.0	4	0.0	—	—
TOTAL	12,354	100.0	13,188	100.0	12,998	100.0
. National Production	6,170	49.9	6,437	48.8	7,534	58.0
. Imp. (Exp.)	6,184	50.1	6,751	51.2	5,464	42.0

1.2. Secondary Energy Supply

SOURCE	1970		1974		-1978	
	TOEx10 ³	o/o	TOEx10 ³	o/o	TOEx10 ³	o/o
HEAVY FUELS	790	23.2	1,392	28.0	1,425	24.5
. Refining	2,739	80.5	3,098	62.3	2,126	36.6
. Imp. (Exp.)	(1,949)	(57.3)	(1,706)	(34.3)	(701)	(12.1)
DIESEL & GAS OIL	915	26.9	1,406	28.3	1,877	32.3
. Refining	1,486	43.7	1,667	33.5	1,574	27.1
. Imp. (Exp.)	(571)	(16.8)	(261)	(5.3)	303	5.2
GASOLINES & NAPHTHAS	687	20.2	950	19.1	1,175	20.2
. Refining	913	26.8	1,058	21.3	933	16.1
. Imp. (Exp.)	(226)	(6.6)	(108)	(2.2)	242	4.2
KEROSENE & TURBO FUELS	384	11.3	411	8.3	315	5.4
. Refining	559	16.4	489	9.8	424	7.3
. Imp. (Exp.)	(175)	(5.1)	(78)	(1.6)	(109)	(1.9)
OTHERS	627	18.4	810	16.3	1,016	17.5
. Ref. Cab. Trans., Plant.	609	17.9	776	15.6	946	16.3
. Imp. (Exp.)	18	0.5	34	0.7	70	1.2
TOTAL	3,403	100.0	4,969	100.0	5,808	100.0
. National Production	6,306	186.3	7,088	142.6	6,003	103.4
. Imp. (Exp.)	(2,903)	(85.3)	2,119	(42.6)	(195)	(3.4)

Note: TOE means Tons of Oil Equivalent, a standard measure that converts different energy sources to a common figure.

Table 1 (Cont.)

2 Consumption Sector

2.1. Final Energy Consumption by Sectors

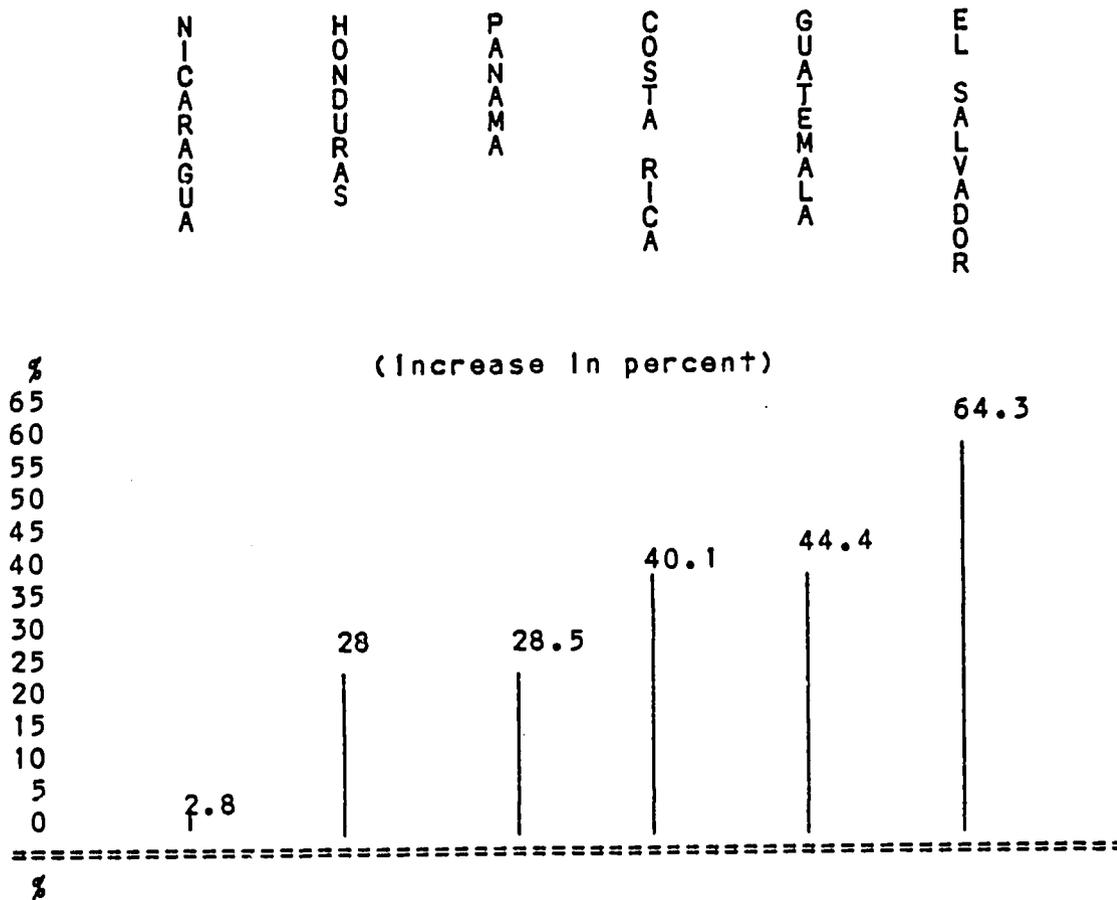
SECTOR	1970		1974		1978	
	TOEx10 ³	o/o	TOEx10 ³	o/o	TOEx10 ³	o/o
RES., COM., & PUBLIC	4,865	68.2	5,290	57.5	5,886	53.9
TRANSPORTATION	1,235	15.8	1,658	18.0	2,166	19.8
INDUSTRIAL	1,546	19.8	2,032	22.1	2,614	23.9
OTHERS	172	2.2	218	2.4	263	2.4
TOTAL	7,818	100.0	9,198	100.0	10,929	100.0

2.2. Consumption Structure by Sectors

SECTOR	1970		1974		1978	
	TOEx10 ³	o/o	TOEx10 ³	o/o	TOEx10 ³	o/o
RES., COM., & PUBLIC		100.0		100.0		100.0
. Firewood	4,378	90.0	4,709	89.0	5,071	86.2
. Electricity	177	3.6	245	4.6	357	6.1
. Kerosene y Turbo Fuels	145	3.0	140	2.6	156	2.7
. Others	165	3.4	196	3.7	302	5.1
TRANSPORTATION		100.0		100.0		100.0
. Gasolines & Naphthas	720	58.3	906	54.6	1,142	52.7
. Diesel & Gas Oil	418	33.8	644	38.8	884	40.8
. Kerosene & Turbo Fuels	88	7.1	100.0	6.0	126	5.8
. Others	9	0.7	8	0.5	14	0.6
INDUSTRIAL		100.0		100.0		100.0
. Firewood	1,489	31.6	541	26.6	537	20.5
. Heavy Fuels	388	25.1	517	25.4	640	24.5
. Other Plant. Animal Fuels	306	19.8	469	23.1	625	23.9
. Others	363	23.5	505	24.9	812	31.1
OTHERS		100.0		100.0		100.0
. Others Plant, Animal Fuels	86	50.0	100	45.9	145	55.1
. Diesel & Gas Oil	44	25.6	59	27.1	70	26.6
. Electricity	15	8.7	23	10.6	27	10.3
. Others	27	15.7	36	16.5	21	8.0

Figure 1

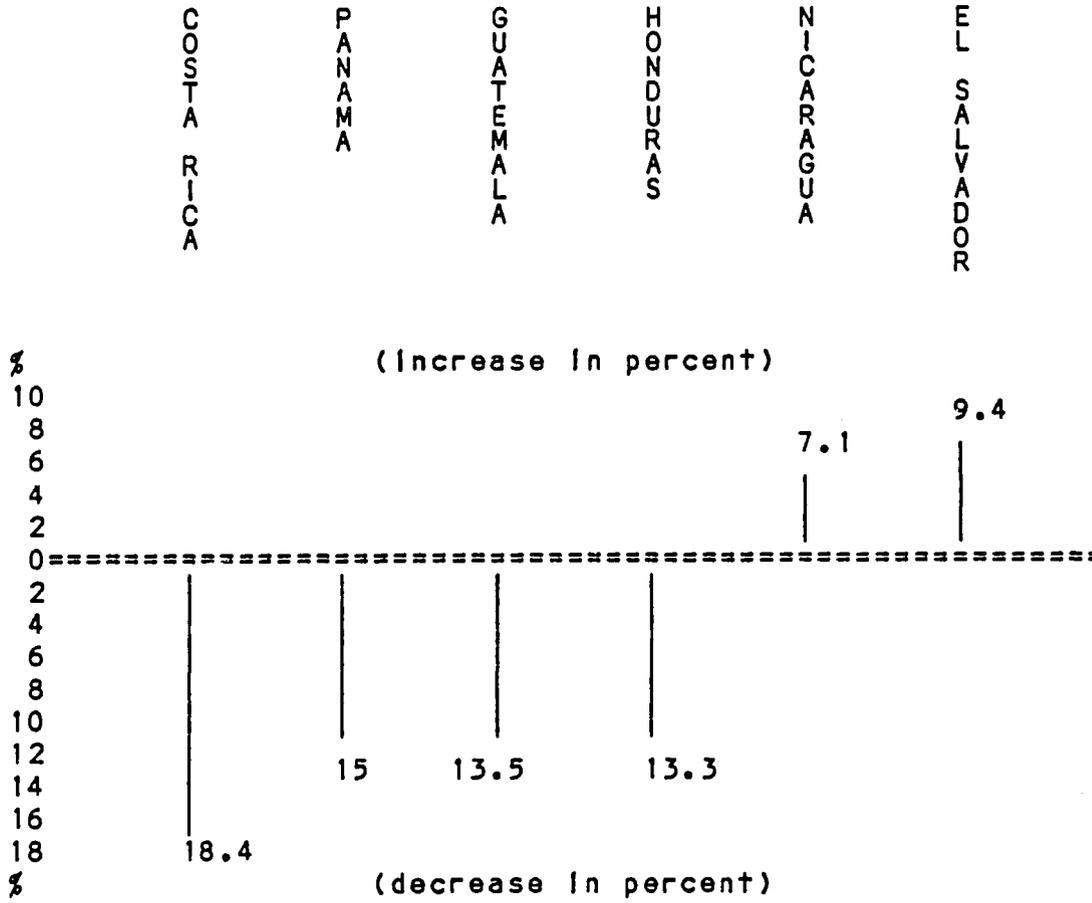
PERCENT CHANGE BETWEEN 1970 AND 1979
IN GROSS PRIMARY ENERGY CONSUMPTION
(per capita)



Note: Energy consumption in the United States increased by 10 percent during the same period.

Figure 2

PERCENT CHANGE IN TOTAL ENERGY CONSUMED
PER DOLLAR OF GROSS DOMESTIC PRODUCT
BETWEEN 1970 AND 1979



B. Petroleum Dependency

Putting Central America's annual use of oil in perspective, one finds that it is equivalent to the amount of all commercial energy used in the United States during less than one day. Although oil in Central America is a "drop in the barrel" to the United States, it is profoundly important to the livelihood of 23 million Central Americans. With the exception of Guatemala, which produces about 15% of its oil needs, all petroleum used is imported. The percentage of foreign exchange required to pay for oil has increased several fold for all of the countries in the region (see Table 2 and Figure 3) during the same period when the ability to purchase this oil with the sale of their traditional commodities has diminished (Table 3). Higher import costs and this substantial shift in the terms of trade have been major factors in the increased balance of trade deficits experienced by the region since the early 1970s.

For the region as a whole, excluding Belize, 42.3% of primary energy consumed was supplied by petroleum in 1978. Dependence on oil to meet energy requirements varies among countries, from a high of 57% in Panama (1978) to 24.7% in El Salvador (1979), 28.2% in Honduras (1979), and 28.7% in Guatemala (1979). While oil requirements for electricity generation are declining in several countries as major hydroelectric projects start producing, oil imports as a whole will need to grow in order to satisfy transport needs and the energy requirements of the industrial sector. In 1978, these two sectors accounted for over two-thirds of all petroleum uses in the region.

C. Firewood Depletion

The traditional source of energy in Central America, particularly in rural areas, is wood and charcoal. Nearly 80% of the households in the region depend on wood for cooking. In addition, many small scale rural-based industries use wood as their primary source of fuel. Bakeries, ceramic and brick producers, the tobacco industry, coffee processing plants, lime kilns, and salt producers are examples of important rural industries that use wood for drying and process heat. Overall, 86.2% of the energy consumed for residential, commercial and public uses in the region in 1978 was from firewood, and 20.5% of the energy used by industry came from this source.

The countries most dependent on firewood are Honduras and Guatemala (see Table 4). In 1979, over 63% of total energy consumed by these countries was supplied from this source. In El Salvador, 49.5% of total energy consumed came from this source; in Nicaragua firewood accounted for 44.4% of energy consumption. Only Costa Rica and Panama did not rely on firewood to meet a substantial share of their energy needs. In all countries except Panama, firewood accounts for over 75% of residential, commercial and public energy use. In Guatemala and El Salvador, this figure exceeds 90%. Firewood is also an important source of industrial energy in Guatemala (34.5%), Nicaragua (31.5%), and Honduras (28.4%).

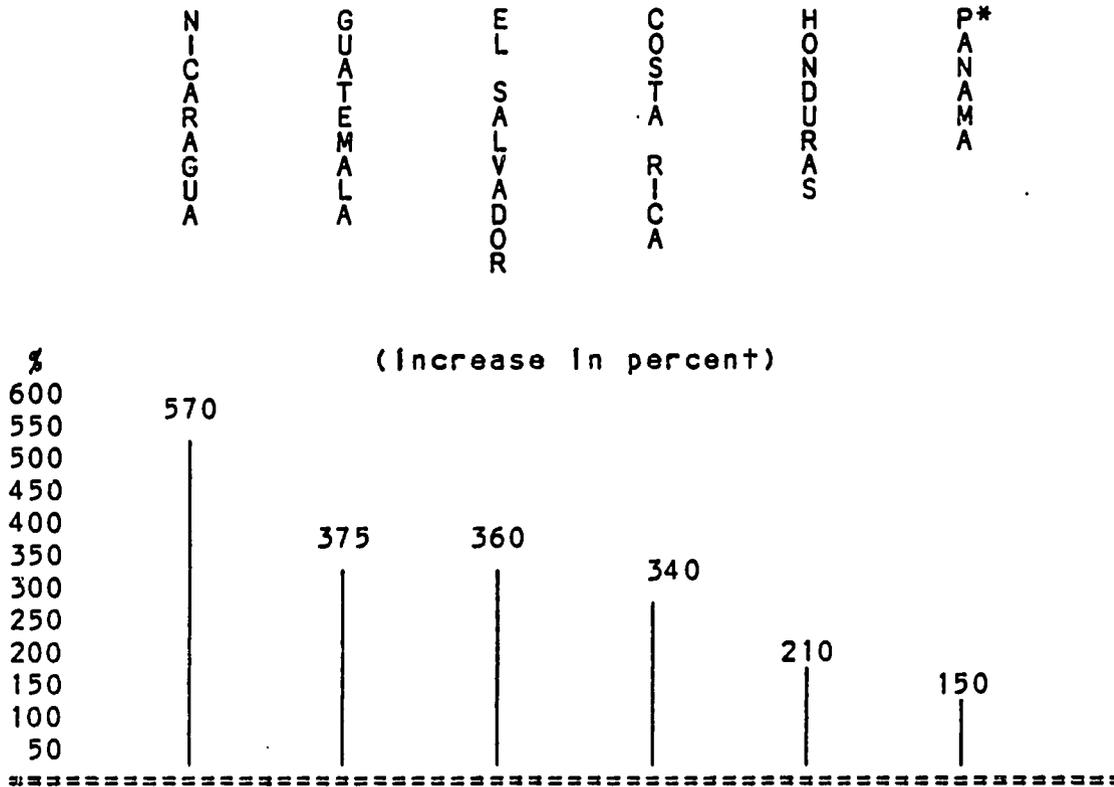
TABLE 2

OIL IMPORT COSTS FOR CENTRAL AMERICA

<u>Year</u>	<u>Oil Imports</u>	<u>Exports</u>	<u>Oil Imports as % of Exports</u>
1973	101.4	\$1,663.6	6%
1974	277.4	2,109.1	13
1975	295.1	3,007.7	10
1978	339.3	3,855.3	10
1980	928.0	4,703.4	20
1981	1,007.0	4,938.0	22

Figure 3

PETROLEUM IMPORT COSTS AS A % OF EXPORTS:
PERCENT CHANGE (INCREASE) BETWEEN 1972 AND 1980



* Panama refines and re-exports petroleum products. These numbers are gross imports and exports, and therefore overstate petroleum's working participation in Panama's economy.

Table 3

CHANGES IN CENTRAL AMERICAN TERMS OF TRADE
1981 COMPARED TO A 1960-1973 BASE PERIOD

<u>Commodity</u>	<u>Increased commodity production needed to buy a barrel of oil in 1981 over 1960-1973 base period.</u>				<u>Exporting Country *</u>					
					<u>C</u>	<u>E</u>	<u>G</u>	<u>H</u>	<u>N</u>	<u>P</u>
Bananas	8.5	times	more	production	X		X	X	X	X
Beef	9.8	"	"	"	X	X	X	X	X	X
Cocoa	6.8	"	"	"	X		x		x	
Coffee	7.1	"	"	"	X	X	X	X	X	x
Cotton	6.9	"	"	"	x	X	X	x	X	
Fishmeal	8.6	"	"	"						x
Maize	9.8	"	"	"		x		x	x	.x
Sugar	7.9	"	"	"	X	X	X	x	X	X

Critical Central American region export commodities and the production increase (over 1960-1973 base period) needed to buy one barrel of crude oil at average 1981 world prices. (\$32.00)

Current 1983 markets are somewhat depressed, so most production multiples are understated even with lower world crude oil prices.

* Lower case "x" indicates minor export.

Table 4

Firewood Energy Consumption in Central America

<u>Country</u>	<u>% of primary energy supplied by firewood</u>	<u>% of residential/ commercial energy consumption supplied by fire- wood</u>	<u>% of indus- trial consump- tion supplied by firewood</u>
Belize	N/A	N/A	N/A
Costa Rica (1979)	32.8	75.0	4.9
El Salvador (1979)	49.5	91.9	7.5
Guatemala (1979)	63.2	90.4	34.5
Honduras (1979)	63.6	87.7	28.4
Nicaragua (1980)	44.4	79.2	31.5
Panama (1978)	10.2	66.8	--
Regional Total (1978) [*]	43.8	86.2	20.5

*Excludes Belize

Meeting these firewood requirements places a considerable strain on the ecology of the region. The increased cutting of fuelwood is a major cause of deforestation, with its resultant effects on the degradation of watersheds and increased erosion, which adversely affect agricultural and hydropower production. Prior to the mid-1970s there was a growing trend to substituting traditional fuels with kerosene and gas. As petroleum prices have gone up, however, this trend has been halted and may be reversing. This is occurring at the same time that population growth in the region demands more wood, making it more expensive as it grows scarcer due to extensive clearing for crop and pasture land.

D. Hydroelectricity

Over 58% of all electricity generated in the region came from hydropower. Dependence on hydroelectricity is greatest in Costa Rica, where 82.8% of electrical generation in 1979 was from this source. El Salvador also produced a high proportion (74.5%) of its electricity from hydroelectric sources. While Guatemala only generated slightly less than 20% of its electricity from hydro sources in 1979, hydro generation will approach 100% of electrical generation by the mid-1980s as new hydroelectric sources begin production. Costa Rica currently exports a surplus of hydroelectric generation to Honduras over Nicaraguan electrical lines. Thus, hydroelectric generation is an important source of energy supply in these countries, and is expected to become increasingly so in the future.

Hydroelectric generation has a strong comparative advantage to other energy sources due to the region's topography and rainfall. Major investments have been made in large hydroelectric projects by several Central American countries, including the Chixoy project in Guatemala, El Cajon in Honduras, and San Lorenzo in El Salvador. During the 1980s, an estimated \$4 billion will be spent on these and other hydroelectric projects. These investments represent a major portion of the infrastructural investment programmed in the region during the next decade. The magnitude of these investments, and the increasing reliance on hydro generation of electricity accentuate the need for greater attention to the management of the watersheds of the hydroelectric reservoirs to guard against erosion and siltation.

E. Inefficiencies in Energy Use

The inefficient use of both petroleum and wood fuels is a contributing factor to the energy problems of Central America. The countries of the region have many low-cost opportunities to save energy, and the energy saved in most cases will be far less expensive than the cost of acquiring additional energy.

On the petroleum side, significant inefficiencies occur from refining, to power generation, to end use in industry and transport. Each country has its own small refinery. These are some of the smallest and most inefficient refineries in the world. Refinery production is

geared primarily to domestic diesel consumption. Because the re-export price of surplus fuel oil is so disadvantageous, it is economically unattractive to run the refineries at capacity. They are too small to be worth retrofitting with catalytic equipment to boost diesel production, and are thus operated at an average of less than 50% of capacity. Electrical generation from diesel in the region is very inefficient; the thermal efficiency for generation is approximately 26%, which compares unfavorably to average efficiencies above 33% for generation in the United States. In terms of end use energy efficiency in industry, surveys have indicated that improvements of from 10% to 30% can be achieved at low cost in a wide range of industries.

Wood stove and rural wood using industries are the final area of energy use inefficiencies. The majority of household cooking is done over open fires with three stones supporting the pot. Kilns for lime and charcoal production, like the driers for coffee and tobacco, are all very inefficient. The introduction of better wood stoves and other wood converting and using technologies could save up to 50% of the wood used in these processes. The technologies are not costly; it is their adaptation, application, and dissemination that is complicated.

II. TRANSPORTATION

The location and quality of the road networks have a limiting effect on economic activities in Central America, and poor roads limit opportunities for increased incomes and access to social services for the rural poor. The Pan American Highway traverses the entire isthmus, and serves as the backbone of the primary road system in all countries except Belize. The main road system, most of which is paved, primarily serves the highly populated areas, generally to the western side of the isthmus (see Map 1). While there is an important secondary road network of gravel roads, major rural areas of Central America have only limited access to the main roads due to a lack of feeder or access roads.

A total of 108,715 kilometers of roads exist in Central America. However, only 13,185 kilometers (12%) are paved, while an additional 31,969 kilometers (29%) are of gravel or crushed stone. The majority of the roads in the region, 63,561 kilometers or 59% of the total, are classified as improved earth or unimproved earth roads (see Table 5). These types can range from footpaths to one-lane, rutted roads. Only paved and gravel roads are normally considered all-weather roads which can be utilized during the rainy seasons. While there are some variations between the countries, only Panama has over 20% of its total road network paved, while this figure is below 10% in Nicaragua and Costa Rica.

Road maintenance is a major problem throughout the region. Gravel roads, and particularly dirt roads, require substantial regular maintenance, especially given the heavy seasonal rains in many areas of

the isthmus. The Central American governments, in general, have not dedicated sufficient resources to create and sustain effective maintenance capabilities. Therefore, many newly constructed roads deteriorate rapidly and may require major reconstruction after only a few years.

The railway system (3,588 kilometers) in Central America is limited and fulfills specific requirements (see Table 5). The lines generally run from the capital cities to the seaports. In addition, several small scale railroads constructed by international fruit companies serve the limited areas where agricultural export crops are produced and are used almost exclusively for the transportation of these crops to port.

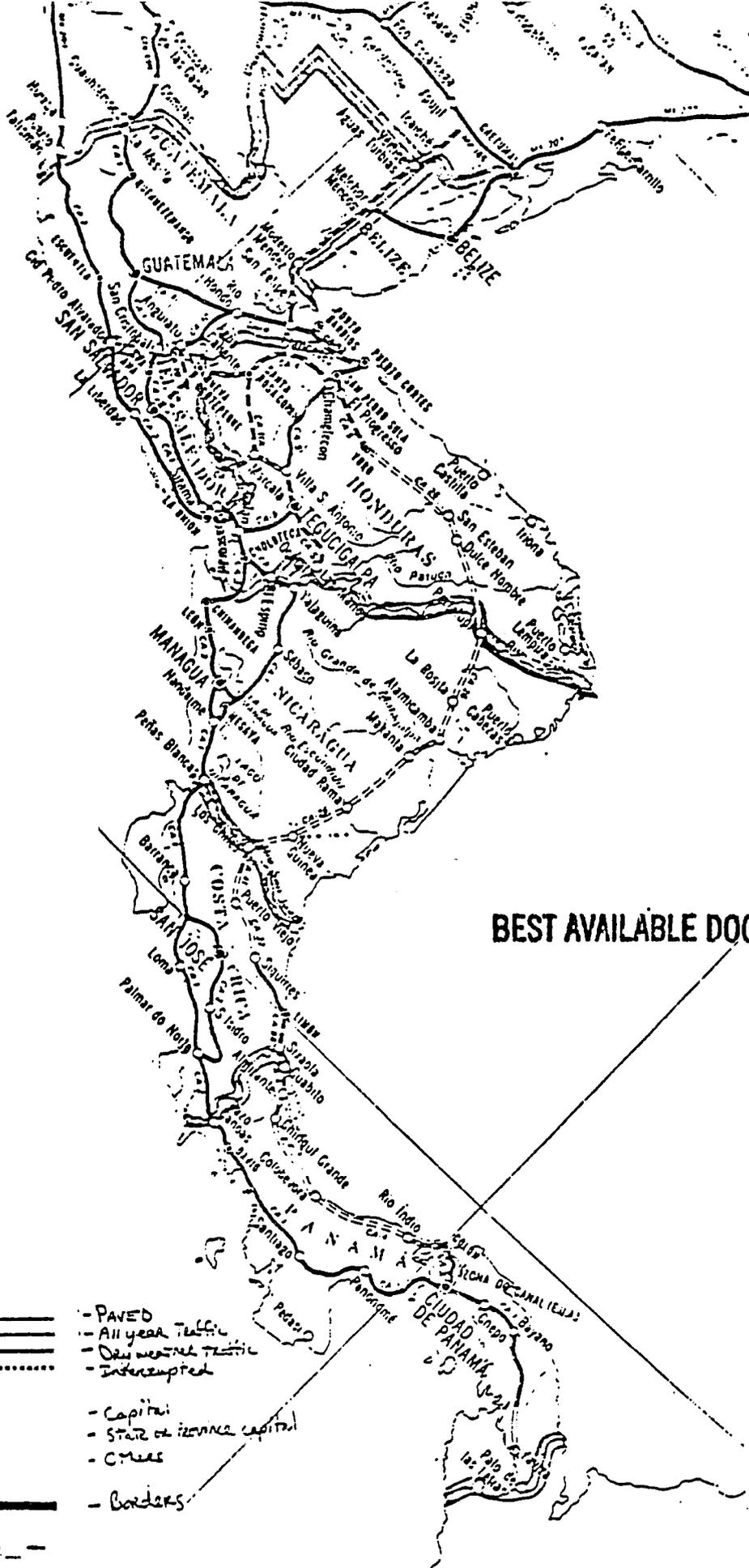
Adequate seaport facilities exist in each country, frequently on both the Pacific and Caribbean coasts (see Table 6). Generally, each country has one or two major ports, with several smaller ones scattered along the coasts handling local traffic. The main ports have international cargo shipping capabilities. However, several main facilities are in a state of deterioration due to a lack of maintenance and upgrading. Furthermore, storage facilities at the major ports, both cold and dry warehouses, are in need of repair and improvement.

Air passenger and cargo facilities are generally good throughout the region. All countries have terminals which handle international traffic, and domestic air service is available. Each country has several airstrips, although modern airports with long paved runways are primarily limited to the capital cities (see Table 7). Airports have been a major recipient of government infrastructure investment resources during the past two decades.

III. TELECOMMUNICATIONS

The internal telecommunications systems in Central America are generally poor, with modern telephone service limited to the capital and larger cities. The number of telephones per 100 people ranges from a low of 0.7 in Honduras to a high of 8.9 in Panama, with the majority of the other countries on the lower end of this range (see Table 8). The telephone systems are now close to total automation, however, and international connections are generally good. All countries in the region are tapping into more advanced communications systems, such as satellite ground stations and submarine cables. Also, the countries are interconnected into the Central American electrical, micro-wave system (see Map 2).

Radio and television are also generally available in Central America, although television is limited to the major urban areas. Four countries have over 100 radio stations, while all but Belize have several television stations (see Table 8). On a per capita basis, the number of radios is highest in El Salvador and lowest in Guatemala and Honduras.



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Major Highways

CONVENÇÕES

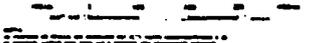
RODOVIAS
 PAVIMENTADA (PAV)
 TRAFEGO TODO ANO (TA)
 TRAFEGO TEMPO SECO (TS)
 INTERROMPIDA (INT)

NUCLEOS
 CAPITAL DE PAIS
 CAPITAL DE ESTADO, PROVINCIA
 OU DEPARTAMENTO
 CUIPAS

DIVISAS
 LIMITE INTERNACIONAL

- PAVED
- All year Traffic
- Dry weather Traffic
- Interrupted
- Capital
- State or Province Capital
- Cities
- Borders

ESCALA 1:600,000



COUNTRY	HIGHWAYS (Roads)				Railroads	
	Total Km.	Km Paved	Km Gravel and/or Crushed Stone	Km. Improved earth	Km. unimproved earth	Total Km.
BELIZE	2,575	340	1,190	735	310	None
COSTA RICA	28,215	2,425	9,300		16,450	750 160 electrified
EL SALVADOR	10,000	1,500	4,100	4,400 (includes unimproved earth)		602
GUATEMALA	26,429	2,851	11,438		12,140	909
HONDURAS	8,950	1,700		5,000	2,250	751
NICARAGUA	24,126	1,654	2,711	5,427	14,384	344
PANAMA	8,400	2,715	3,170	2,515 (includes unimproved earth)		192

A. Sources for Tables 5-8 include: The CIA World Fact Book (1982), The Quarterly Economic Report (Annual Supplements 1982-83),
The 1983 World Almanac, Various A.I.D. documents

B. All data is derived from 1982-83 sources unless otherwise noted.

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TABLE 6
PHYSICAL INFRASTRUCTURE: TRANSPORT

COUNTRY	Inland Waterways Navigable Km. (description)	Seaports		Pipelines (oil & natural gas)		
		No. of Major ports (names)	No. of Minor Ports	Kms. crude	Kms. refined	Kms. natural gas
BELIZE	None mentioned	1, Belize	4			
COSTA RICA	710 perennially navigable	3, Limon, Golfito, Puntarenas	4		318	
EL SALVADOR	Lempa River partially navigable	2, Acajutla, La Unión	1	1051	431	365
GUATEMALA	260 year round	2, San José, Santo Tomás de Castilla	3	48		
HONDURAS	1200 by small craft	5, Puerto Cortés, La Ceiba, Tela, San Lorenzo, Puerto Castilla	3	None mentioned		
NICARAGUA	2220, including two large lakes	1, Corinto	7	56		
PANAMA	800 by shallow draft vessels 112 Panama Canal	2, Colon (Cristobal, Coco Solo), Panama City (Balboa)			96	

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COUNTRY	LEVEL III					AIR FIELDS	
	No. of Transport Aircraft	Total	Usable	No. with permanent surface	No. with length 2440-3659 m	No. with length 1220-2439 m	
BELIZE		37	28	4			
COSTA RICA	14	217	216	27	1	9	
EL SALVADOR	4	158	146	5	1	8	
GUATEMALA	14	532	527	10	2	17	
HONDURAS	14	217	213	5	2	6	
NICARAGUA	7	349	326	9		11	
PANAMA	16	151	150	39	2	16	

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TABLE 8
PHYSICAL INFRASTRUCTURE: TELECOMMUNICATIONS

COUNTRY	Telephones in use (a)	Radio (AM & FM) & Television Stations	Radio & T.V. Receivers in use	Other Description
BELIZE	5,800 (3.9 per 100 pop)	0	No data available	Radio - relay system 1 Atlantic Ocean INTELSAT station
COSTA RICA	185,000 (8.0 per 100 pop)	65	400,000 (b) 160,000	Connection into Central American microwave net
EL SALVADOR	70,000 (1.5 per 100 pop)	69	1.4 million (b) 148,000	Nationwide trunk radio-relay system; Connection into Central American microwave net 1 Atlantic Ocean satellite station
GUATEMALA	82,000 (1.2 per 100 pop)	117	280,000 (c) 150,000	Modern telcom facilities limited to Guatemala City Connection into Central American microwave net 1 Atlantic Ocean Satellite station
HONDURAS	27,000 (0.7 per 100 pop)	116	163,000 (b) 48,000	Improved system, but still inadequate Connection into Central American microwave net
NICARAGUA	55,800 (2.2 per 100 pop)	115	170,000 (d) 600,000	Low-capacity, radio-relay and wire system being replaced after war damage Connection into Central American microwave net Atlantic Ocean INTELSAT station
PANAMA	157,000 (8.9 per 100 pop)	120	285,000 (d) 220,000	Domestic and international telcom facilities Connection into Central American Microwave net Atlantic Ocean ground station 1 coaxial submarine cable
	(a) 1982-1983 data (b) 1977 data (c) 1978 data (d) 1979 data			

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