REGIONAL IMPACT OF PORT AND TRANSPORT POLICIES

- THE ECUADOR CASE -

by

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Edgardo Raul Derbes

Submitted to the Department of Urban Studies and Planning and the Department of Ocean Engineering on December 19, 1971, in partial fulfillment of the requirements for the degrees of Master of City Planning and Master of Science.

This thesis has focused on appraisal of the impact on the development of Ecuador of a set of transport policies already under way or proposed. Decisions about port development and the interplay of ports with the rest of the transport system influence other transport modes and promote the evolution of a set of locational advantages for certain areas. Consequently, for developing countries located on the seaboard, the role of ports can be a crucial factor in determining their geographic development.

This study has been directed toward developing a comparative static model for testing the interaction of independent submodels dealing with the production of goods, highway operating costs, inland waterways, and coastal operations, interface operations, the overseas transportation subsystem and government policies in these areas. Through this model, the behavior of commodity flows has been simulated in the context of the Ecuadorian situation, selected as a case study. Successive "packages" of parameters constituting the combination of policies proposed or under way have been tested to appraise their comprehensive interplay in national development.

The conclusions reached fall into two categories: the first deals with the physical extent of port hinterlands and with transport costs generated by each "package" of parameters. The second category supplies helpful insights for long-range planning at the national or regional level.

The study indicates that Guayaquil will remain the major port of the country, but that over the next decade implementation of the integrated coastal barge system, proposed herein for interconnecting the existing ports, would lead to a modest over-all reduction of transport costs and facilitate development of outlying regions of the country. A more balanced distribution of inland flows toward ports, as well as a reduction in requirements for foreign exchange might be rated as additional advantages.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

Chapter I

1.1 Foreward

For this study, we wish to examine the system of national and regional transportation for Ecuador. The sets which make up the system are socioeconomic and geographic, and deal with the nature of ports. Their primary components are:

1. the nature and production of commodities;
2. the inland transportation scheme;
3. the sea transportation scheme;
4. the influence of political policies.

Selection of the topic for this thesis grew out of the author's interest in the problem of port policies and transport development, as they relate to countries in preliminary stages of development, as they relate to countries in preliminary stages of development. In such countries, with weak markets and a minimum of transport structure, isolated decisions may create unexpected political and economic effects. However, it is important that the decisions taken be soundly based since they can profoundly affect the health of a struggling economy. Marginal effects in terms of transportation planning may assume a variety of forms and can be discussed in a meaningful manner only in the context of a particular situation. The author chose to focus his attention on the specific problems of Ecuador.

It is the author's belief that at present sufficient technical tools exist to permit a significant reduction in the degree of uncertainty associated with public decisions either in the allocation of society's resources or in dealing with individual decisions in the society.

We shall employ a systems analysis approach in which, by testing alternative combinations of parameters from the enumerated components, we simulate transportation flows. And the transportation flows that we are concerned with move to and from the ports of Ecuador, creating as they go, a regional and economic space. We shall examine in detail the induced changes which occur in these regional and economic spaces for the purpose of obtaining a prospective view for planners at levels both private and public.

Port development, as well as development in other areas of transport, typically is the concern of government decision makers, while the modes of possible control, ownership and management range from entirely private enterprises to national or state owned businesses, and include a spectrum of mixed combinations. Whatever the type of organization, conflicts of interests arise when marginal effects of decisions by those responsible for one transport mode put in jeopardy the rights of others. Usually an unaccountable chain of incremental decisions results from the conflict, each new decision being made to alleviate problems resulting from a previous decision. Conflict is inseparable from human interaction, and a variety of techniques have been developed in order to prevent or reduce its intensity.

In this study, we attempt to show through a reduced model of the Ecuadorian transport system, how groups of alternative policies, tested in a computer, may assist public decision makers. Previous goals, new hypotheses and the impact of particular parameters over the entire system are evaluated with the aid of the model.

The movement of commodities through the territory is conceived of as an integrated system which is viewed simultaneously from its "inward" and "outward" sides. (Ref. 1) In essence, the model used here is the combination of several models originally designed to deal with particular aspects of transport or general operations research type problems.

In proposing a Coastal Barge System for Ecuador, we have tried to answer the question of whether such a country should concentrate on one or two ports backed up by a suitable land transport system or should continue to maintain a number of minor feeder ports at the regional level. In the course of the study we considered, among other things, business location, colonization programs, regional development and sectoral growth.

Although ports are transfer points, their location and activity promote a more or less important geographic polarization. Such concentration begins with the convergence of several transport modes and leads to the evolution of a set of locational advantages.

Ports are points of obvious conflect between technology and those interests and institutions participating in trade. Different patterns of protection by each nation and agreements among private associations, traders, unions, corporations, cartels, and conferences are but some of the intricate elements which must be considered when port and maritime national policies are designed.

Technological advances and subsequent developments in port and marine operations, as well as innovations in marine vehicles, involve complex decisions demanding the creation of specialized facilities, large port configurations, and new vehicle fleets. The economies of scale in large port operations suggest that considerable expenditures on inland transport might be justified in order to achieve the savings associated with size. But these transport plans are, clearly, an integral part of the overall national planning -- programs must be developed on the basis of existing settlement patterns and the corresponding distribution of activities. The decision to develop a unique and highly efficient port facility must be made with a realization of the depressive effect that will follow in the minor ports and their hinterlands. For in developing countries, minor ports can act as bridgeheads in the colonization processes. Trading, banking, minor industrial activities, and different services agglomerate and increase their influence as penetration routes extend inland. Thus minor ports are local poles which foster the growth of more complex structures whose value should be measured in more than monetary terms. The history of many countries is rich in examples of abandonment; port-cities were too often wiped out by "progress".

Superimposed on such considerations is the importance of external trade involving developing countries in the worldwide economic space.* They are increasingly confronted with the need for efficient delivery of services and the lowering of transfer and production costs. In order to compete and trade in world markets, developing countries must meet minimal concurrence requirements and at the same time, create conditions for the improvement of local socio-economic levels; as Hirschman says, they cannot afford to be economical.**

The important question though, is how, in programming the spatial incidence of economic growth, is the regional impact of transportation to be controlled? In as much as the planning and programming of social overhead capital is necessarily a selective process, it is required that a strong and cohesive government exercise control to prevent indiscriminate spread of facilities and services.

Decades are necessary for modifications of a given territorial organization and public decision makers must be cognizant of the spatial and sectoral effects of their actions. Private investment, while significant, cannot be expected to shoulder or assume such responsibilities. The definition of long term goals, as well as

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*Refer to Appendix I for a definition of economic space.

**Ref. 2.

the supply of capital investment needed for developing the main infrastructures of transport is a risk that only government can afford to take.

1.2 The Ecuadorian Case

The uniqueness and singularity of each country's problems, in terms of national and regional development, do not make further general speculation particularly useful.

Clearly, there is a threshold beyond which the behavior of complex systems requires a close contact with real world situations. Thus, in choosing Ecuador as a case study, we direct our attention to a country which meets a number of explicitly or implicitly settled characteristics.

First, it is the general philosophy of the persons in the Commodity Transportation and Economic Development Laboratory at M.I.T., that countries in the lower per capita income bracket are badly in need of basic studies. Immediate problem-solving studies claim most of the energies and scarce resources in developing nations with the result that more comprehensive analyses are delayed. Consequently, decisions having long term implications are taken with too little forethought. Only by building up a background of basic longer term studies will these countries and the international lending agencies be able to develop effective long range policies.

Second, the size and geographic extension of Ecuador and make it appropriate for the application of a model necessarily limited in its scope.

A final and perhaps more important reason is attached to the particular committments of Ecuador itself.

1.2.1 Background

Ecuador's great basic economic resource is its abundance of fertile land, much of it virgin. Such lands have great potential for the country's present and future exports. Richly endowed subsoils and fertile lands are a powerful combination of resources for future agricultural and industrial growth.

The country's population was estimated to be 4.4 million in 1962. One third lived in 27 urban centers of 5,000 or more; the two-thirds not in towns were widely dispersed in small villages and rural settlements, many living on the land with little or no participation in the money economy. Between 1950 and 1960, total population increased by a million person (31 per cent) which corresponds to an average annual rate of 2.8 per cent. It is estimated that the rate of increase between 1960 and 1973 will rise to more than 3 per cent per year. As in most of Latin America, the growth of urban population has resulted from substantial movement from depressed rural areas into the towns and cities. In the decade 1950-1960, urban population increased by 56 per cent --- 500,000 persons --- while rural population increased by only 22 per cent, although this increase amounted to the same absolute number. It is expected that these trends will continue and, in fact, accelerate according to the estimate of the Planning Board. (Ref. 3)

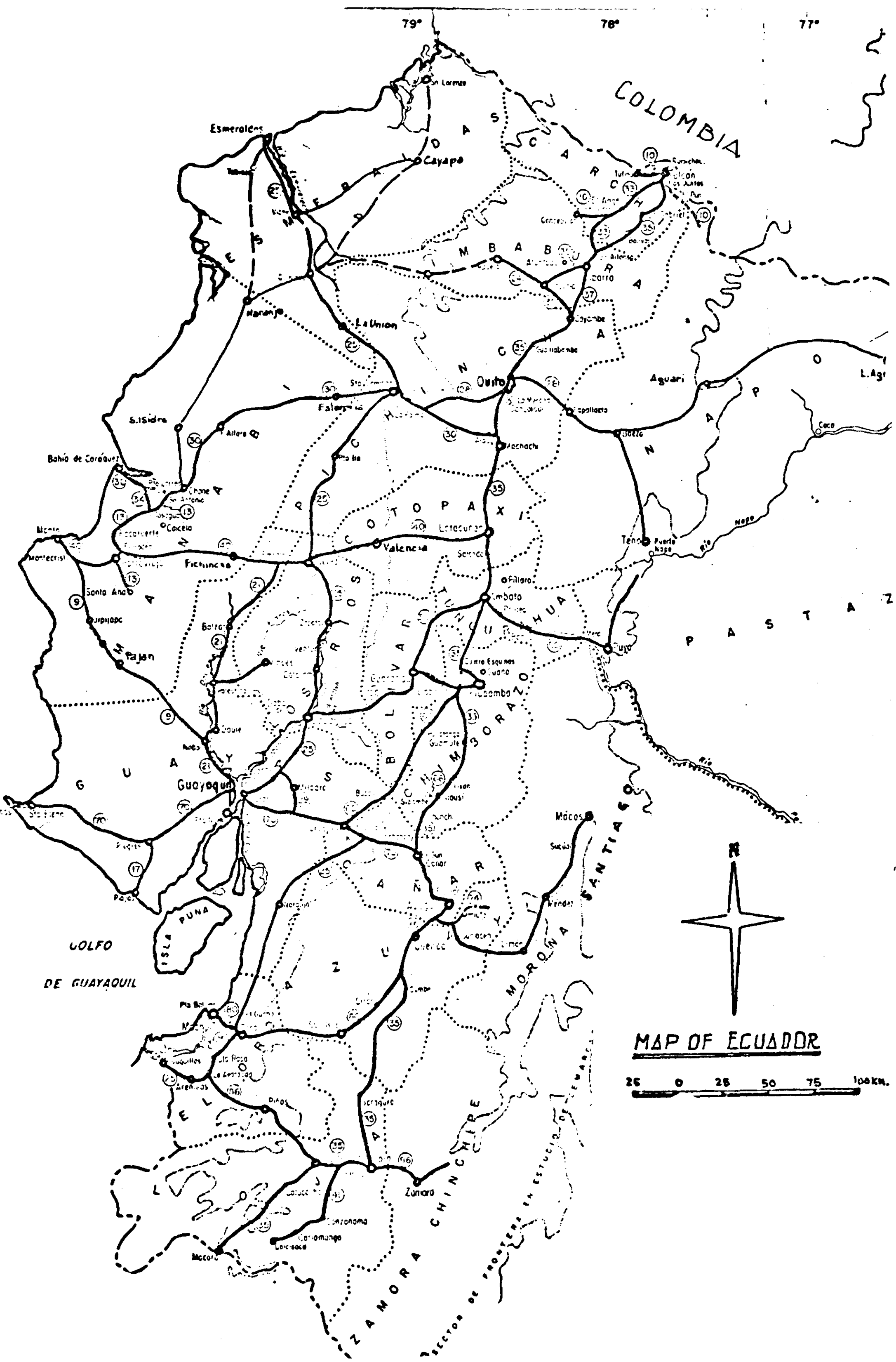
National development plans have been putting strong emphasis on the increase in production and the provision of relocation opportunities in new colonization schemes. Geographically, all five provinces in the Costa, a well-endowed 100 mile-wide fringe along the Pacific Coast, are expected to grow in population at a faster rate than the country as a whole. A dozen centers in the Costa are projected to grow at rates greater than any urban center in the rest of the country. In relative terms, many small centers in the Northern Oriental region will also share this growth as oil activities expand.

These forecasts suggest that substantially increased volumes of freight and people will need to be moved among urban centers. To an even greater extent, the traffic flows may be expected to be oriented dominantly toward focal points such as the system of ports and production centers.

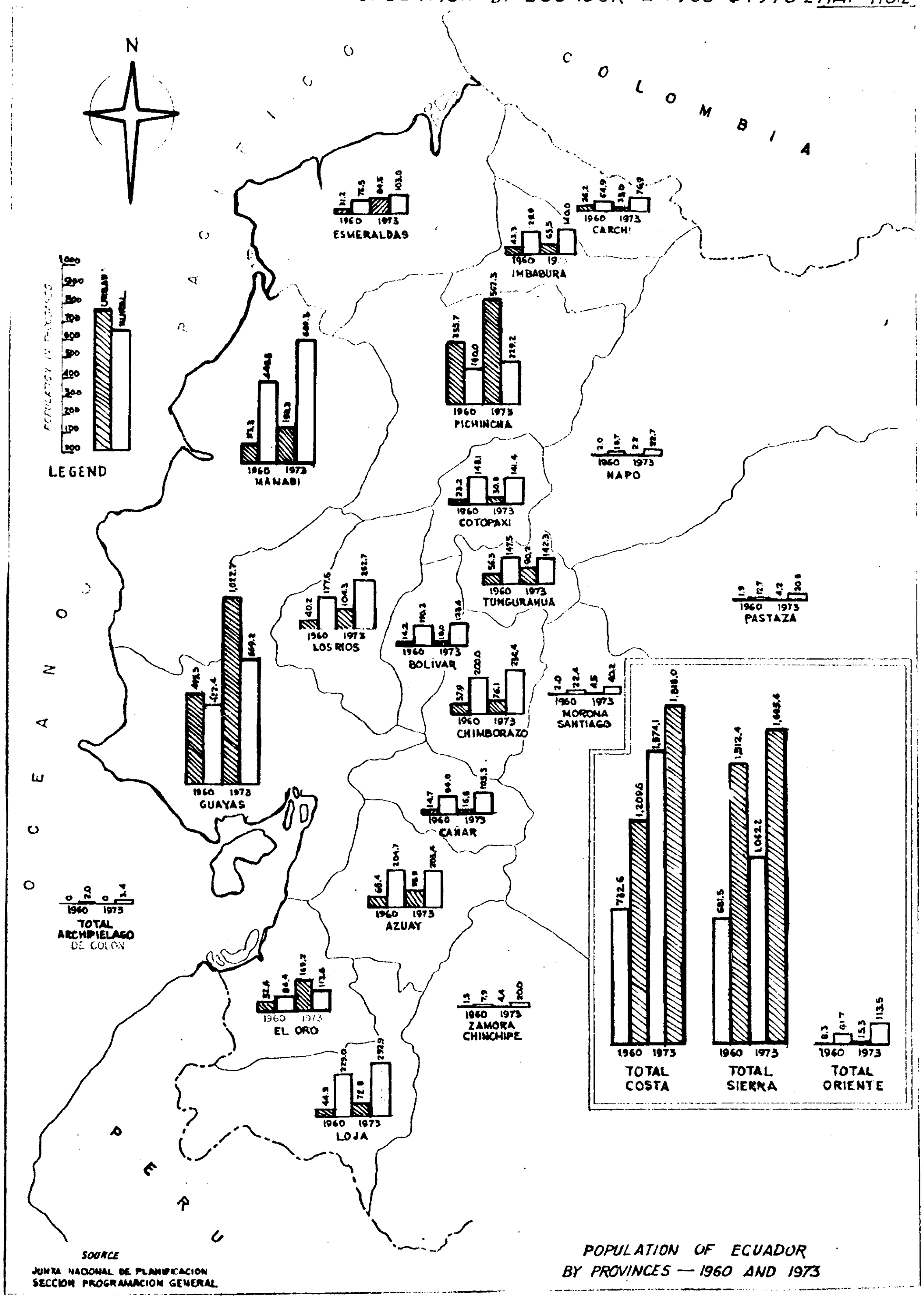
In 1962, the national gross product was estimated at slightly above 15,000 million sucres (at 1960 prices, one U.S. dollar = 18.44 sucres) which corresponds to roughly 187 U.S. dollars per capita. By the year 1969, the total population was around 5.9 million inhabitants while income per capita had risen at an average annual rate of about 2.7 per cent to 244 U.S. dollars. (Ref. 4, page iv, and Ref. 8, page 23)

The leading agricultural and forestry products for export are produced in the fertile areas of the Costa. These products

GEOGRAPHIC MAP OF ECUADOR — MAP No. 1

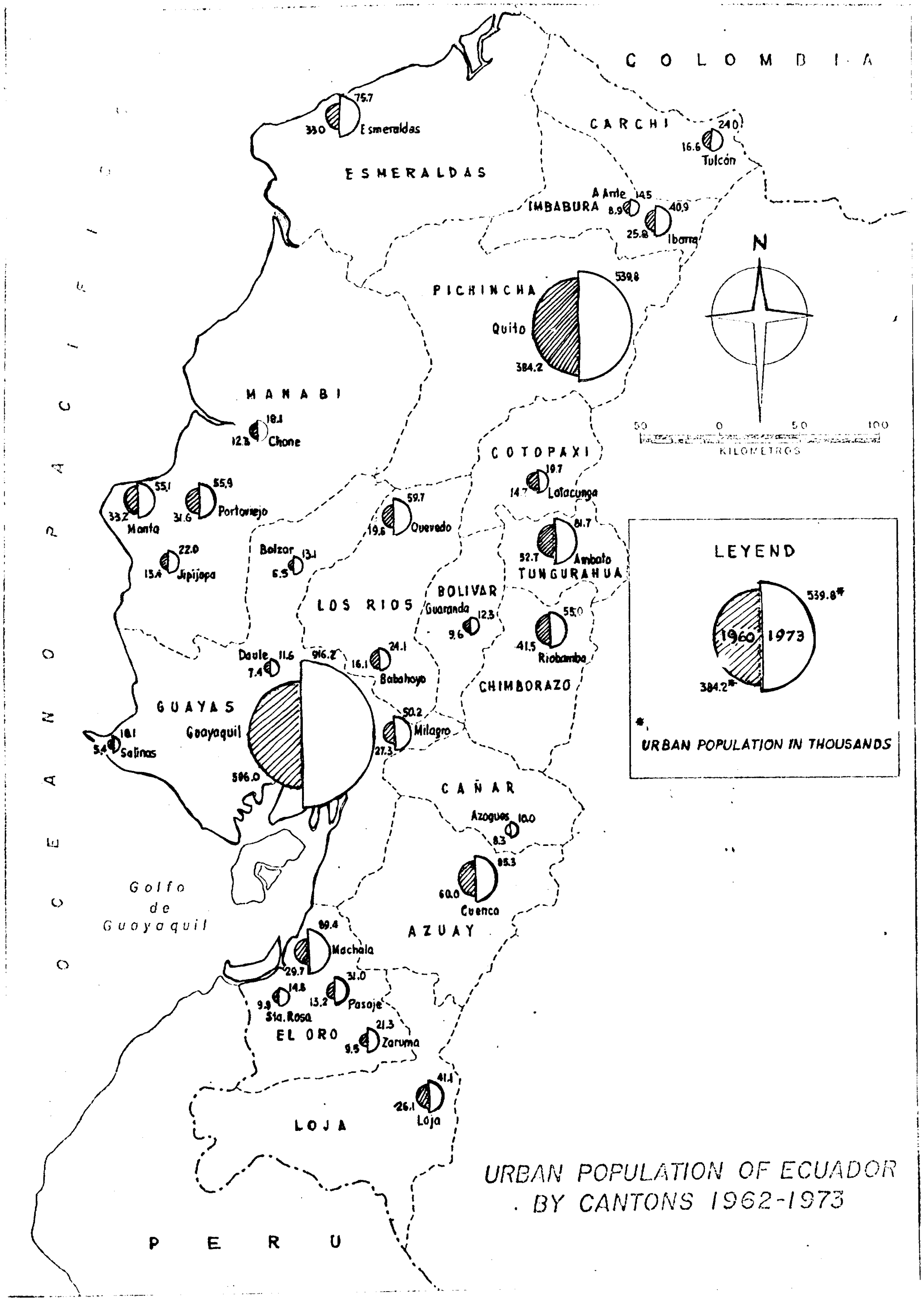


POPULATION OF ECUADOR — 1960 & 1973 — MAP No.2



POPULATION OF ECUADOR BY PROVINCES — 1960 AND 1973

URBAN POPULATION OF ECUADOR - MAP No3



move comparatively short distances, characteristically less than 125 kilometers (75 miles) to port. Processing of these products (related to primary production), accounts for the principal manufacturing activities of the port cities. Flour mills, sugar mills, petroleum refineries, and to a lesser extent, breweries and cement factories, are the prime producers of substantial continuing industrial traffic.

A very large proportion of imports is used either for consumption of for processing within the port city through which it enters the country. Some of the import tonnage after use in manufacturing, does move from port cities to points of consumption, but again, a substantial portion of the final consumption occurs within the port city.

1.2.2 Future Trends of Economic Development

The number of possible major developments in agriculture, mining, and forestry far exceeds that which can be undertaken simultaneously. Limitations of capital, management and technical skills prevent successful expansion of these many possibilities at once.

The major increments in national income are expected from agriculture, oil production, and industry. Economic growth for Ecuador has been retarded by shortages of investment capital, the limited entrepreneurial initiative, and unstable or uncertain conditions of governmental control on domestic and foreign markets. Physical barriers to transportation facilities have played a role, though not a dominant one.

Thirty-seven per cent of the gross domestic product in 1962 was accounted for by agriculture, forestry, and fishing. More than one-third of the value of agricultural production was exported, and accounted for over 90 percent of Ecuador's exports; this continues to be the case at the present time. The major role of exports in Ecuador's economy is inevitable, given the small population, the present capital requirements for exploiting identified resources in certain raw materials, and the constraints on the range of domestic industrial activity. Since a critical part of the additional fixed plant needed for production expansion cannot be produced in Ecuador, earning of foreign exchange assumes a critical significance in Ecuador's development.

1.2.3 Transportation Planning and the Present Situation

The transportation programs undertaken in Ecuador during the past decade represent a substantial part of the total investment in the country. Furthermore, they have absorbed an important share of the capital borrowing by public agencies and from external sources.

More than one-third of Ecuador's public investment for all purposes by all levels of government combined has gone to intercity infrastructure and transport facilities each year since 1950. Construction of fixed facilities reached 333 million sucres in 1960 out of 882 million sucres total public investment. In addition, there has been a substantial private investment, mainly in motor vehicles. Out of total investment in fixed assets of 1856 million sucres, nearly 350 million sucres went into transport vehicles in 1960. It was estimated that 20 to 25 per cent of total public and private investment was in transport facilities and vehicles for other than strictly urban use. (Ref. 3, III-5)

The National Plan of Transportation estimated in 1963 that in fiscal terms, "the heritage of past public investments in transportation is a substantial existing debt. Annual payments of principal and interest due on external and internal obligations amount to 192 million sucres equivalent in 1964, and decline to 81 million by 1973." (Ref. 3, page III-9)

Many of the planned goals however, are still not consummated, nor have they been changed up to now. Shortage of funds, delays in the realization of programmed works, and local political pressures have delayed the realization of programs with respect to the planning schedules. While the expected number of motor vehicles, for example, is close to the projected number of units, the railroad rehabilitation program has been but minimally materialized. Repeated mismatching of financial scheduling, unavailability of human resources, lack of adequate skill and equipment among local contractors, as well as funding failures for certain programs are responsible for the repetitious delay and lackadaisical attitude.

The evaluation of the Transport Program made by the National Board of Planning in 1967 (Ref. 4, page 193) may be summarized as follows:

investments in transport projects have made a great contribution to national growth; however, the actual benefits have been below the total expected results. The main reasons why the program has not achieved the desired results have been the lack of managerial capabilities and coordination of the program by the central government.

Excessive regionalism and the absence of leadership from the central government allowed the dispersion and unnecessary diversification of investment in transport. Duplication of energy and resources has been a distinctive characteristic of the 1963-1967 period analyzed by the Board of Planning.

Evaluation of Each Modal Transport Program

Highway Program: Alterations in total costs, structure of investments, and construction scheduling have led to delays in the projected program by an order of magnitude close to 30 per cent in the 1963-1967 period. Simultaneously, vehicle inventory grew at a cumulative rate of 8 per cent per year. Table 2 provides a comparison of actual motor vehicle inputs with the figures projected by the Plan in 1962, while Table 1 lists the actual

Table 1: Registered Motor Vehicles in Ecuador per Region and Year

Region	Year				
	1963	1964	1965	1966	1967
Sierra	17,191	17,700	19,734	20,928	24,275
Costa	17,504	14,167	17,963	20,285	22,723
Oriente	146	135	208	208	281
Total Country	34,841	32,002	37,905	41,421	47,279

Source: Junta Nacional de Planificacion.Transport section. Ref. 4, page 98.

Table 2: Projected Demand of Motor Vehicles and Actual Demand

Years	Projected No. of VHC	Projected CIF Value Sucres	Actual Imports No. of VHC	Actual Imports CIF Value Sucres
1962	2,359	132,519	2,395	114,050
1963	5,750	323,012	3,305	160,261
1964	6,014	337,842	6,166	274,866
1965	6,286	353,122	5,263	239,892
1966	6,581	369,694	5,601	217,955

Source: Junta Nacional de Planificacion.Transport section.Ref. 4, page 98.

motor vehicles registered in the country for the years 1963-1967.

The lack of adequate legal and institutional controls as well as inadequate entrepreneurial skills have led to further serious distortions in the transport market. The monopolistic practices by a reduced number of operators and the high rate of bankruptcy among small operators have motivated low standards of service in the main corridors. (Ref. 4, page 90) The main determinants of excessive unitary costs in highway transportation are attached to the existing design standards of certain roads, poor maintenance of road surfaces, and low rates of vehicle utilization due to inadequate management. (Ref. 4, page 92)

Railroad Rehabilitation Program: Delays in the railroad rehabilitation program have been by far the most serious in the whole transport sector. The main reasons, according to the Ecuadorian Planning Board, are: (Ref. 5, page 129)

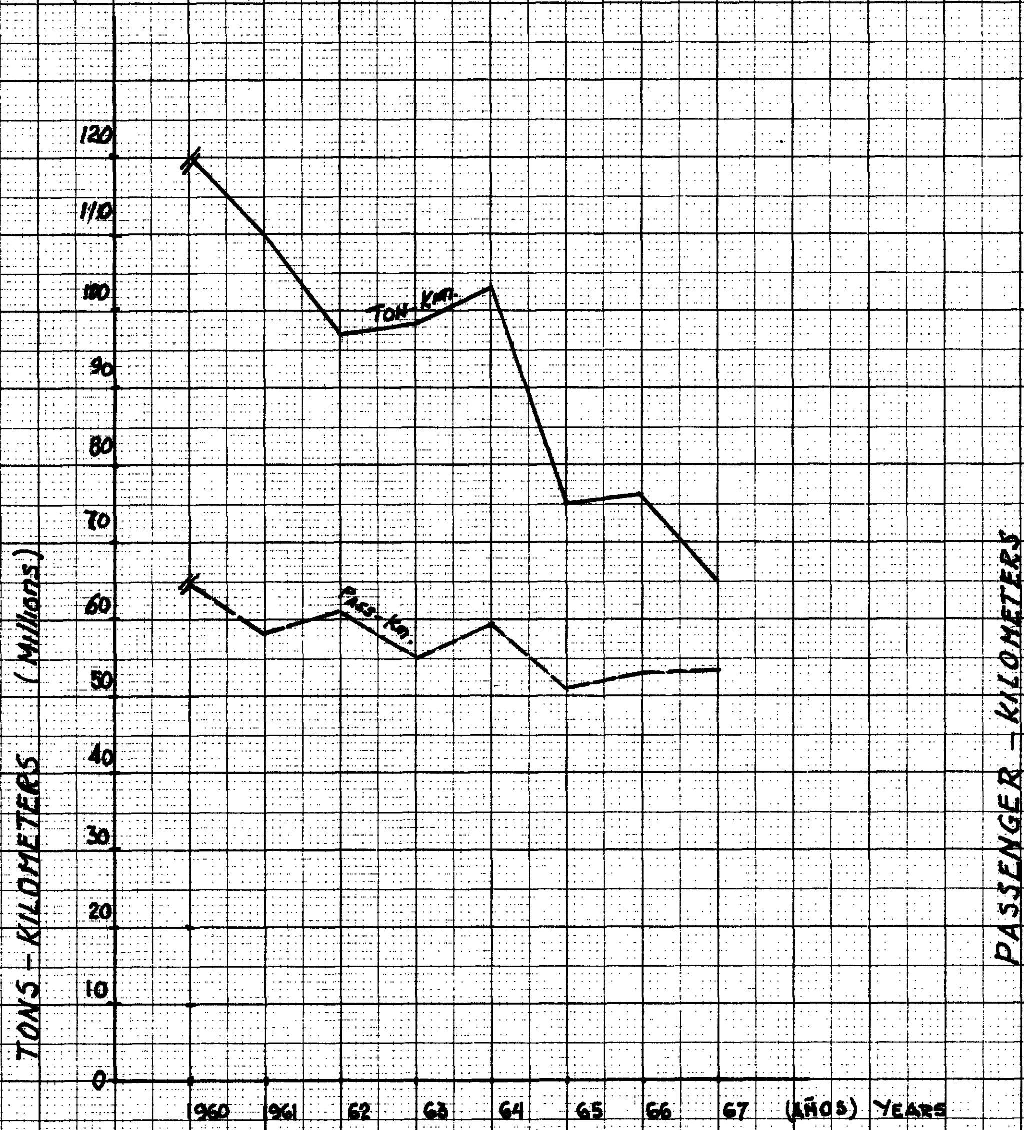
1. failure to unify the two autonomous Federal Railroad Administrations because of political pressures and opposition by local interests;
2. unsuccessful negotiation with international loan institutions for funding the rehabilitation.

As a consequence, growing inefficiency in the level of service has produced a sustained drop in cargo and passenger traffic; Fig. No. 1 reproduces the actual traffic carried by the system. For the Quito-San Lorenzo line, the operational deficit has been

FIGURE 1

PICTURE OF TRAFFIC TENDENCIES INTO THE ECUADORIAN STATE RAILROADS

QUITO – GUAYAQUIL – CUENCA



	1960	1967
TONS TRANSPORTED:	522.485	264.239
MEDIAN DISTANCE	219	232

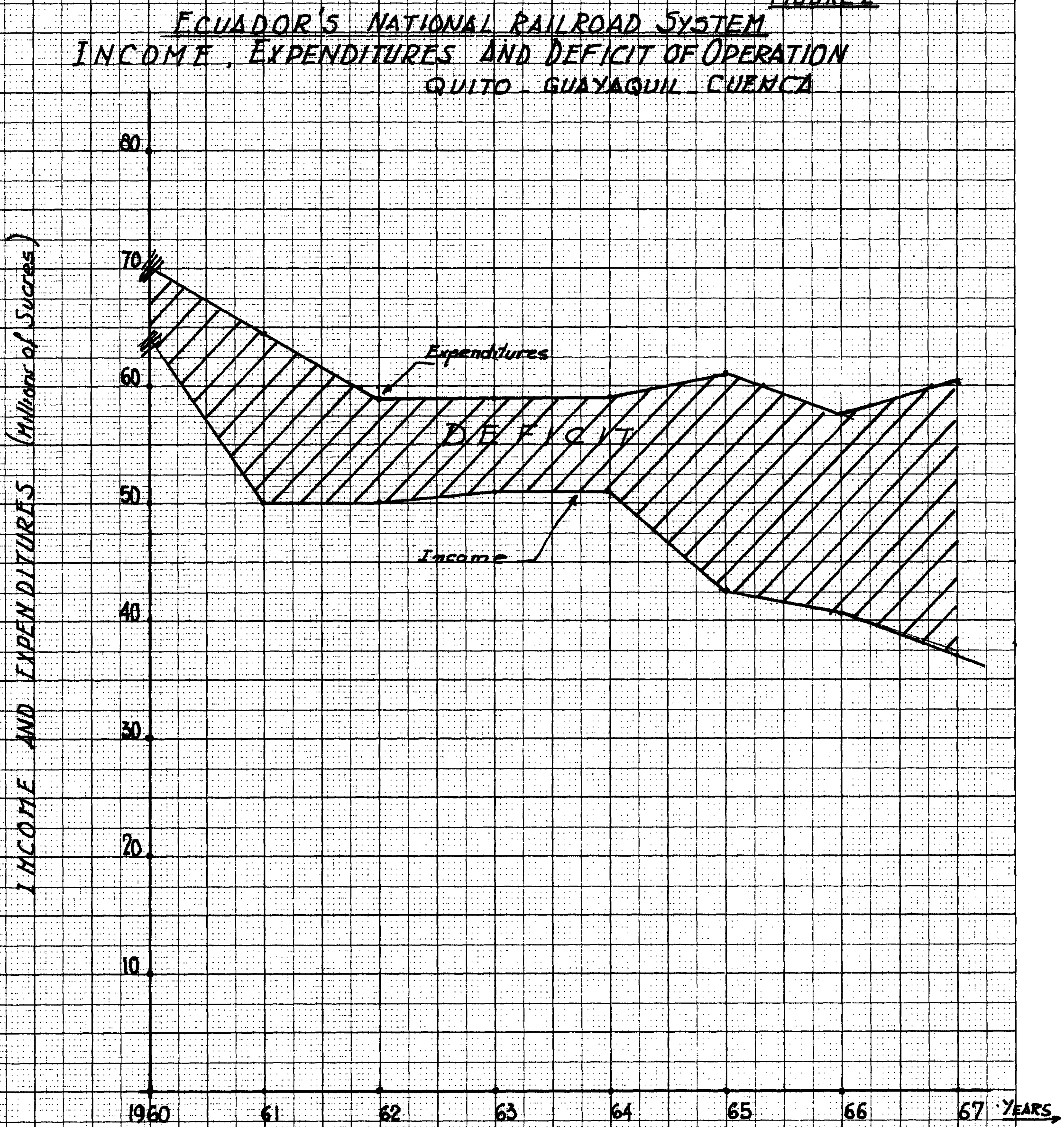
SOURCE: JUNTA NACIONAL DE PLANIFICATION Y COORD. ECONOMICA.

estimated at 23.4 million sucres in 1967, while for the Quito-Guayaquil line, the operational deficit would be 8 million sucres in the same year --- (Fig. No. 2.) The operating income of the second line is estimated at 43 per cent of the operating expenses. Later information in 1970 has indicated that the Federal Government has succeeded in the unification of the two Railroad Administrations, however no indication exists about traffic recuperation which is retarded by the substantial increase in highway transport supply.

Port Program: The unsuitable consequences of the Port Program have to be attached to initial conservative estimates for the program's capital requirements. The lack of sufficiently developed engineering studies, accurate market studies, evaluations of actual and potential commodity flows, and effective evaluations of the size and extent of each port's influence area were cited as the main causes of the shortcomings. (Ref. 4, pages 176-178)

The initial cost for the whole program was estimated at 55.3 million sucres in 1962. After the necessary reconsideration, this amount was increased by 167.9 million sucres, distributed as follows:

FIGURE 2



SOURCE: JUNTA NACIONAL DE PLANIFICACION Y COORD. ECONOMICA.

Port	Cost Increase (In Millions of Sucres)
New Port-Guayaquil	91.4
Bolivar	18.0
Manta	58.1
Others	0.4
Total	167.9

However, an examination of Table 3 provides some interesting insights. Obviously, the consequences are not exclusive to the port program, rather they are the results of combined changes in Ecuador's regional and economic space.

From 1962 to 1966, the total volume of exports decreased in the ports of Bahia de Caraquez, Esmeraldas and Bolivar, while Guayaquil, Manta and San Lorenzo have been increasing their volume. Guayaquil has been showing an accelerated increase of imported goods, keeping its hegenomic position with respect to the remaining ports.

Ecuadorian overseas traffic has been decreasing at a rate of 2.6 per cent per annum. Although the total volume exported in 1966 was 32 per cent above the corresponding 1962 figures, the country used 272 vessels less in 1966 than the number required in 1962. An increase in the average ship loading rate is apparent.

Table 3: Export-Import Movement Per Port in Thousands of Metric Tons

Year 1962

Port	No. of Vessels			Tons				Cabotage	
	I	E	%	I	%	E	%	Vessels	%
B. Caraquez	66	66	2.5	-	-	6.9	.6	44	.5
Esmeraldas	221	218	8.4	0.7	.34	89.4	8.0	1912	21.2
Guayaquil	1493	1501	57.1	194.3	94.53	711.6	63.8	2616	26.0
Manta	335	333	12.8	7.9	3.82	49.2	4.4	374	4.0
P. Bolivar	315	315	12.0	0.03	.01	235.2	21.1	2941	31.3
Salinas	53	53	2.0	2.7	1.30	23.4	2.1	1173	12.6
S. Lorenzo	136	136	5.2	*	-	*	-	408	4.4
Total	2619	2622	100.0	205.63	100.0	115.7	100.0	9468	100.0

Source: Ref. 5, page 168, Table 2.

Notes: I = Import   * = No date of tonnage

E = Export

Table 4: Export-Import Movement Per Port in Thousands of Metric Tons

Year 1966

Port	No. of Vessels			Tons				Cabotage	
	I	E	%	I	%	E	%	Vessels	%
B. Caraquez	36	36	1.5	2.50	.3	3.4	.2	127	1.8
Esmeraldas	149	147	6.3	1.7	.2	61.3	3.7	430	6.2
Guayaquil	1645	1625	69.3	471.6	54.6	1342.2	80.8	2586	36.5
Manta	260	263	11.1	9.3	1.1	51.1	3.1	226	3.3
P. Bolivar	209	210	8.9	16.2	1.9	174.5	10.5	2336	33.2
Salinas	64	61	2.6	360.9	41.9	21.7	1.3	1030	14.7
S. Lorenzo	8	8	.3	-	-	6.4	.4	296	4.3
Total	2371	2350	100.0	862.2	100.0	1660.6	100.0	6937	100.0

Source: Ref. 5, page 168, Table 2.

Notes: I = Import

E = Export

Later fragmentary information from different sources (Refs. 5,6,7) and shown in Table 4, suggest new shifts in the relative participation of each port in the country's trade. Our hypothesis is that these changes are a direct consequence of the sequencing and scheduling in the construction of public works.

The leading factor has been the termination at different points in time of key sections of the highway network. The termination of some engineering works in Manta and Bolivar and certain promotional policies has been responsible for the changes, too, but to a lesser extent.

We conclude that changes in port activity result from a combination of parameters whose weight and relative influence may be tested by an appropriate analysis.

Certainly the whole National Development Plan has been revised frequently, and once more it is apparent that such public commitment requires not only adequate institutions, but also well-developed managerial capabilities among those responsible for planning and final enactment.

Programs do not constitute the indication of what must occur, rather they provide the definition of a course of action that must be followed in order to accomplish collectively agreed upon objectives and goals. The conditions as well as the political motivations for the establishment of such objectives and goals may change, so periodic revisions and corrections should be, in essence, part of the planning process itself.

In light of the invaluable accumulated experience during the last ten years, a redefinition of goals and policies for all the sectors in the economy must begin. The whole of the National Plan will require a deep and serious readjustment for the next period, and it is our desire that this work may represent some contribution for understanding certain aspects of the transportation system and its role.

1.3 Objectives and Scope

In Ecuador, there exists no agency with the authority to formulate and implement a national policy of ports and waterways. No agency has the authority to determine requirements, budget funds for these requirements, and determine port charges in keeping with costs to the National Government.

In developing a national port system, the growing National Merchant Fleet must also be considered a part of the total transport operation. Better utilization of scarce management and scarce resources of nationally owned assets strongly suggest such an approach. To the extent that existing contractual commitments would not be jeopardized, the pooling of resources would make possible capital and service improvements on a more economic basis. Healthy competition and local initiative require coherent policies and decisions from public authorities.

Concerned institutions and interested parties, apart from the National Planning Board, which is obviously engaged in the formulation of specific policies, have discussed the problem through local publications and reports.

The main alternatives may be synthesized as follows:

a. full development of only one ocean terminal;

b. retention of the existing seven ocean terminals as ports of entry for international shipping;

c. development and maintenance of a limited set of ports gauged to the amount of regional production, efficiency of feeder systems, and advantages for promoting external trade policies.

Our main concern in this study is to identify parameters which would have relevant influence upon port hinterland changes. The extent and complexity of hinterlands is the result of the interplay of three main factors --- the nature of the commodities being shipped, the mechanism of sea transport, and the influence of political policies. (Ref. 8)

Our objective is to consider how the influence and interaction of a limited number of parameters will affect the entire transport operation for a chosen set of commodities, a particular sea transportation scheme, and a set of inland transport policies, either in isolation or combined. Marginal effects over the economic and regional space obviously are not going to be considered in all of their extent and consequences. Such an objective would be beyond the scope and possibilities of this study.

1.3.1 Nature and Selection of Commodities

Up to the present, the export pattern of Ecuadorian trade has been that of a primarily agricultural economy. Products of Ecuador's farms, forests, and fisheries accounted in 1961 for about 98 per cent of the value of her exports. Almost 90 per cent of annual export earnings have been accounted for by bananas, coffee, and cocoa. In 1962, over five million metric tons of freight moved within the country, more than half of the total tonnage was agricultural commodities; more than one-quarter was oriented to foreign trade. Projections for 1973 estimate that foreign trade of agricultural produce will account for 18.5 per cent of the tonnage and 22 per cent of the ton-kilometers of the total Ecuadorian traffic. (Ref. 9, page 1) In Table 5, the composition of import permits from 1964 to 1969 is indicated, and the increasing participation in total tonnage of agricultural capital goods from 2.8 per cent in 1965 to 6.3 per cent in 1969 is evident. Table 6 shows the relative importance of different exports from the period 1960 to 1969. In spite of some slight changes, there is no doubt of the leading role of bananas, cocoa, and coffee, and their influence on transport demand. With respect to imports, the selection of capital goods for agriculture is rather arbitrary, and was decided upon mainly for its "demand dispersion", i.e., for evaluation of the influence of alternative transport combinations over transport unit costs.

1.3.2 Sea Transportation Scheme

An integrated transport operation requires that the stochastic inputs that enter be consolidated in one or more of the intervening sections of the operation. Because ships are the largest transport unit, it is apparent that they are also the most

Table 5: Import Permits According to the Use or Economic Destination of Goods

-Per Cent Tonnage-

Economic Destination	Year 1965	1966	1967	1968	1969
Raw Mat. & Intrmdt. Goods	18.5	28.3	23.5	22.5	19.5
Ind. Cap. Goods	1.10	2.20	1.50	1.31	1.22
Transp. Eqpmt.	1.	1.50	1.27	1.92	2.9
Non-Durable Consumer Goods	1.60	1.35	.87	1.10	1.85
Petroleum & Derivative	68.	52.	62.5	60.	55.0
Durable Consumer Goods	.58	.79	.57	.59	.57
Construction Mat.	4.18	9.4	5.55	6.6	10.2
Cap Goods for Agriculture	2.8	4.45	3.85	4.6	6.3
Total	100.	100.	100.	100.	100.

Elaborated with data from, "Boletin del Banco Central del Ecuador," Ano XLIII - No. 5. 515-516, June and July, 1970, p. 152.

Table 6: Main Exports of Ecuador - Principal Articles - in Thousand Metric Tons

Year	Bananas & Platanos	Cocoa	Coffee	Veg. Oils	Wood (mainly balsa)	Fish Products	Industrial Goods (1)	Total Exports
1960	895.0	35.5	31.3	10.6	5.3	5.1	46.4	1076.0
1961	842.3	32.0	22.7	18.5	4.8	6.7	46.0	1007.0
1962	897.8	31.6	32.9	20.3	6.1	5.5	92.7	1127.0
1963	1014.3	35.4	29.4	21.0	8.8	4.8	84.3	1270.0
1964	1086.7	28.7	24.6	25.5	11.1	6.0	84.0	1310.0
1965	874.5	39.2	47.5	18.8	14.4	7.2	134.2	1777.0
1966	1070.6	32.2	43.0	10.4	13.5	7.4	107.2	1384.0
1967	1145.2	45.0	57.0	9.4	15.1	12.3	115.3	1450.0
1968	1259.1	65.4	49.0	9.3	11.7	9.2	104.5	1561.0
1969	1173.8	32.6	38.0	10.3	12.9	14.0	136.5	1479.0

Source: Banco Central of Ecuador - Pages 188-195.

Annuarius del Comercio Exterior - Ministry de Finanzas - Ecuador - Nos. 515-516.

(1) Includes sugar, molasses . . .

affected by inadequate coordination of other sections of the chain.

We are not going to discuss the advantages or failures of state ownership of merchant marines. Achievements in this area cannot be appreciated under scattered experiences occurring over two or three decades.

Ocean shipping business and trade agreements have numerous intricacies whose combined effects have significant impacts on the trading position of many countries. A recent U.N. Study (Ref. 12) and an M.I.T. thesis by V. M. Livanos (Ref. 13) offer particular insights into the influence of cartel and conference practices in Latin American trade patterns. However, it is increasingly recognized that improvement in scheduling and routing techniques in combination with the reduction of handling time, storage problems, and cargo losses can significantly reduce the cost of ship operation. (Ref. 1)

One of the policies that Latin American countries have been adopting is the development of state owned enterprises. In accord with these policies, the Ecuadorian Government exercises strong control possibilities over the GranColombian and State Banana Fleets. We will restrict ourselves to the consideration of ships operating in these fleets. In spite of only a 16 per cent participation by these fleets in the total port traffic in 1969, implementation by them of the sea transport scheme which we are proposing would offer advantageous conditions for testing alternative combinations and evaluating potential increases in efficiency.

1.3.3 Influence of Policies

The extent to which regional economic growth can be stimulated through port development depends upon the physical situation with regard to ports, and whether or not the government is attempting to achieve other objectives, too.

The decision to promote regional development requires that government be willing to determine who is going to pay for it. In developing countries, that question does not have a quick answer, and depends upon the capacity and real power of government to control local and general policy effects, and on the degree of freedom open to it for choosing or proposing alternate or simultaneous policy objectives. (Ref. 13, pages 194-197)

Some of the usual instruments that governments may employ to promote development of ports and transport infrastructure are the following:

1.3.3.1 Port Pricing Policies

a. Stimulation of one region at the expense of another through establishment of excess pricing at one to permit subsidization of others.

b. Direct subsidization of the development of specific ports, without affecting other ports' pricing policies. In this case, the charges would be levied against the economy as a whole.

1.3.3.2 Location of Specialized Facilities

Enhancement of a port's facilities through construction by different branches of government of specialized facilities, such as grain elevators, special warehouse facilities, refineries which are not attached to port administration.

1.3.3.3 Enhancement of Port Accessibility

a. Improvement of access routes and infrastructural facilities such as bridges.

b. Provision of low interest loans for transport vehicle acquisition.

c. Imposition of preferential tolls, taxes and the like affecting operative costs. (See Appendix 1)

d. Provision of subsidies and loans for multimodal access to ports, i.e., pipelines, cabotage, railroad, etc.

1.3.3.4 Custom Policies

Reduction of taxes over selected commodities to promote locational and economic advantages in certain regions.

This analysis is not intended to support such actions as the most convenient, they are only mentioned as an exemplificative list of possibilities from which alternatives might be extracted for testing the sensitivity of the overall system.

1.4 Scope

A systems analysis approach is applied to consideration of the physical and economic factors interacting in the polarized space* generated by ports, and the way in which ports and other sections of the transport system respond to different categories of stimuli. Although there are many possible categories of "optimum" for each one of the components, that of cost will be accepted as being economically the most logical. The analysis and simulations so far applied to the Ecuadorian transportation system follows two different conceptual approaches.

1. The first approach is based on a static optimum, achieved with the best use of existing facilities or entailing investment with the construction of optimal capacities of the facility in relation to unchanged cargo and traffic flows. An appropriate set of public and private operating rules within each section of the system and methods for enforcing those rules are needed for simulation.
2. The second approach attempts to achieve a dynamic optimum. While the static optimization is concerned with a situation in which a stable or constant flow of cargo and traffic is

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*For definition, see Appendix I.

assumed to be flowing through facilities that are being changed to insure an optimum relationship between them and unchanged trade or shipping conditions. The dynamic optimum is concerned with growth effects on the system. Here, the optimum is the result of a compromise between minimum operating cost conditions on one side and the expansion of facilities on the other. Expansion of infrastructure cannot proceed on a continuous or even in a succession of small steps. On the contrary, the process becomes one of relieving congestion by creating over-capacity in sections of the system until gradually all of the system capacity may be used.

The main potential of the model developed so far lies in its application to the planning process where it can be used to supply information about alternative transport conditions, to appraise their presumed impacts on the location of particular facilities, and to measure some marginal effects over the location of other economic activities.

In order to forecast the throughput of the entire system of ports, we have selected a set of parameters whose importance and sensitivity vary according to their degree of interaction.

Our main assumption is that perfect information exists among producers, users, consignees, and shippers, that the actual unit cost of transportation from different production areas (nodes) to markets is known and that producers will choose those markets which will be cheapest to reach, or in the case of a supply-oriented industry, the Nodes which will minimize transport costs given the constraints of a) Internal Trade, and b) External Trade.

As a result, port hinterlands result which are defined by the set of nodes whose transportation costs are equal with respect to one or more 'markets'. The boundary defined by these nodes constitutes an imaginary isocost line for the region.

Chapter II

2.1 General

Conceptually, our approach is one which defines a spatial structure. Here, urban centers are "nodes"; rural areas are homogeneous open spaces; roads, rivers, air and ocean routes, and communications nets are links. Nodes, spaces, and links interact in such a way as to create a particular configurational network. Communications, economic activity, physical movement, of people and goods generate flows throughout the links of the network as an expression of socio-economic interaction. This is predominantly a dynamic process brought about by changes in the interacting elements. Each element may be conceived as a subset of fluctuating parameters. These parameters react in response to exogenous stimuli. Thus, we have a fixed reality of space. A network defined and viable.

In terms of transportation services, interaction among nodes promotes differentiated movement of goods as they flow throughout the network. Each flow demands different links. When considering the summation of all flows within the system, each link may be demanded by more than one flow. For example, when prices on a specific link change, each flow that is demanding that link reacts differently. The extent of the reaction depends on the proportion of usage of that link as compared to other links.

The flow supply, on the other hand, is the aggregate of fixed and non-fixed facilities necessary to provide the required services. Though not indicated in this model, it is assumed that flows have an origin and destination; however, for cost purposes, destination nodes will not be considered trip-ends. In evaluation of certain parameters, we will include back-trips.

In general, the analytical sequence of the model may be divided into two main functions:

1. the location of the actual and predicted demand for transportation;
2. the prediction of usage patterns of the network, and the cost performance of specific intervening mode subsystems.

The first function has been exogenously inputed into the model. The assignation has been made on a node basis disregarding the actual origins of the goods to be transported around these nodes. Imported goods appear in proportion to urban population size. We also disregard transport operations from rural productive units to nodes in the main network. This would represent an unnecessary multiplication of Origin-Destination nodes, otherwise impossible to manage within the computational capacity of the model.

The assumed geographic distribution, given the availability of data, of bananas, coffee, and cocoa, as well as their production distributions and estimated flows to ports, are described in Tables 7, 8, 9, and 10 which Maps 4 and 5 compliment. Further explanations are under Inter-Nodal Commodity Supply and Demand, in the model's structural description.

The second function of the model is achieved through the use of a set of independent submodels; each one deals with one specific operation or transport mode. The overall model integrates into a single operation the participating elements which interact to produce final transport costs and distributional patterns under different sets of constraints.

One of the direct outputs of the model is a description of the manner in which a port's hinterlands is affected as a consequence of users' reaction to costs or prices and their aggregate effects upon flows. Hinterlands' boundaries may adopt different shapes and sizes depending upon the level of commodity aggregation flowing through the port. Our approach is based on a commodity-by-commodity analysis, with the result that hinterlands reflect transport modal preferences and flow orientation more accurately than would be possible in a more aggregated analysis. While this degree of aggregation reduces complexity of the analysis, it also prevents it from being applied for studying details of the system. Nonetheless, we believe it is appropriate to this type of situation. It should be sufficiently simple to encourage analysis of transport problems in less developed countries. For it is in these countries that transport problems are aggravated by the lack of a coherent flow orientation. Network frictions and facility bottlenecks occur regularly.

In the second place, a dearth of accurate data makes frequent appeals to common sense --- "educated guesses" --- with the result that the detailed effort needed to implement entire portions of a more complex model would be unjustified.

2.2 Structure of the Model

The model is relatively straight forward. The whole transportation system is conceived of as a link-node net. As we have seen, transport interfaces, cities and towns are nodes, while roads, waterways, air routes, railroads, are links. Key factors in development of the network are:

1. handling operations at interfaces of nodes;
2. transport unit costs on each link;
3. characteristics of vehicular and facility performance as well as special requirements for the transport of specific products.

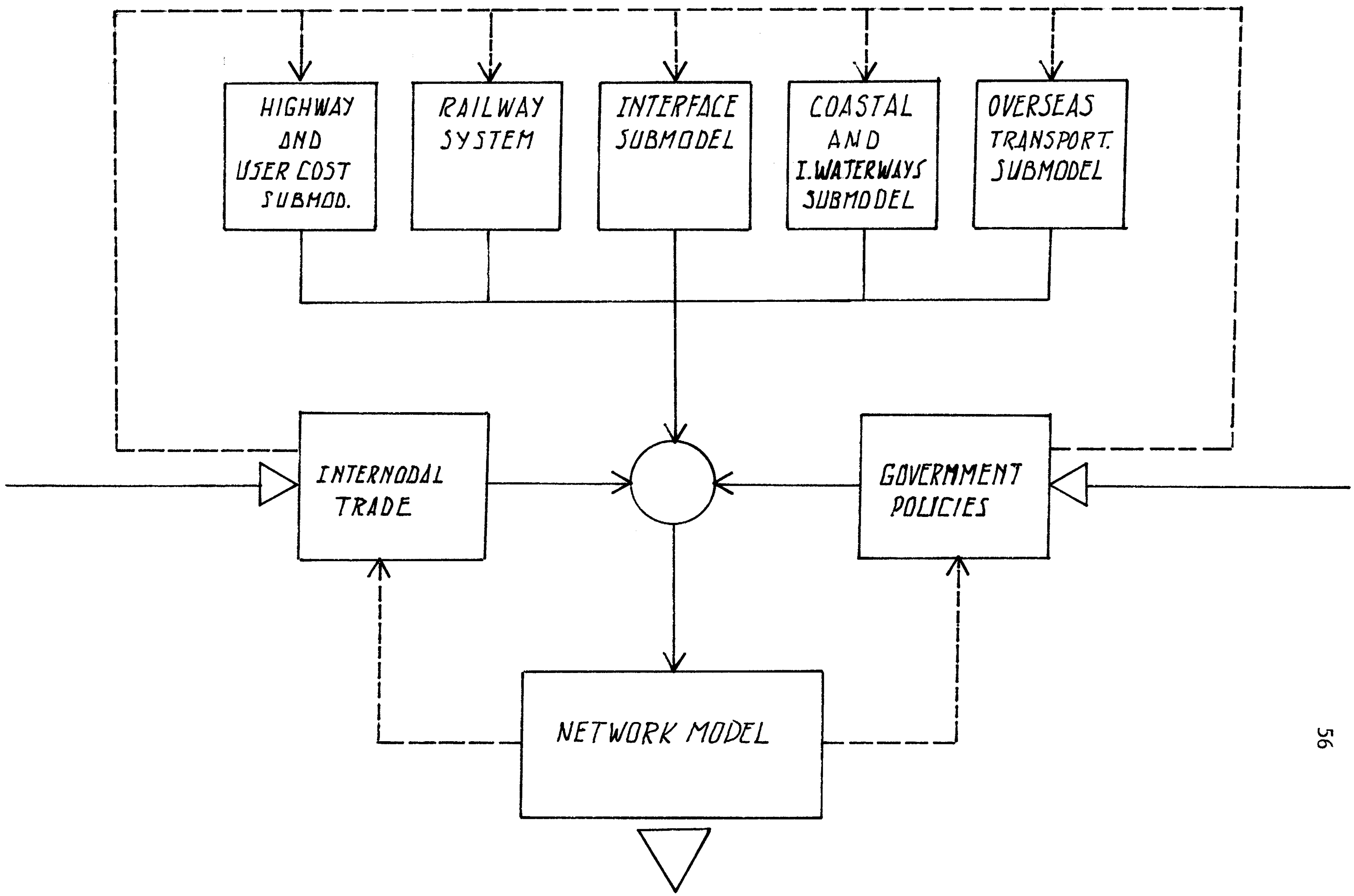
Schematically, our model is represented by seven "blocks" or submodels which together create a feed-back process. (Figure 3)

2.2.1 Part 1 - Internodal Trade

A prerequisite for predicting the magnitude of commodity flows is to know the quantity and location of commodity supply and demand. Networks are necessarily a synthetic representation of the real world and it

FIGURE 3

MODEL'S FLOWCHART



would be impractical to design a network locating every unit of production within the territory.

Consequently, a hierarchy of nodes is decided upon beforehand. Each of the nodes has a particular area of influence. Supply and demand to each of these areas are assigned to the node, disregarding local movement.

In the case of agricultural goods, the production is assumed concentrated in one point in space, the node. When sufficiently disaggregated statistics, land use and other agronomical studies are available, the accuracy of production assignation to nodes would insure a more precise evaluation of traffic demand.

In Ecuador, a great number of statistics are aggregated on a province-by-province basis, and the assignment of production to minor nodes (canton heads) other than capital provinces, requires numerous indirect calculations. Thus, guesses, ad-hoc analysis of geographic and agronomic bases, as well as inferences from disperse information on production and trade have been resorted to where necessary.

The Ecuadorian inter-nodal commodity movement in 1962 was predominantly agricultural, representing 52.9% of the total tonnage moved that year. Almost 1.2 million tons of agricultural commodities moved from production areas to ports for export. Included were industrial goods such as processed sugar and molasses. Export freight represented about one-fourth of all intercity freight movement. Imports from ports to inland points were a small portion of total inter-nodal traffic, amounting to two per cent of the total tonnage of the country's freight moved during the same year. (Ref. 4, V-6)

Intercity traffic in Ecuador may be represented by four major corridors which concentrate the regional flow of four groups of provinces. These corridors become helpful analytical tools when further prognoses are made in relation to certain commodity origin-destination movements.

The major corridors are:

1. Sierra-Costa --- provinces of Azuay, Canar, Chinborazo, Cotopaxi, Guayas, Pichincha, Tungurahua, and part of Bolivar, the Oriente and the area between Costa and Sierra.
2. Costa --- provinces of Guayas, Los Rios, Manabi, Esmeraldas and part of Bolivar.
3. Southern provinces of El Oro and Loja.
4. Northern provinces of Carchi and Imbabura.

Geographic Distribution and Production of Bananas, Cocoa and Coffee

This section is a discussion of the author's interpretation of the Ecuadorian data. It is meant to describe the bases upon which projections for the year 1983 were made.

Bananas

According to estimates derived from Ref. 17, and listed in Table 7, the total production of bananas in Ecuador was 2.75

million metric tons in 1967. However, the Central Bank of Ecuador reports (Ref. 19, page 139) a total production of 2.3 million metric tons for the same year. The difference in tonnage reported could be attributed to differences in criteria used for evaluating the production. While the "Direccion de Estadistica y Censos" figure is the estimated banana production, the second corresponds to the number of bananas actually marketed. Although according to a minister of production report (Ref. 17) an approximate 16% of bananas are not harvested, that figure is far below the estimate 30% made by the Economic Commission for Latin America in 1959. (Ref. 12)

In spite of the fact that 2% of the bananas are exported on stems, (Ref. 29, p. 80) we choose to overlook such a small percentage and instead, assume that all bananas are boxed on shipping.

Different statistics reporting banana exports do not represent the effective flow from origin nodes to ports. An approximate 15% allowance for shrinkage and rejection (Ref. 29, p. 80), plus another 16% for local consumption and processing in port cities make up a total of 31% more than the actual exported tonnage.

Projections of Export Tonnage for the Year 1983

A cross-analysis of the estimated growth rate by the National Transportation Planning staff (Ref. 4, pages V-8, V-9, and V-10) for 1973 and the annual rate of growth of export between 1960-1969, shown in Table 5, were made. An average increase of 3%

ESTIM. AREAS OF BANANA PLANTATIONS - MAP No. 4

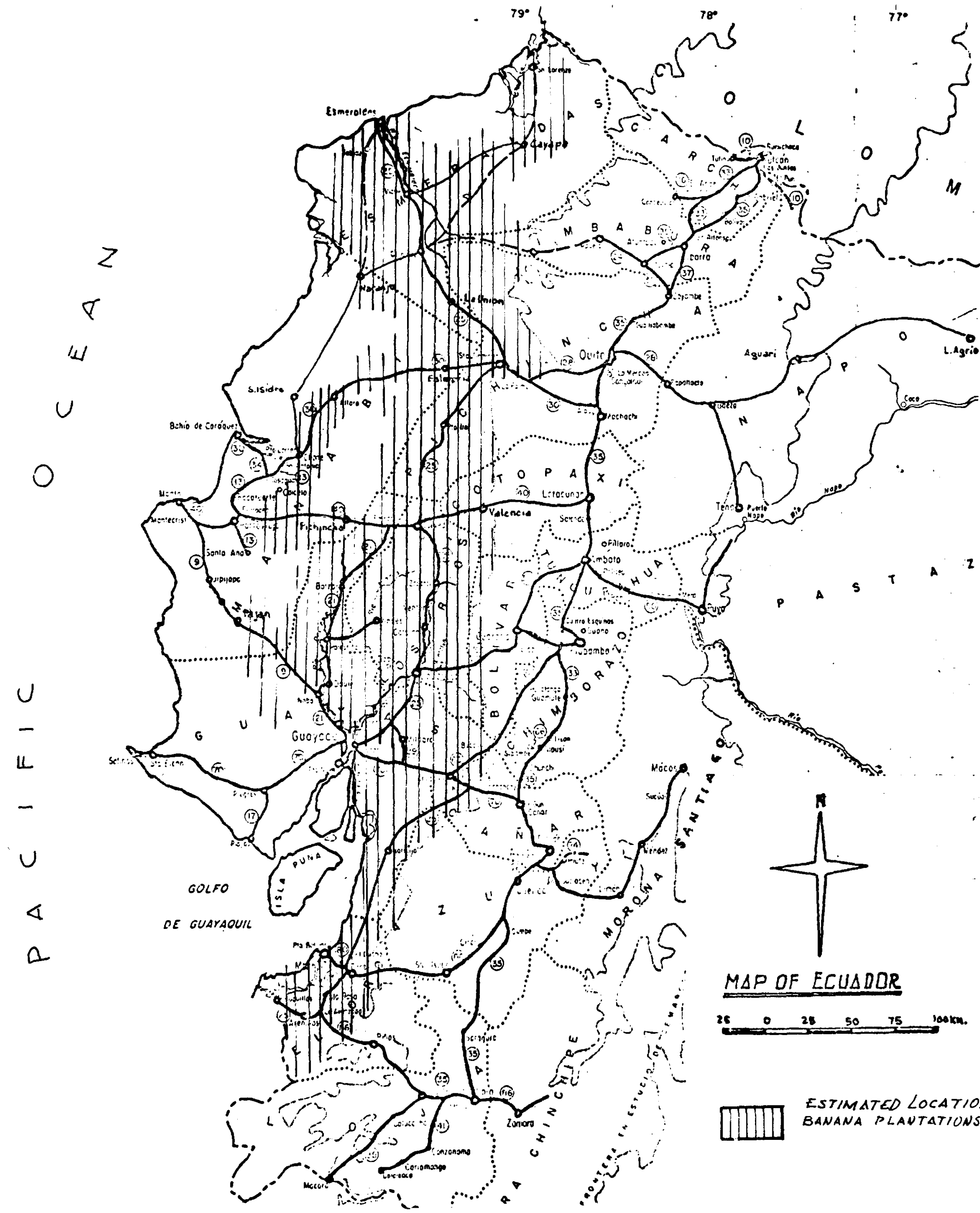


Table No. 7: Productive Units, Acreage and Production per Provinces in Ecuador

Provinces	Bananas (*) No. of Prod. Units (1)	Bananas (*) Acreage in Hectares (1)	Estimated Market Demand 1000 x Tons 1968 (2)	1973 (Project.)	1983 (Project.)
(S) Azuay	134	42	0.25	0.32	0.390
(S) Bolivar	1,995	1,608	19.96	21.00	23.50
(S) Carchi	447	337	5.90	6.40	8.40
(S) Canar	1,555	4,864	48.60	58.40	78.00
(S) Cotopaxi	1,944	10,699	100.00	120.00	162.00
(S) Imbabura	17	63	0.80	1.23	1.96
(S) Loja	6,671	2,100	20.70	22.70	26.40
(S) Pichincha	5,450	42,683	483.55	520.00	714.00
(C) Esmeraldas	12,563	46,342	245.80	280.00	370.00
(C) El Oro	8,480	34,298	220.00	268.00	360.00
(C) Guayas	8,780	31,238	322.00	380.00	520.00
(C) Los Rios	6,848	51,746	680.00	810.00	1,120.00
(C) Manabi	16,244	23,593	108.50	154.00	212.00
(O) M. Santiago	1,758	1,091	22.30	24.60	29.50
(O) Napo	961	723	11.30	13.00	15.00
(O) Pastaza	863	755	11.60	11.80	13.50
(O) Z.Chinchipe	1,339	986	15.90	17.00	19.70
Total Country			2,307.86	2,698.45	3,668.35

(S) Sierra Region
(C) Coastal Region
(O) Oriente Region

(*) Elaborated with data from Ref. 17
(1) Plantations of bananas and platanos in productive age.
(2) Stems calculated at an average weight of 55 lb. (25 kg)

Table No. 8: Location of the Banana Production and Exporting Flows Toward Port Cities

Province	Node of Origin	Production in 1968 1000 x tons	Estimated Exporting Flows 1968 Tons-Day	1973 (Projection) Tons-Day	1983 (Projection) Tons-Day	Annual Rate of Growth
Azuay	S. Isabel	0.25	.80	.88	1.07	1.5
Bolivar	Guaranda	16.60	45.00	49.50	57.00	1.5
Carchi		5.90	16.00	17.60	23.00	1.5
Canar	Chilcales	28.00	77.00	84.50	97.80	1.5
	Cochancay	20.60	57.00	76.50	118.00	5.
Cotopaxi	Valencia	85.60	234.00	280.00	375.00	3.
Imbabura	Moreno	.80	2.50	3.35	5.20	5.
Loja	Las Chinchas	20.70	57.00	62.70	72.20	1.5
	Zaruma					
Pichincha	S. Domingo	220.00	602.00	830.00	1,132.00	4.
	P. Ila	120.00	329.00	416.00	580.00	4.
	La Palma	70.00	190.00	209.00	240.00	1.5

Table No. 8: Continued

Province	Node of Origin	Production in 1968 1000 x tons	Estimated Exporting Flows 1968 Tons-Day	1973 (Projection) Tons-Day	1983 (Projection) Tons-Day	Annual Rate of Growth
Esmeraldas	Quininde	70.00	190.00	227.50	300.00	3
	Viche	60.00	137.00	163.00	218.00	3
	Esmeraldas	35.00	95.00	107.50	130.00	2
	Cayambe	12.50	34.00	38.20	48.00	2
	S. Lorenzo	19.00	51.00	69.00	106.00	5
El Oro	Pasaje	66.00	177.00	210.00	275.00	3
	Arenilla	60.00	165.00	231.00	355.00	5
	Pinas	30.00	82.00	90.50	103.50	1.5
	Bolivar	30.00	82.00	92.10	112.50	2.
Guayas	Balzar	40.00	109.40	124.00	150.00	2.
	Palestina	20.00	54.70	61.80	75.00	2
	Daule	60.00	164.00	220.00	340.00	5
	Nobol	40.00	109.40	124.00	150.00	2

Table 8: Continued

Province	Node of Origin	Production in 1968 100 x tons	Estimated Exporting Flows 1968 Tons-Day	1973 (Projection) Tons-Day	1983 (Projection) Tons-Day	Annual Rate of Growth
	Nobol	40.00	109.40	124.00	150.00	2
	Progreso	12.00	32.50	35.70	41.20	1.5
	Naranjal	80.00	218.80	260.00	350.00	3
	Duran	40.00	109.40	120.00	139.00	1.5
	Milagro	30.00	80.60	103.50	179.00	5
Los Rios	Quevedo	150.00	410.00	460.00	562.00	2
	Zapotal	150.00	410.00	490.00	655.00	3
	Catarama	100.00	273.00	327.00	435.00	3
	Babahoyo	220.00	602.50	680.00	875.00	2.5
	Vinces	100.00	273.00	308.00	424.00	2
Manabi	Portoviejo	13.00	35.30	38.70	44.70	1.5
	F. Alfaro	60.00	164.00	220.00	355.00	5
	Chune	70.00	190.00	228.00	304.00	3

Table 8: Continued

Province	Node of Origin	Production in 1968 100 x tons	Estimated Exporting Flows 1968 Tons-Day	1973 Tons-Day	1983 Tons-Day	Annual Rate of Growth
	S. Isidro	15.00	41.00	49.00	65.40	3
	Naranjo	35.00	96.00	108.00	132.00	2
	Pajan	24.00	65.00	73.20	89.00	2
M. Santiago	Limon	16.00	43.00	48.50	59.00	2
	Macas	3.00	8.50	9.60	11.60	2
Napa	Papallacta	5.60	15.00	18.00	24.00	3
	Baezo	4.00	10.00	12.60	13.73	2
Pastaza	Puyo	9.80	25.00	27.50	31.60	1.5
Z. Chinchipe	Zamora	13.50	36.00	39.50	45.70	1.5
		2,286.00	7,500.00	8,950.00	12,000.00	

Sources: Ref. 17, Ref. 18, pp. 10-18, Ref. 19, pp. 138-146.

per year was estimated. Present agricultural policies, new technology, and the adoption of more productive varieties of bananas were taken into account for determining the location and volume of production. We foresee by 1983 the full operation of colonization and agricultural projects proposed by the National Planning Agency for the period 1962-1973. Production increases may be incremented at a rate of 6% per year, based on the managerial and technological advantages offered by the projects. (Ref. 3)

Cocoa

Table 6 shows that during 1968, Ecuadorian cocoa exports rose 65.4 thousand tons. While the productive acreage was around 251,980 hectares, the estimated total production was 98,482 tons, which gave a productivity of 0.39 tons per hectare. (Ref. 17 and 19) Needless to say, 1968 was the peak year for the Ecuadorian cocoa business for the 1960's. Though it would not be fair to consider it a representative case for our study, we have selected it on the fact that more accurate data was available in 1968 than in any other year.

Projections for 1983 cocoa exports were based upon average annual export during the period 1960-1969, which amounted to 37.96 thousand metric tons. We have assumed that an average annual increase of 2.5 per cent will take place in the Ecuadorian annual exports between 1969-1983, based on estimates of the Ralph Watkins study (Ref. 10, page 23) So we conclude that the expected

Table No. 9: Geographic Distribution of Coffee Production and Export Tonnage for the Year 1968 and Projection for 1983 (in metric tons)

		1968 (1) Production in areas of origin	1968 (2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Annual rate of growth	1983 (5) Projected export tonnage	(6) Colonization or irrigation projects
Pichincha							
	Quito						
	S. Domingo						[1]
	P. Ila						
	La Palma						
Cotopaxi							
	Pilalo						
	Tingo						
	Valencia						
Canar							
	Cochancay						
	J. M. Calle						[5]

Table No. 9: Continued

		1968 (1) Production in areas of origin	(2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Annual rate of growth	1983 (5) Projected export tonnage	(6) Coloniza- tion or irrigation projects
Loja		920		.100			
	Zaruma	-		-			
	Guaquich	300	255	.100		382	
	Orianga	240	205	.100		310	
	Cotacocha	380	322	.100		485	
Esmeraldas		800		.225			
	Quininde	400	340	.225		510	
	Vichi	400	340	.225		510	
	Esmeralda						
	Tabiazo						
	Chumundi						[3]
	S. Cayapas						[3]
	Latola						
	La Union						

Table No. 9: Continued

		1968 (1) Production in areas of origin	(2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Annual rate of growth	1983 (5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
	Muisne						
	S. Lorenzo						
Manabi		24,620		.343			[3]
	Portoviejo	-		-			
	Falfaro	3,200	2,720	.400		4,870	[4]
	L. Union	2,600	2,210	.400		3,950	[4]
	S. Isidro	2,800	2,380	.400		4,300	[4]
	Jama	900	765	.300		1,380	[4]
	Cojimies	-		-			
	Manta	3,900	3,300	.435		3,830	
	Montecrist	1,760	1,500	.196		1,600	
	Jipijapa	700	598	.100		800	
	Chone	4,800	4,100	.200		6,700	[4]
	Calceta	3,560	3,050	.356		3,670	

Table No. 9: Continued

		1968 (1) Production in areas of origin	(2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Annual rate of growth	1983 (5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
	S. Ana	500	425	.100		405	
	B. Caraquez	-		-			[4]
Los Rios		7,900		.280			
	Quevedo	1,200	1,100	.300		1,650	
	Zapotal	-	-	-			
	Vinces	2,800	2,380	.400		3,550	
	Catarama	900	765	.300		1,150	
	Montalvo	600	510	.300		760	
	Babahoyo	2,400	2,050	.400		3,060	
Guayas		3,900		.267			
	Vinces						
	Daule	1,200	1,010	.267		1,980	[6]
	Nobol	-		-			
	Duran	-		-			

Table No. 9: Continued

		1968 (1) Production in areas of origin	(2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Annual rate of growth	1983 (5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
	Milagro	-		-			[5]
	Chicale	-		-			[5]
	Naranjal	-		-			
	Balzar	800	680	.267		810	
	Empalme	1,300	1,100	.267		1,452	
	Guayaquil	600	510	.267		700	
El Oro		1,940		.196			
	Arenilla	392	335	.196		670	[2]-[5]
	El Guabo	1,763	1,500	.196		2,250	
	S. Rosa	490	415	.196		620	
	La Avanza	-	-	-		-	[2]
	Pasaje	295	250	.196		210	
	Pinas						
	S. Isabel						
	Machala						

Table No. 9: Continued

		1968 (1) Production in areas of origin	1968 (2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Annual rate of growth	1983 (5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
Bolivar		1,660	1,420	.196		2,140	
	Guaranda	235	200	.196		300	
	S. Antonio	827	708	.196		1,105	
	Balsapamb	598	505	.196		785	
Others		860	735	.225		1,100	

[1] Trapecio Santo Domingo (Manabi Province) Ref. 4, p. iv.-9.

[2] Arenilla, Huaquillos (in Southern El Oro Province), Ref. 4, p. iv.-9.

[3] San Lorenzo (in the extreme northwestern corner of Esmeraldas Province), Ref. 4, p. iv.-9

[4] Central coastal region tributary to Bahia Caraquez

[5] Irrigation Projects at Milagro, M. J. Calle, Chilcales and Arenillas (more than 12,000 HA each), Ref. 4, p. iv.-10

[6] Irrigation Project at Daule, Ref. 4, p. iv.-10

[7] Projects over different areas of the Oriente Provinces, Ref. 4.

Table No. 10: Geographic Distribution of Cocoa Production and Export Tonnage for the Year 1968, and Projection for 1983 (in metric tons)

		1968				1983	
		(1) Product per provinces of origin	(2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Estimated acreage -HA-	(5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
Pichincha		685		.49	337		
	Quito	19	13			5.0	
	S. Domingo	340	225			600.0	[1]
	P. Ila	266	178			9.90	
	La Palma	60	15.2			12.20	
Cotopaxi		1,375		.136	10,699		
	Pilalo	500	335			175.	
	Tingo	175	117			40.	
	Valencia	700	465			162.	
Canar		1,200		.246	4,864		
	Cochancay	600	400			138.	
	J. M. Calle	700	465			1,050.	[5]

Table No. 10: **Continued**

				1968			1983
		(1) Product per provinces of origin	(2) Estimated export tonnages	(3) Estimated productivity (tons/HA)	(4) Estimated acreage -HA-	(5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
Loja		420		.20	2,100		
	Zaruma	300	200			69.	
	Guaquich	20	13.4			4.6	
	Orianga	100	66.5			23.	
	Cotacocha						
Esmeraldas		22,600		.49	46,342		
	Quininde	5,000	3,300			1,160.	
	Vichi	5,000	3,300			1,160.	
	Esmeralda	2,700	1,800			623.	
	Tabiazo	1,100	730			253.	
	Chumundi	700	465			1,080.	[3]
	S. Cayapas	400	266			600.	[3]

Table No. 10: Continued

		1968				1983	
		(1) Product per provinces of origin	(2) Estimated export tonnages	(3) Estimated productivity (tons/HA)	(4) Estimated acreage -HA-	(5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
	Latola	700	465			920.	[3]
	La Union	1,400	945			322.	
	Muisne	1,200	800			276.	
	S. Lorenzo	400	267			92.	
Manabi		15,500		.65	23,593		
	Portoviejo	1,500	1,000			1,345.	
	Falfaro	4,000	2,660			4,620.	[4]
	L. Union	1,500	1,000			1,730.	[4]
	S. Isidro	1,200	800			960.	[4]
	Jama	200	133			230.	[4]
	Cojimies	100	66.5			23.	
	Manta	1,600	1,065			1,367.	
	Montecrist	1,550	1,060			357.	
	Jipijapa	550	368			1,127.	

Table No. 10: Continued

			1968		1983	
	(1) Product per provinces of origin	(2) Estimated export tonnages	(3) Estimated productivity (tons/HA)	(4) Estimated acreage -HA-	(5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
Chone	1,400	970			1,730.	[4]
Calceta	400	266			92.	
S. Ana	1,200	800			276.	
B. Caraque	300	200			340.3	[4]
Los Rios	23,850		.46	51,746		
Quevedo	4,000	2,660			922.	
Zapotal	5,000	3,340			1,160.	
Vinces	1,400	970			323.	
Catarama	1,050	700			242.	
Montalvo	2,000	1,330			1,460.	
Babahoyo	10,400	7,000			2,600.	
Guayas	20,600		.66	31,238		
Vinces	2,900	1,940			1,638.	
Daule	5,100	3,400			3,600.	[6]

Table No. 10: **Continued**

		1968				1983	
		(1) Product per provinces of origin	(2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Estimated acreage -HA-	(5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
	Nobol	1,480	970			342.	
	Duran	1,900				940.	
	Milagro	2,580	1,750			1,806.	[5]
	Chilcale	2,600	1,760			3,000.	[5]
	Naranjal	2,040	1,450			422.	
	Balzar	250	166			58.	
	Empalme	1,200	800			276.	
	Guayaquil	550	315			127.	
El Oro		10,800		.315	34,298		
	Arenilla	1,000	665			1,560.	[2]-[5]
	El Guabo	2,600	1,740			600.	
	S. Rosa	1,000	665			230.	
	La Avanza	1,900	1,270			1,800.	[2]

Table No. 10: Continued

		1968				1983	
		(1) Product per provinces of origin	(2) Estimated export tonnage	(3) Estimated productivity (tons/HA)	(4) Estimated acreage -HA-	(5) Projected export tonnage	(6) Coloniza-tion or irrigation projects
	Pasaje	900	600			707.	
	Pinas	1,900	1,270			935.	
	S. Isabel	400	266			920.	
	Machala	1,100	734			252.	
Bolivar		625		.38	1,608		
	Guaranda	370	247			85.	
	S. Antonio	180	120			41.	
	Balzapamb	75	50			123.	
Others(*)		925	650		2,593	69.	
Total Country		98,482	65,400	.39	251,977	51,400	

(*) Others include: Carchi, Imbabura and Azuay Provinces in the Sierra. With respect to the Oriente provinces while highly promissing for future developments it was not possible to obtain precise or approximate information from Ecuadorian sources.

exports of cocoa will be approximately 51.4 thousand metric tons by 1983.

Production and Location

In most cocoa producing areas of Ecuador, cocoa and bananas are currently interplanted, so that the bananas serve as shade for the cocoa. This planting system makes it relatively easy for the small farmer to become established in cocoa growing. Given our lack of adequate information, we suppose that cocoa plantations are located in the same areas as are the banana plantations. However, changes in the volume of production of certain areas are postulated for the 1969-1983 period. The reason, again, is the assumed increase of productivity per hectare in the already metioned areas of agricultural development. (Table 9 and Map No. 3 indicate these areas)

Coffee

The annual rate of growth for coffee exports from Ecuador was around 4.5 per cent for the period 1952-1962. (Ref. 10, page 29). As shown in Table 6, during the period 1960-1968, the average rate of increase of exports was around 5 per cent per year, and in spite of differences between the predicted volume of exports, and the actual figures for 1968, (16 per cent below)(Ref. 10, page 229), we have assumed that the predicted per cent increase in the coffee exports of 3.5 for the period 1968-1973 will be realized.

With respect to the period 1973-1983, and considering the quota limitations specified by agreement with the International Coffee

Council, we have assumed the following:

1. Consumption of the importing countries, including Eastern Europe and the USSR, will increase at a rate of 2.75 per cent per year, which is equal to the expected annual rate of increase in world consumption between the 1968-70 and 1970-72 levels; (Ref. 10, page 228).
2. Ecuador will maintain a constant 1.2 per cent share of world exports.

With the assumed 2.75 per cent increase in world consumption, Ecuador will have to export around 57,800 tons of coffee by the year 1983, the equivalent of 970,000 bags.*

In Table 10, column 5, the projected tonnage for 1983 has been distributed under the assumption that new irrigation and agricultural developments, together with the utilization of more productive varieties of plants will increase production per hectare. At the same time, a reduction in the total acreage will parallel these policies in areas where no official programs are under development (see column 6, Table 10, and footnotes on Table 9).

The assumption obviously excludes private initiative as an independent factor for production increase and amelioration of agricultural patterns. However, given the predominantly small size of the productive units (88 per cent under 50 hectares, 65 per cent under 20 hectares in 1968) in Ecuador (Ref. 17).

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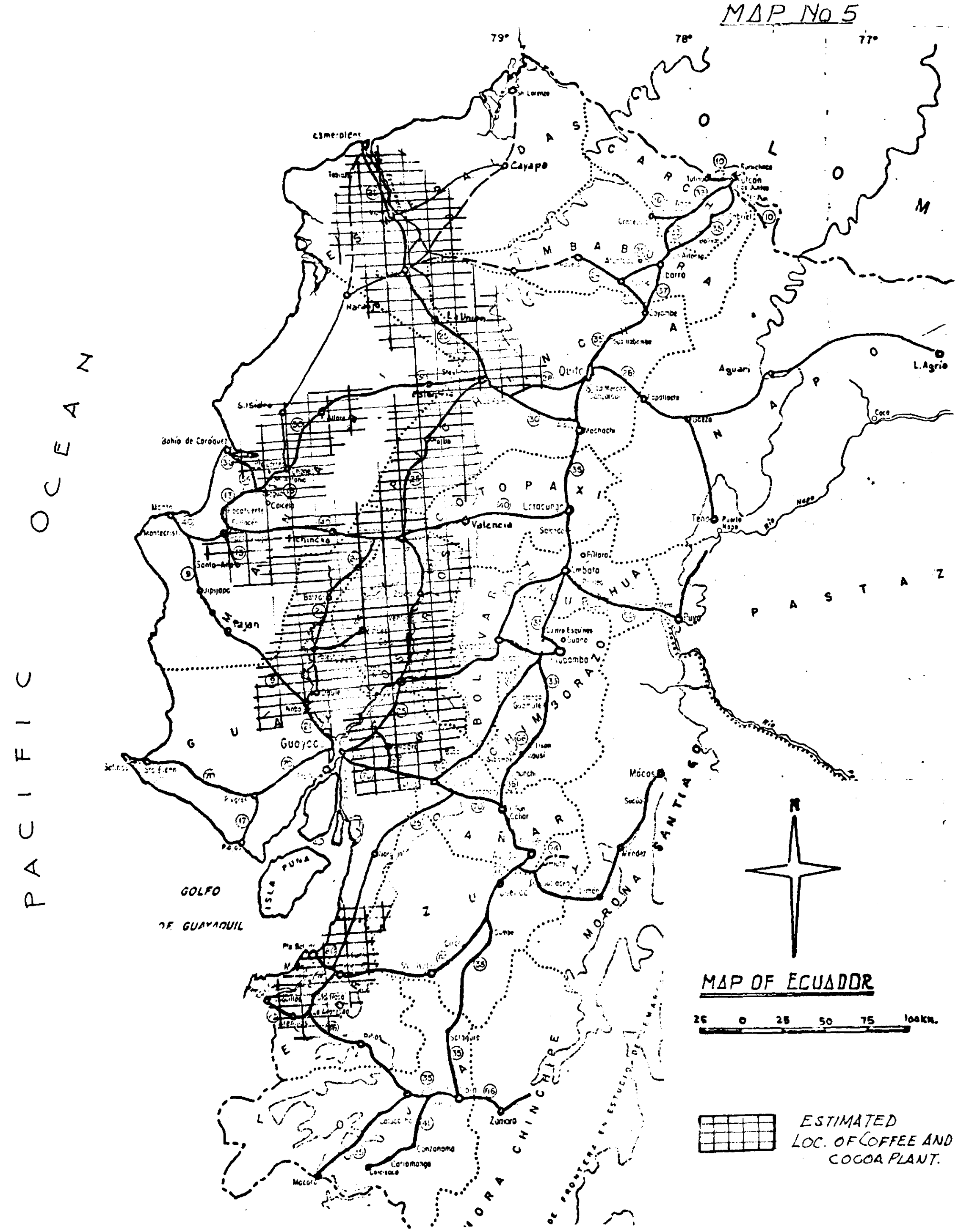
*Bags, refer to the standard coffee bag of 60 kilos, 132,276 lbs.

GEOGRAPHIC LOCATION OF COFFEE AND COCOA PLANTATIONS

MAP No 5



2.2.2 Part 2 - Governmental Policies

Part 2, which represents government policies, was commented upon in Sections 1.3.2, 1.3.3 and 1.3.4. Further considerations are developed in relation to the analysis presented in Chapter 4 and in conjunction with some of our findings in Chapter 5.

2.2.3 Part 3 - Highway and User Cost Submodel

This model is essentially one developed by C.L.M. Systems, for the International Bank for Reconstruction and Development. (Ref. 21) It has been slightly modified in order that it be made more responsive to the particular needs of our study. For our purposes, we will make use of two subroutines: roadway maintenance and vehicle operation. Both estimate resource consumption first, and then calculate the money cost of those resources. The maintenance subroutine predicts surface deterioration as a function of specified construction and road design standards, a specific maintenance policy and an estimated volume of traffic, which is allowed to grow during the period under evaluation.

Costs of vehicle operation are regarded as being functionally related to the type of vehicle and the state of the roadway conditions. Different tradeoffs among parameters affecting road standards, maintenance policies, and vehicle characteristics for each link may be analyzed. Although the original model is capable of calculating construction costs, this operation was omitted in as much as the average cost approach is not considered in our general model.

The highway model can handle multifarious combinations of inputs. It is intended that it supply alternative optimal combinations adequate for planning purposes where sometimes the order of magnitude provides more valuable insight than exact disaggregated calculations.

The model accepts different levels of data accuracy relating highway transport costs to highway design and maintenance standards. It is designed as an iterative time simulation model of construction, maintenance, and operation activities. Flexibility emanates from iterative characteristics which allow for the simulation of important physical and economic relationships.

2.2.3.1 Simulation Structure

The model starts by assuming that road characteristics and design standards are given, while maintenance and operation activities are simulated for each year in the proposed time horizon. The projected traffic flow and the projected maintenance policies (which may follow standardized actions and maintenance standards) serve as inputs. Resource consuming activities such as patching of pavement, or vehicle operation, can be simulated using the above inputs.

Outputs, in particular, costs, may be shown for each year and a corresponding breakdown of labor, materials, transport and equipment is possible. Also, operating costs per vehicle type on a per kilometer basis, as well as a breakdown in driver costs, tires, and gasoline may be obtained.

The analytical time horizon is divided into years, and the years into seasons, thereby permitting a sensible evaluation of traffic conditions during different rainfall periods.

Maintenance Resources

The cost estimate of maintenance is made by using Alexander's model. (Ref. 22) The principal factors entering into the cost structure are:

1. surface maintenance,
2. shoulder maintenance,
3. drainage maintenance,
4. vegetation control.

The major difficulties in predicting maintenance costs appear when the rate of road deterioration and the post-maintenance quality standards are calculated. In our particular case, these estimates were borrowed from prior experiences gained from applying the model to other underdeveloped countries* whose characteristics and standards are similar to those of Ecuador.

2.2.3.2 Operating Costs

The costs associated with

1. the time for the journey (salaries, interest on the vehicle, etc.),
2. fuel costs, and
3. cost of wear and tear on the vehicle (maintenance, depreciation, and tire wear)

*Bolivia

are three of the main expense categories demanding operating resources.

Journey time cost prediction is dependent upon the particular conditions of the roadway and on the vehicle performance. A modification of Saal's model (ref. 23) allows for the estimation of fuel costs as a function of surface type and horsepower used to climb a continuous grade road. Vehicle wear and tire wear expenses are obtained from a set of tables developed by Jan de Weille (Ref. 24) and are included in the model.

Tradeoff Factors Between Vehicle Operation and Maintenance Costs

Roadway surface characteristics provide the main tradeoff determinant between vehicle operation and road maintenance costs. The effects of maintenance are reflected in the speeds that vehicles are able to achieve. Surface deterioration necessitates slower operating speeds and concomitantly increases vehicle wear.

2.2.3.3 Vehicle Performance Cost

This routine operates iteratively to determine the cost of vehicle operation under different road conditions and over different sections of the highway. Vehicle design characteristics are similarly considered. The outputs obtained in this case reflect the capacity of the vehicle design to overcome road conditions.

The analytical approach used to predict vehicle operating costs is related to the vehicle average speed while traversing a road. Numerous intervening factors influence the average trip time, and it has been assumed that only one factor at a time reduces speed. The adopted criteria reject the velocity linear function approach;[1] instead, each of the following factors is considered as an independent constraint to maximum velocity.

a. The design performances of the vehicle, (note: speed is determined by maximum engine operating speed, transmission, and tire size);

b. roughness of the roadway surface;

c. average curvature of the alignment;

d. horsepower potential of the vehicle to overcome rolling surface resistance and air resistance, and to climb grades.

The estimation of fuel requirements, tire wear, vehicle maintenance, and depreciation all depend upon vehicle speed. Consequently, they follow the determination of maximum limiting velocity. After maximum limiting velocity is calculated, fuel requirements are seen as a function of vehicle weight and roadway profile and roughness. Next follow maintenance, tire wear, and depreciation costs. The main computation steps applied and repeated for each vehicle type are:

1. computation of resource requirements per vehicle kilometer;

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[1]Linear additive functions require the estimation of coefficients relaying upon non-experimental data.

2. market cost per vehicle calculated, and then used in conjunction with demand schedule;
3. estimated traffic volume
4. total annual costs for the analyzed vehicle computed in turn.

Many other capabilities and advantages may be obtained from the described model, which are not of our immediate concern. Those interested in more detailed descriptions may refer to the User's Manual, by C.L.M. Systems, Inc. (Ref. 21)

The first level operating costs per vehicle type are computed on a per kilometer basis and are broken down as:

a. vehicle depreciation,
b. maintenance (parts and labor),
c. crew wages,
d. tires, and
e. fuel.

The second level, detailed output for user cost, is listed by vehicle type and per vehicle kilometer:

a. labor hours,
b. velocity, kph,
c. fuel consumption in liters,
d. market costs,
e. parts' cost factor per 1000 kilometers,

f. incremental willingness to pay,

g. number of vehicles in each period.

Only final costs per vehicle and on a per kilometer basis are inputed to the main network program. However, the above indicated outputs allow a great deal of flexibility in the analytical process by permitting a check on the effects of certain parameters. Samples of the output tables are added in Appendix II.

2.2.3.4 Data Input and Assumptions

We will consider the criteria followed by the National Transportation Plan in those aspects related to highway classification.

1. geometric design standards;
2. pavement design;
3. vehicle size and weight limitations

All of the above are explained in more detail in Appendix II.

The highway maintenance submodel evaluates costs derived from a set of technical and operative assumptions that are basic for insightful analysis. We have assigned to Appendix II major details on these aspects, as well as some mathematical and empirical criteria used for specification of those road characteristics required by the model.

2.2.3.5 The Highway - Submodel User Cost and the Assignment of Standard Costs to Different Links of the Ecuadorian Network

The highway design model developed by C.L.M. Systems, Inc., focuses upon the relationship among construction costs, road

Table No. 11: Recommended Geometric Highway Design Standards

	Class C Primary		Class D Primary	Class E Secondary	Class F Penetration
	Initial	Future			
Average Daily Traffic 1983 (vechiles	500-1,200	Over 1,200	100-508	25-100	Under 25
Design Speed (km/hr.)					
Flat	100	100	80	70	60
Rolling	80	80	70	60	50
Mountainous	55	55	45	40	35
Horizontal Curves-Desirable Minimum Radius (meters)					
Flat	300	300	200	160	100
Rolling	200	200	125	70	50
Mountainous	100	100	60	50	30
Grades-Maximum Desirable (per cent)					
Flat	6	6	6	6	8
Rolling	6	6	7	8	10
Mountainous	8	8	8	10	12
Non-Passing Sight Distance (meters)					
Flat	155	155	115	95	-
Rolling	115	115	95	75	-
Mountainous	70	70	55	45	-

Table No. 11: Continued

	Class C Primary		Class D Primary	Class E Secondary	Class F Penetration
	Initial	Future			
Passing Sight Distance (meters)					
Flat	640	640	510	440	-
Rolling	510	510	440	350	-
Mountainous	305	305	215	170	-
Pavement Width (meters)	6.5	7.3	6.1	-	-
Shoulder width (meters)					
Normal Section					
Cut	2.4	2.0	2.0	-	-
Fill	1.9	1.5	1.5	-	-
Minimum Section					
Cut	1.9	1.5	1.5	-	-
Fill	1.4	1.0	1.0	-	-
Out-to-out Shoulders (meters)					
Minimum	9.3	9.3	8.1	5.5	5.0
Maximum	11.3	11.3	10.1	6.5	6.0
Bridges					
Loading (AASHO)	H-20-S16	H-20-S16	H-20-S16	H-15	H-15
Curb to curb (meters)	8.5	8.5	7.3	6.7	4.0
R.O.W. Width (meters)	60	60	60	30	30

Source: Ref. 4 - Table VI-2.

maintenance and vehicle operating costs. It is basically oriented to planning and preliminary design test on a given road, with the objective of improving the basis for decisions on road design standards. Our decision to use the model was principally dictated by the advantages of its versatile outputs, in response to changes in maintenance policies and traffic patterns. Our approach is to expand over an entire network the evaluation of operative costs. A set of "sample roads" is taken from the network each sample road representing other roads with equal design standards and traffic patterns. Operative costs are evaluated for each one of the "sample roads" and are then applied to the group of roads represented by them. Pursuing this, the Ecuadorian highway network has been reclassified by the author using two variables:

1. the highway design class (first seen in Table 11);
2. the topographical characteristics of the terrain.

The following Table shows the result of the above comments, in column one we have the "road sample" number or road type to be inputed into the model.

Road Typification

Road Type (1)	Highway Class Transp. Nat. Plan (2)	Topography (3)	Avg. Length (4)
1	C	Mountain	35.
2	D	"	35.
3	E	"	60.
4	F	"	85.
5	C	Rolling	68.
6	D	"	76.
7	E	"	50.
8	F	"	00.
9	C	Flat	45.
10	D	"	88.
11	E	"	100.
12	F	"	00.

(1) Author's Typification

(2) Ref. 4 & Table 11

In column 3, topographic characteristics have been divided into three main categories which predominate in Ecuador; however, detailed analyses of roadway configuration have been based upon maps of specific areas.*

In column 4, the average length of roads has been indicated. It is an auxiliary input permitting more accurate evaluation of roadway configuration (rate of rise and fall, alignment, etc.) because its influence on operating cost is remarkable. Expansion of this topic is provided in Appendix II.

Operating and User Cost Data

This section of the highway submodel requires data inputs covering two main aspects

1. general costs such as those concerned with vehicle maintenance in terms of labor, driver, and fuel costs, either diesel or gasoline;
2. vehicle-specific costs such as initial cost, tire costs, vehicle cost in sucres/hour, etc.

The already mentioned studies in Refs. 4 and 5 by the Transportation Planning Agency and the "Junta Nacional de Planificacion" staffs, have been the main sources for our estimates. That is the reason why costs are made on a dollar-sucre parity for 1963.**

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*These were drawn to the scale of 1 25.000 and 1 50.000.

**1 dollar = 18 sucres

It is worthwhile to describe some of the basic concepts used in those studies and consequently transferred to our estimations:

2.2.3.6 Operating Ratio and Gross Income Estimates

Operating ratio is defined in (Ref. 4, page VII-6) as the "percentage (......) by which operating costs, including depreciation, are divided to obtain the corresponding gross revenues necessary to cover such costs, including depreciation, and provide a reasonable return on investment."

Under these conditions, an operating ratio of 0.75 requires a charge of 33 per cent over operating costs to indicate the needed revenue. The normal expectation of business practice in Ecuador for financing vehicles is assumed to be in the range of 18 to 20 per cent.

Throughout the model, costs are calculated following two economic criteria. First, Economic Costs which include those costs, not including taxes, which are the social opportunity costs of the resources. Second, Market Costs, which are costs borne directly by the user, including taxes.

2.2.3.7 Vehicle Characteristics

Vehicles considered in this study were classified in four types:

Trucks - those vehicles between 3 and 12 tons, and semi-trailers of 15 tons (Including tank trucks, usually of a 2,000 to 3,800 gallons capacity) "mixtos" - a combination of bus-truck usually between 7-8 short-tons.

Light vehicles - light trucks, pick-ups, jeeps, and automobiles.

A 1973 estimate of the expected useful life for average vehicles would be as follows:

	Life Expectancy (years)	Annual Depreciation
Heavy vehicle	10	10.0%
Light vehicle	11	9.1%

<u>The Average Truck</u>

By "average truck" is intended a vehicle with the following characteristics:

Motive power	80% gasoline-20% Diesel Oil
Vehicle capacity	7.6 short-tons
Vehicle load	3.0 short-tons
Vehicle load factor	40.0%
Vehicle price with tires	S/168.300
Tire price per set	S/17.000
Estimated for 1973	
Kilometers per year	54.000
Ton-kilometers	162.000
Depreciation rate per year	12%

Operating costs were evaluated for six different vehicle types, in order to test vehicle performances under different road conditions and for different vehicle types. With the exception of Truck III (a 15-ton payload semi-trailer (2-S1)) all the vehicles analyzed are currently found in service in Ecuador.

The numbers follow the order assigned in the computer output to each vehicle type:

Vehicle No.	Type	Description	H.P.	max. speed km/hr	fuel used*	gross vhc. wt.**	*** avg. annual rate of growth	**** expected annual deprec.%
1	Passenger Car		80	140	0	1000	0.08	9.1
2	Truck I	1-Ton Panel on P.UP.	100	130	0	2700	0.12	9.1
3.1	Truck II	3.5-Ton Stake or Van	140	120	0	6560	0.12	10.
3.2	Truck II	7.8-Ton Truck-"Mixto"	190	110	0	13400	0.14	10.
3.3	Truck II	10-Ton Truck	210	40	1	14000	0.07	10.
5	Truck III	15-Ton Tractor Semi-trailer 2-52	240	90	1	25500	0.02	10.

* 0 = gasoline
1 = diesel

** weight in kilograms

*** 1951-1962 period (Ref. 4, p. VII-1)

**** due to increase in life expectancy by 1973 heavy vhc. 10 years, light vhc. 10 years.

Truck average loading - unloading time = 1-1/4 hours.

Semi-trailer average loading - unloading time = 30 minutes

Crew Hours/Vehicle Hours Ratio

Vehicle #	Crew	Crew Hours Per Year	Vehicle Hours Per Year	Ratio
** 1	-	52	40	1.3
** 2	-	680	255	2.7
3.1	1	615	440	1.4
3.2	1	1620	1610	1.1
* 3.3	2	1680	1670	1.1
4	2	3180	3100	1.2

* Trip distance one-way 410 km. Guayaquil-Quito. Average velocity 55 km. hour, for an 8-hour trip. (8 + 1 hour, 15 minutes = 9 hours, 15 minutes per man)

** See Ref. 4, page VII-3. A relatively high percentage of passengers are carried in light vehicles, mainly pick-ups and light trucks. Vehicle initial costs are estimated on the basis of the National Transportation Planning Studies, and from several manufacturers' prices for the year 1963.

We have the following Economic and Market Costs. Prices do not include tires. Import duties are included in market vehicle and tire costs.

<u>Vehicle Initial Costs - 1963</u>

Vehicle #	Economic Cost Sucres	Market Cost Sucres
1	29,000	40,000
2	26,100	36,000
3.1	36,500	50,000
3.2	151,400	209,000
3.3	217,000	270,000
5	440,000	600,000

Prices in sucres, 1963.

<u>Tire Costs - 1963</u>

Vehicle #	Economic Cost	Market Cost
1	2,600	2,900
2	2,600	2,900
3.1	11,500	15,000
3.2	15,200	19,000
3.3	19,800	22,000
5	52,200	58,000

Prices in sucres, 1963.

Vehicle Cost per Hour - 1963 Prices - **

Vehicle No.		(1) Avg. Km/Yr.	(2)* Avg. Speed Km/Hr.	(3) Mkt. Cost & Interest	(4) Veh. Cost Sucres/Hr.
1	Private Cars	2,800	70	47,200	59
2	Pick-ups, Jeeps, Short Dist. Hauls	12,800	50	42,500	57
3.1	Light Trucks Locals	26,500	60	59,000	94
3.2	Banana Trucks	96,000	60	246,500	51
3.3	General Cargo	100,000	60	318,500	64
5	Gasoline and Semi-trailers (general cargo)	155,000	50	740,000	80

(3) Interest 18 per cent over three years payment for trucks, two years for passenger cars

* 20 per cent increases over 1963 vehicle-kilometers due to better roads. (Ref. 4, page VII-7 whole country) Estimated speed increase by the same reason, 10 per cent.

** Includes the opportunity cost of the capital invested in the vehicle.

(4) Vehicle Cost in sucres/hour = VC S/H

$$VC1 = \frac{(2) \times (3)}{(1)} \times 0.5$$

$$VC2 \text{ to } VC5 = \frac{(2) \times (3)}{(1)} \times 0.33$$

2.2.3.8 Traffic Demand

Out of a total 5,043,000 metric tons of freight transported over the main corridors of Ecuador in 1962, 3,338,000 metric tons (66.3 per cent) were transported by highway. According to the National Transportation Planning estimates (Ref. 4) an expected 78.8 per cent of the total tonnage for 1973 will be transported on the main corridors of the country. (See Map 6) In spite of that, these calculations were done assuming the Ecuadorian railway system has been rehabilitated. The author believes that it is fair to adopt the same 78.8 per cent distribution given the fact that the expected movement of freight has not achieved the projected growth. So we expect that the simplifications resulting from this assumption will not induce a serious error in freight movement over the system.

Adopting the distribution by corridors, proposed by the National Transportation Plan, (Ref. 4, page V-9) we postulate in Table 14 the total freight distribution by highway in the four corridors for 1973.

In Table 12 are summarized the estimated fleet requirements (average trucks) in order to move the annual tonnage over each of the four corridors. Assuming that an average truck will travel 54,000 km. per year over improved roads, (Ref. 4, Page VII-13) and complete an average intercity trip of 166 kilometers per day (the same item was estimated as 140 kilometers for 1963, Ref. 4, Page VII-7). The number of hours that an average truck is on the road (ATOR) traveling at an average speed of 55 km/hour was calculated:

$$\text{ATOR} = \frac{166 \text{ kilometers}}{55 \text{ kilometers/hour}} = 3 \text{ hours}$$

Assuming a uniform distribution of vehicles over the 24 hours on the road, and taking from Table 12 the fleet requirements, it is assumed the following daily traffic of trucks per corridor:

Sierra-Costa	420 average trucks/day
Costa	416 average trucks/day
Southern	99 average trucks/day
Northern	36 average trucks/day
Total	971 average trucks/day

However, these figures refer only to intercity freight movement, so in order to complete the picture about average numbers of vehicles it is necessary to estimate the relative participation of other vehicles. According to the National Transportation study (Ref. 4, page VII-2) the average numbers of different types of vehicles in intercity service in 1963 were as follows:

Vehicle Type	Quantity	Percentage Distribution
Trucks	2,830	24.5
Mixtos	960	8.3
Buses	1,060	9.7
Light Vehicles	6,600	57.5
Total	11,450	100.00

However, intercity freight movement is made not only by trucks. The average-truck concept includes all those vehicles which participate in intercity freight movement. To distinguish those vehicles, we make a cross analysis between the number of vehicles in intercity service summarized above,in table ,16 which was elaborated with vehicle inventory data from the "Junta Nacional de Planificacion" (Ref. 5, page 108) for 1967.

Estimated Average Per cent Distribution of Vehicles per Corridor for 1973

Freight Vehicles	53.3
Trucks	24.3
Mixtos	8.3
Pick-ups and 1 Ton Trucks (Camioneta)	20.5

MAIN TRANSPORT CORRIDORS - MAP No.6

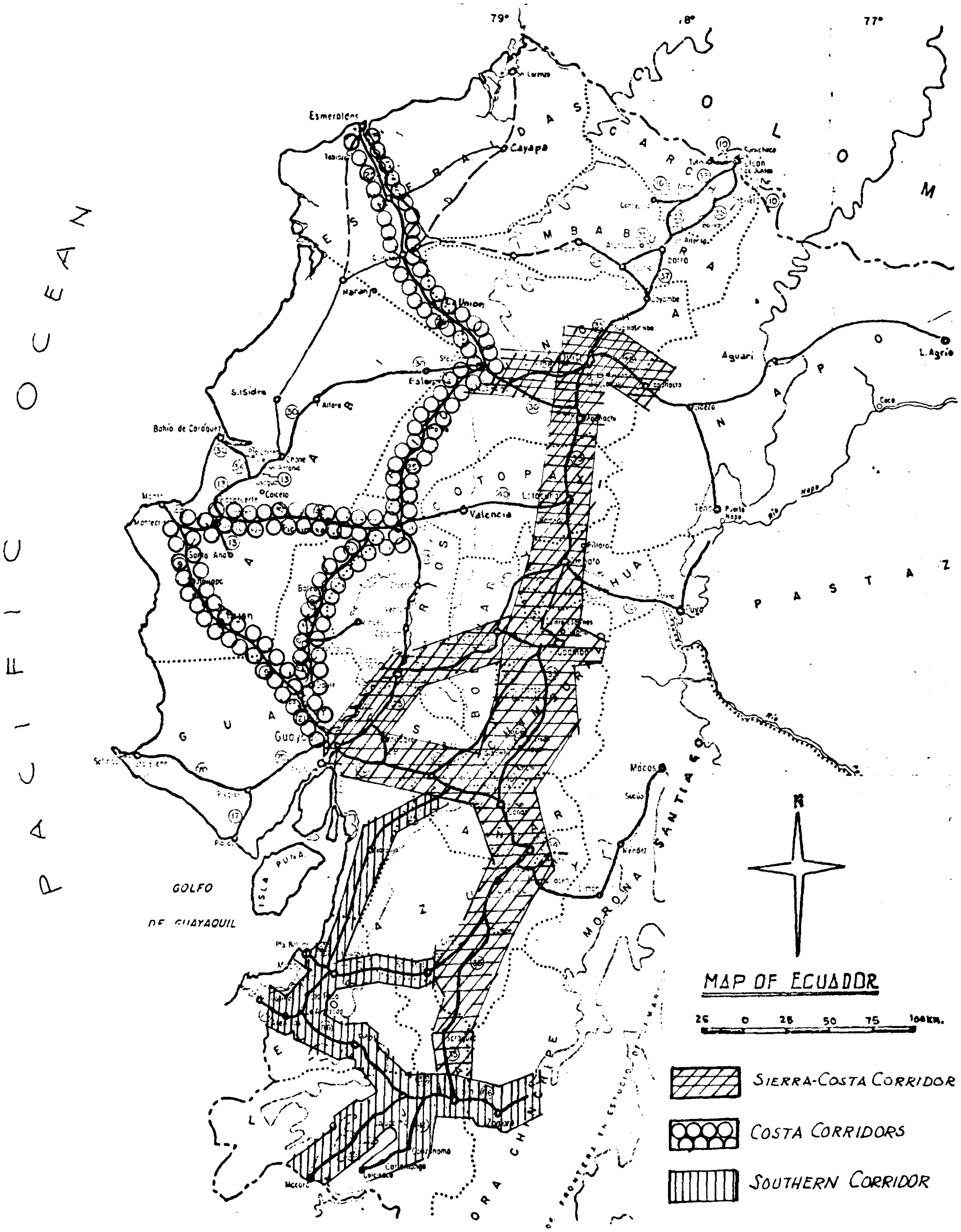

Table 12: Estimated Freight Distribution by Corridors and by Highway (in thousands of metric tons)(*)

Commodity Types	Corridors: Sierra-Costa	Costa	Southern	Northern	Total
Agricultural Including Exports	1,090	2,430	562	84	
Livestock & Dairy Products	210	110	34.8	49.4	
Industrial	2,410	885	231	175	
Exports, Excluding Agric. Exports	61	84	11.4	-	
Imports	37	47	22.8	15.6	
Total Tonnage	2,818	3,686	870	324	8,700

(*)Elaborated with data from Ref. 4, (p. V-6 to V-8)

Notes: Total intercity highway freight movement was estimated around 78.8 per cent of the total intercity freight proposed for 1973. Total projected freights per corridor, has been broken down using the same percentual distribution as in 1962.

Table 13: Estimated annual ton/km per Corridor and Average truck demand for the year 1973. (in thousands of ton/km).

	Corridors				Total
	Sierra-Costa	Costa	Southern	Northern	
Total ton/km thousands	498,704	485,000	112,000	41,500	1,137,204
Average truck for intercity op. ton/km (short) thousands	162	162	162	162	162
Fleet Req. of 'Avg' trucks (3 short tons-load factor)	3,370	3,340	770	285	7,765

Elaborated with data from Ref. 4 (Table VII-5 and pp. V-6 to V-8)

Table No. 14: Estimated Vehicle Inventory of Ecuador broken down by Vehicle Type, Year 1967

Vehicle Types	Number of Vehicles	Per cent
Light Vehicles	33,636	71.5
Passenger car	14,151	30.
Jeep & Station Wagon	7,696	18.
1 Ton Pick-up	11,789	23.5
Heavy Vehicles	10,997	23.3
15 Ton Semi-Trailer	32	0.1
10 Ton Truck	2,450	5.2
8 Ton Truck	2,720	5.7
3.5 Ton Truck	247	0.6
"Mixtos"	1,946	4.2
Buses	3,598	7.5
Others	2,650	5.2
Total Registered	47,279	100.

Tabne No. 15: Estimated Average Number of Vehicles per day per Corridor, Year 1973

		Corridors			
Vehicle No.	Description	Sierra Costa	Costa	Southern	Northern
1	Passenger car	285.3	284	69	25.
2	Truck I	158.7	158	38.5	13.6
3.1	Truck II	16.8	16.1	4.2	1.5
3.2 (1)	Truck II	139.4	175.4	35.5	13.4
3.3 (2)	Truck II	155	132	39	18.2
5	Truck III	3.8	4.5	1.7	0.3
	Total	775	770	187	68

(1) Includes "Mixtos"

(2) Includes "Buses"

2.2.4 Part 4 - Railway System

Although the railway system is mentioned in our schematic flow chart, it was not developed for two specific reason. The first relates to the uncertain future of the rail system in Ecuador, and to a lack of pertinent data.

The second factor relates to the present relationship between port and rail policies. No port in the country, with the exception of San Lorenzo,* has direct connections with the national rail system, i.e., the bridge over the Guayas River at Guayaquil does not handle rail traffic. Thus, a serious disparity is created between the competitive position of the rail and the highway systems in the country's main port. Obviously, the decision to provide no rail crossing of the Guayas was not arrived at as part of an integrated transport policy. Based on the present financial situation of the railroads, their continued dependence upon general resources and the amount that would be required for rehabilitation of the system, it is concluded that Ecuadorian railroad policies will depend on a comprehensive review of the past and present condition of the system. The social cost of its rehabilitation as well as its expected benefits for the country are subjects which would require very serious and concentrated study.

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*See Tables 4-5, 0.4% of the total Ecuadorian export of 1967.

2.2.5 Part 5 - The Interface Submodel

Commodity flows are highly dependent upon the level of complexity of trade interactions. With the exception of short distance hauls, flow demand is normally supplied by the combined services of a variety of network conveyors and links.

The provision of a variety of alternate modes of transport is a cause and effect process subject to environmental requirements and constraints. The term environment is used here as an expression encompassing socio-economic, geographic and transactional patterns within an economic space.

One of the physical results of modal diversification is a convergence in time and space of vehicles with differing payloads, performances and right of ways toward singular points in the network. These points are called interface nodes. They are facilities where cargo and/or passengers are transferred from one mode to another to assure the continuity of flows.

2.2.5.1 Conceptual Approach of the Model

Network terminology provides a convenient graphical means for describing the class of optimization problem with which we are here concerned. The interface submodel deals with the operational system involved <u>in the process of commodity transfer</u> between different modes passing through an interface facility.

This transfer process consists of N operational subsystems or tasks. The time and cost of performing each task are known or estimated, and a precedence-ordering among tasks is made to indicate which must be finished before each particular new task is initiated.

The goal is to calculate the completion time and costs either for the entire operation or for groups of tasks for each mode and each commodity moving through the entire facility. Stated in these terms, our formulation is an application of the "critical path scheduling" problem. Obviously, our problem is to optimize a transfer process taking into consideration two variables: the mode of transport, and the commodity to be transferred.

Let us analyze the process in terms of the mode. It consists of four tasks indicated in the following Table.

Modal Transfer Process - (One mode, two commodities)

Operational Subsystems Description	Nomenclature	Immediate Predecessor	Completion Time
Waiting in queue for unloading berth	A	-	t_A
Unloading operations of commodity 1	B	A	t_B
Queue time, while waiting for a loading berth	C	B	t_C
Loading time operations of commodity 2	D	C	t_D

In order to formulate the mathematical optimization model, it is only necessary to introduce the variables representing the starting time of each of the tasks, so that:

y_A = starting time of operation A

y_B = starting time of operation B

y_C = starting time of operation C

y_D = starting time of operation D.

With y_E representing the entire time in which the whole process is finished the problem can be stated in terms of an appropriate linear programming model, whose object is to minimize y_E.

A rough graphical representation of the process with alternative completion times for each task may be represented by a network through which the optimum path is a compromise between the minimum time and minimum cost for the entire operation.

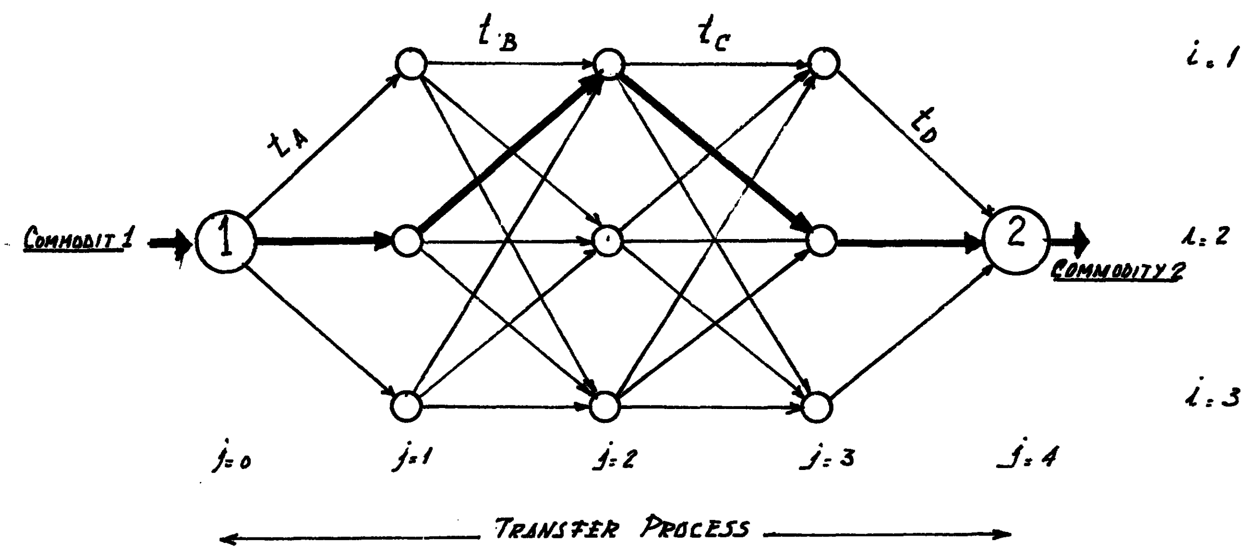

FIGURE 4

In summary we can say that interface operations in our model may be represented by a path* in which flow "resistance" is expressed by the cost of traversing the "links" throughout the facility.

The analysis in terms of a one commodity transfer process proceeds in an essentially similar fashion, but here the cross-relationship is established between the two transport-modes in the system (a given commodity is transferred through the facility from mode A to mode B). In the case in which the process is viewed in terms of cargo (one commodity) a four task process is also envisioned.

Commodity Transfer Process (one commodity, two modes)

Operational Subsystems Description	Nomenclature	Immediate Predecessor	Completion Time
The cargo is waiting, while mode A is in queue for an unloading berth	F	-	t_F
The cargo is unloaded from mode A, (Inbound Node)	G	F	t_G
The cargo is stored in interface facilities waiting for departure of mode "B" (1)	H	G	t_H
The cargo is loaded into mode "B", (Outbound Node)	I	H	t_I

*Directed Chain

The mathematical optimization model follows exactly the same steps as in the previous case. The variables representing the starting times of each of the tasks are:

y_F, y_G, y_H and y_I while y_J is the variable representing the time expended in the whole process. This latter variable is to be minimized through the linear programming approach. Fig. No. 5 reproduces the commodity flow process throughout the operational network. Again, the optimal path is made up of that series of links which offer minimal "resistance" in terms of costs per unit flow of cargo.

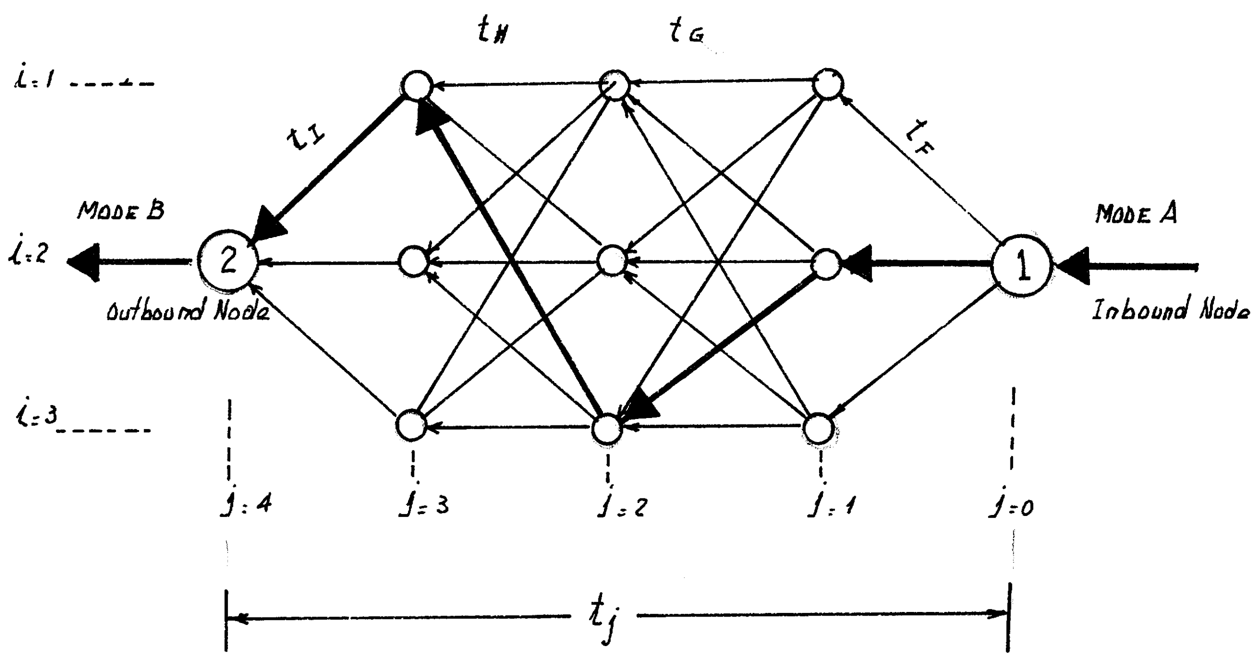

Figure No. 5

In the preceding examples, we have focused on Directed Networks which are conceived of as a set of links connecting pairs of nodes. Whenever the word "path" appears, it must be understood as a Directed Chain (Ref. 30, page 191).

In a bymodal interface facility, each flow direction moves along a singular operational path, and the entire facility is therefore composed of two paths.

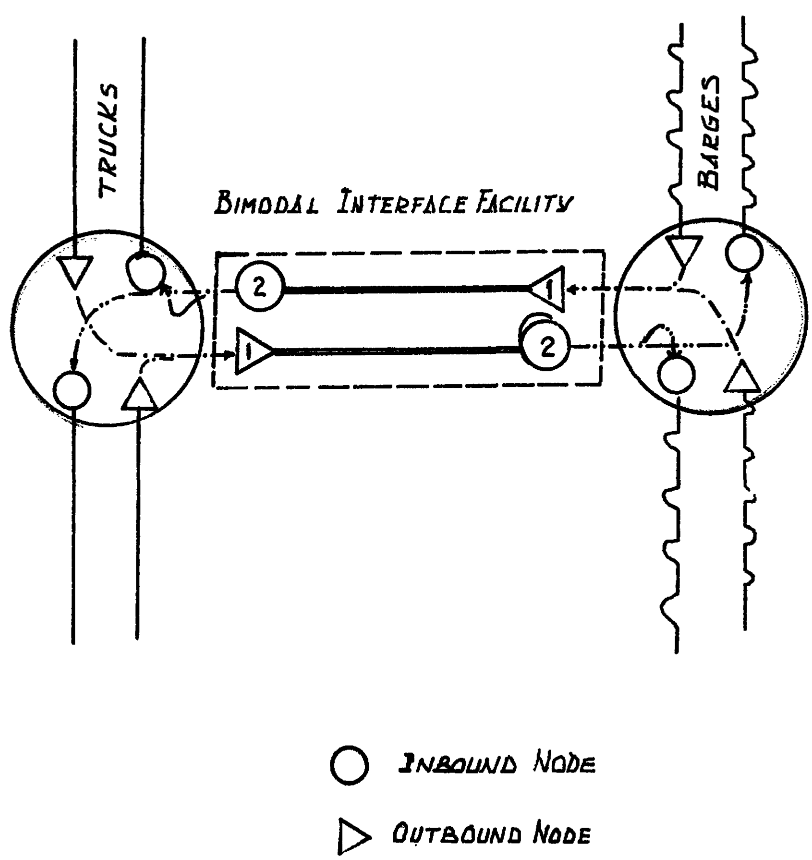

Figure No. 6

As the number of modes which converge at an interface facility increases, operational complexities multiply. The experience gained with regional airport or a port for ocean liners, provides good examples of this increase in complexity.

Our method for analyzing multimodal interface nodes utilizes a combination of the two scheduling problems previously described.

2.2.5.2 Operational Networks and Independent Commodity Sets

The Roberts, Shoup and Ginn model (Ref. 31), and a report by the UNCTAD Secretariat, (Ref. 32) agree conceptually on the disaggregation of commodities into groups having similar technological and handling characteristics. Apparently, numerous arguments and practical illustrations demonstrate the advantages of analyzing, as independent sets, commodities demanding homogeneous handling techniques, e.g., commodities requiring similar facility requirements and the like.

Though in this study a limited number of commodities are considered the same criteria will be followed. Consequently, in dealing with interface and transport operations we have selected three commodity groups

1. special cargo (bananas);
2. general cargo (coffee and cocoa in bags); and
3. general cargo (agricultural capital goods, light machinery).

Once commodities are grouped into homogeneous operational sets, the problem in terms of interface processes becomes apparent. For each operational subsystem (or task), an ample range of possible technologies, handling means, and associated cost characteristics exists. Accordingly, the optimum path through a given facility is made up of a sequence of links connecting nodes. These nodes are now located in a space in which the coordinates are the state of the process (number assigned to each operation subsystem), and the possible stages (the number of possible technological and cost characteristics) that can be used to go from one state to the following state in the process. In this manner, an interface process may be viewed as an operational network in terms of which planners may rank alternative paths.

In formal terms, X_{ij} represents a node in stage i of state j, and the costs of transiting from this node to each one of the possible stages in the next state constitute links of the system. This conceptual framework was illustrated in Figures 4 and 5 and the hypothetical optimal paths there represented were assumed to result from rational decisions in which the required information as well as the adopted optimality criteria were clearly stated.

2.2.5.3 The Model

In their application to the Ecuadorian case the model is dealing with the actual operational processes occurring in each particular interface, no new configurations are assumed during the planning horizon. Performances has been derived from actual local technological and labor standards. The needed information for evaluating state performances of the process are inputed through the use of Tables. Data Tables are made available to the model for each commodity set and for each transport mode which might be utilized in the process. A large number of combinations is possible, and in operative terms, each combination may be evaluated independently and stored.

When a specific facility is to be analyzed, the operative combinations applicable to it are taken from storage and the total transfer cost is estimated. The data input takes the form of rates and performance information for each berth of each final node of the interface process (inbound or outbound). Thus the number of channels or berths serving a given flow must be stated precisely.

Data Input by Commodity Set and by Mode

a) unloading rate per hour, in tons

b) loading rate per hour, in tons

c) ordinary working hours at the facility (labor is paid at the basic wage rate)

d) maximum number of working hours at the facility, per day;

e) number of regular workers employed in the operation (per berth);

f) average basic wage rate of the labor force, per man-hour;

g) fixed operating cost per berth-day;

h) variable operating cost per dock-hour;

i) overtime wage rate;

j) cost associated with probability of losses in the facility.

Data Input Associated with the Transport Mode (vehicle characteristics)

a) payload

b) hours of utilization per day

c) vehicle cost per hour

Data Input Associated with the Interface Commodity Flows

a) average daily tonnage, disaggregated into average inbound tonnage and average outbound tonnage;

b) average number of vehicles per day, disaggregated by vehicle type, inbound vehicles and outbound vehicles.

Breakdown of the Interface Process

In this model the interface process is broken down according to the sequence of states involved in the already described movement of commodities and vehicles throughout the facility. These operational directed chains are divided into the following states:

State 1. Time waiting in queue for unloading berth...

Inbound vehicles carrying the cargo may have to wait for unloading berths. This time was already termed queue time, and its effects on facility congestion and vehicle cost operation are apparent.

State 2. Unloading time...the period of time between vehicle berthing and termination of vehicle unloading.

State 3. Commodity storage time...this part of the process is related with cargo delays in facility installations, and their associated costs.

State 4. Time waiting in queue for loading berth.... Outbound vehicles may have to wait for a loading berth, the effects on facility installations, and vehicle operative costs may be the same as in State 1.

State 5. Time actually loading...This is the time spent by a vehicle at its loading berth while loading operations are underway.

The proposed sequence is the same as that utilized by Roberts, Shoup, and Ginn in their model (Ref. 31), and with the exception of Stage 3, we used the same logical approach to the analysis and evaluation of the other stages. Modifications have been introduced in order to adapt the model to our own needs and data resources.

Outbound-Inbound Vehicles, Waiting Time

The analysis is carried out on a commodity by commodity basis and for each vehicle terminal at the facility. Each vehicle terminal may have S berths which nominally are shared by inbound and outbound vehicles; so two cross processes appear superimposed in the same berth. However, treating them independently offers logical advantages while the additional complications are easily handled by computational procedures within the model. In its final expression, the waiting time (W) for a vehicle is represented by

$$W = \frac{\ell}{r} \qquad (1)$$

Where

W = DWAIT* = waiting time

ℓ = ALENG* = Average length of string of vehicles waiting in a queue

r = ARR* = Arrival rate of vehicles

W is in many respects the result of a direct application of queueing theory. The model assumes an M server queue with random arrivals and exponential service. Details of all the computational steps of this state are shown in Appendix III.

Loading and Unloading Times and Costs

Loading and unloading operations depend upon the characteristics and relationships between interface facilities and vehicles. Interface facility performance is identified by a set of parameters inputed to the model and correlated with the level of technology,

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*Variable names in the FORTRAN Program (Appendix III) manpower, and management as well as the configuration of the facility (design, number of berths, etc.).

The total time for loading or unloading a vehicle is a function of its payload, the hours per day devoted to the process and the relationship of the vehicle with the handling techniques and facility configuration of the terminal. Payload may be specified as the actual capacity of the vehicle or, in cases in which the full capacity of the vehicle is not loaded (or unloaded) at a particular facility, the average capacity of its utilized tonnage can be specified as the payload. For example, ocean-going vessels calling at different ports may, on the average, transfer one-fourth of their total payload at any one port. The flow of a particular commodity may suffer different "friction effects" along the path between its inbound and outbound node. Because of vehicle and cargo handling characteristics, the transfer process at one node, may require different times to move a given tonnage than at another. Having to deal with two direction flows at each nodal termini, the time required is a function of the flows at both termini. This is the starting point for evaluation of a set of items such as:

1. Time required to move the average inbound and outbound tonnage per day;
2. hours within the ordinary working schedule;
3. hours overtime, and their differential effects on labor and operative costs at the facility.

The operating costs for each terminal node and each commodity are then calculated as

$$Q_1 = [c + h(v.f + s) + t(m.v.f + s)] .b \qquad (2)$$

Where:

Q_1 = CSPRDY* = operating cost per day in termini No. L for commodity K.

b = IDOCKS (IP,K,M,L)* = Number of berths at termini No. L for mode M, commodity K and port IP.

C = FIXDOP (IP,K,M)* = number of working hours per day per berth (hours at normal salary rate plus hours at overpay rate)

v = WARATE (IP,K,M)* = weighted average basic wage rate per hour, per man (labor force)

f = LABFOR (IP,K,M)* = number of workers employed at the facility at any given time per berth

s = OPCOST (IP,K,M)* = variable operating costs for one berth, per hour

t = HRSOVR

m = WAMUL (IP,K,M)* = wage multiplier to be used in computing overtime wages.

Once a computation is made for the terminals at both ends of the interface path, the results are summed to arrive at the total

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*Variable names in FORTRAN Program (Appendix III) operating cost per day for a given commodity set K. Then

$$Q = Q_1 + Q_2 \tag{3}$$

In order to obtain the daily operating cost per ton of commodity K, the daily operating cost given in (3) is divided by the sum of the inbound and outbound tonnage as in (4)

$$Q_T = \frac{Q}{A_i + A_o} \tag{4}$$

where

Q = COSTPD = total operating cost per day for commodity set K, and Mode M in port IP.

A_i = ADT (IP,K,M,1) = average daily tonnage inbound, commodity set K, and Mode M in port IP.

A_o = ADT (IP,K,M,2) = average daily tonnage outbound, commodity set K, and Mode M in port IP.

Data input referring to facility installations and vehicle mode are inputed at each run and thus make possible the simulation of the operation of existing facilities on a commodity by commodity, and mode by mode basis.

Commodity Storage Time and Cost Changes

For the purpose of determining interface performance, development of a new routine able to simulate the interaction between commodity storage time, seasonal vehicle availability and seasonal cost variations did not appear to be warranted.

Furthermore, utilization of such a routine, apart from the required computational effort, would demand a data background which is non-existent in the majority of developing countries. In addition, our concentration on a limited set of commodities makes it more practical, for purposes of total interface performance calculations, to use or estimate average storage times and port charges per commodity for each one of the ports. In Ecuador, commodity trade patterns, flow configurations, and interface requirements are strongly influenced by the regional polarization generated by Guayaquil. Under this point of view, interface operations, port warehousing services, and port charges take on a singular connotation, and must be analyzed independently.

We have come to the point in which the states and stages of the interface operational networks may now be put together. The cost and time relationships associated with the path followed by each commodity flow is taken as the measure of interface performance. Thus the model's final computations deal with

1) Total Travel Time of Commodity K

$$T_T = \frac{W_i}{P} + U_T + L_T + \frac{W_o}{P} \qquad (5)$$

where unloading time per ton:

$$U_T = \frac{\mu \cdot s}{A_i} \cdot h \qquad (6)$$

and loading time per ton:

$$L_T = \frac{\ell \cdot s}{A_o} \cdot h \qquad (7)$$

Nomenclature

W_i = DWAIT* = waiting time in queue, waiting for unloading

W_o = DWAIT* = waiting time in queue, waiting for loading

P = PAYLOAD (IP,K,M)* = vehicle payload

u = UNLODR (IP,K,M)* = unloading rate per hour in tons per berth

ℓ = UPLODR (IP,K,M)* = loading rate per hour in tons per berth

s = DOCKS (IP,K,M,L)* = number of berths

A_i = ADT(IP,K,M,1)* = average daily tonnage inbound

A_o = ADT (IP,K,M,2)* = average daily tonnage outbound

h = HRSNOP* = total number of working hours per day per berth

2) Total cost of interface services per ton of commodity K.

$$C_{IF} = Q_T + L_C + T_C \qquad (8)$$

$$L_C + (T_T + S_T) \cdot P_\ell \cdot M_K \qquad (9)$$

$$T_C + V_{LU} + V_C \qquad (10)$$

$$V_C + \frac{W_i + W_o}{P} \cdot M_V \qquad (11)$$

*Variable names in FORTRAN Program (Appendix III) where

C_{IF} = TINCST (M,L) = Total Interface Cost operation

L_C = CSLSPT (M,L) = Cost of losses, per ton

M_V = VOPCST (IP,K,M) = Vehicle Operating Cost, per hour

T_C = TURCST (M,L) = Turnaround Cost of vehicle mode M

V_{LU} = CSPTVO (M,L) = Cost of vehicle time while engaged in loading-unloading operations, per ton

V_C = CSPTWQ (M,L) = Cost of vehicle time while waiting in a queue.

2.2.5.4 Ecuador Ports and Data Input

In general terms, ports in Ecuador correspond, in the marine jargon, to one of two configurations, namely lighterage ports and alongside berth ports. And in the three of its principal ports, Guayaquil, Manta, and Bolivar lighterage and alongside berth technologies are both used.

The consequence in terms of operational and productivity data is that the standard summary information presents misleading figures. While the current data permit a reasonable estimation of some costs, in other areas, such as fixed operating cost per day, personnel on the port payroll, variable operating costs and basic average wages a variety of indirect calculations have been required to obtain useful estimates. Figures in many cases represent our best guesses and were derived on the basis of relationships among operational patterns in a port and its principal commodities. Orders of magnitude among ports were in still other cases the principal factor on which our data was based.

The port of Guayaquil has been the major source of information against which to check and evaluate the figures for other ports. The reasons for choosing that port are

1. In spite of wide traffic differences with other Ecuadorian ports, it is possible to find disaggregated information on lighterage and alongside berth operations;
2. More adequate series of statistical data are available for Guayaquil than for the other ports. Data used in our model were obtained from actual figures regularly published in "Informative Boletin" of the port of Guayaquil.

Direct information especially requested from authorities at the other seaports has also been used as well as other sources like the "Boletin del Banco Central del Ecuador."

Technological and Cost Characteristics for the Ports

Port of Guayaquil

The International Bank for Reconstruction and Development authorized a loan of $13 million U.S.* for the construction of the port in 1959. (Ref. 39, page 25) According to a report of the "junta de Planification y Coordinacion Economica" (Ref. 5, page 173) the original estimated cost for port construction and its equipment was increased by 91 million sucres between 1959 and 1963. Therefore, the total cost of the port was around S/353.5 million

*1 Dollar 1959 = 16.25 Sucres

at 1963 prices.*

Assuming a 30 year loan at 2% interest it was estimated that the annual charge for capital amortization and interest was S/7.31 million at 1963 prices.

The Guayaquil Port Authority also maintains an annual allocation of S/15.715 million to cover maintenance expenses. (Ref. 4, page X-9).

Therefore, the cost to the port authority for capital amortization, interest and reserves for maintenance, totals approximately S/39,500,000 per annum, or S/108,000 per day. However these figures represent only a gross overall expense and it would not be fair to distribute it uniformly among the 12 docks under the jurisdiction of the Port Authority. These capital charges and expenses were a consequence of the construction of the new maritime terminal while the Guayas River installation represents sunk capital.

Consequently it was assumed that Port Authority expenses in the Guayas River accounts for only 20 per cent of the funds allocated for maintenance and dredging of channels. Therefore the fixed cost for the maritime terminal was taken as S/100,000 per day and for the Guayas River installations S/8,240 given total daily fixed costs for the Port Authority of S/108,240.

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*1 Dollar of 1963 = 18 sucres

We thus obtain as an estimated fixed cost for one dock per day* :

S/14,285 for the Maritime Terminal and

S/1640 for the terminals at the Guayas River

Port employees and wages: In 1970 the port's permanent staff was 865 employees comprising 392 white collar workers and 474 laborers. (Ref. 35, page 70) It was estimated that the average pay per employee per day was around S/144,** which represented an average daily expense to the port of S/124,200 at 1963 prices. Service responsibilities of the Guayaquil Port Authority cover, with different degrees, the New Maritime Terminal at Estero Salado and the Guayas River installations. It was estimated that on the average the port authority is responsible for 12 piers and anchorage areas for ships coming to the port. In order to estimate labor charges per dock we decide to assign 70% of the fixed labor costs to the New Maritime Terminal and 30% to the Guayas River facilities. Therefore: the Labor Charges per day are S/87,000 for the New Terminal and S/37,200 for the Guayas River facilities.***

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*Maritime Terminal = 7 Docks; Guayas River installation = 5 Docks

**In sucres of 1963

***According to Ref. 35, p 79:
Average hourly pay per white collar worker = $U.S. 0.85 (1970)
Average hourly pay per laborers (with social benefits included) = $U.S. 1.00 (1970)

Also 80% of the charges in the New Maritime Terminal were assigned to the five alongside berths and the rest to its two anchorage areas. Given these assumptions the following estimates were derived:

Fixed Labor Costs for 5 Alongside Docks = S/69,000 per day

Fixed Labor Costs for 2 Anchorage Docks = S/18,000 per day.

On the basis of the above estimates, the average number of employees may be allocated on the following basis:

Employees per dock in Guayas River installations = 51 persons

Employees per dock in the New Terminal area = 81 persons.

Variable operating costs: These were calculated using Table 18, taken from an M.I.T. Masters Thesis by T.S. Milas (Ref. 35). In this table it is shown that for a 5,000 NRT liner ship with 1,000 tons payload the charges paid per ton of cargo were around $U.S. 5.46*, excluding stevedoring charges, which in our model are considered separately. Assuming that the average alongside dock has 56.12 tons per hour througput (Ref. 37, page 71) in 1969, it was estimated that the variable operating cost per dock-hour (excluding stevedoring charges) was $U.S. 312 equivalent to S/5630 (sucres of 1963) (Ref. 19, Annex page 11).

With respect to the Guayas River, it was assumed that port charges were made up mainly of port dues, which are related to cargo in weight tons (T) and length of the ship (L). Port dues

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*$U.S. 1970 = 24.75 sucres

could be estimated as follows (Ref. 35, page 67). Port Dues = \$0.2L + \$2 T. And in the case of our "sample vessel" this will amount to \$U.S. 2.10* per ton. However, some reduction in cost may be necessary since a lighthouse is not available on the river, and in turn, no dues are charged for this service.

In many respects, port charges are quite similar between Guayaquil and the port of Buenaventura in Colombia (Ref. 35, pp. 70-71). From information available on the Colombian port it was estimated that lighthouse dues were \$U.S. 1.46 per cargo ton for a ship of 5,000 NRT. Therefore, the resultant port dues on the Guayas River would be: \$U.S. 2.10 - 1.46 = \$U.S. 0.64 per ton.

It is known that municipal taxes and tolls are charged to the owners of private docks located along the river, our best guess in this matter is that they may be close to \$U.S. 1.00 per ton, therefore total operating charges per ton would be around \$U.S. 1.64. The average throughput for a dock in the Guayas River, according to calculations shown in Table 19, is around 45 tons per hour. In consequence, it was estimated that variable operating cost per hour in a River Dock (excluding stevedoring charges) was \$U.S. 66 equivalent to S/1160 (sucres 1963). (Ref. 19, Annex page 11)

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*\$U.S. 1970 = 24.75 sucres

Stevedoring Charges

In Guayaquil port stevedoring charges take a "flat rate" form They are left to private firms and do not appear in the port tariff. This method of handling stevedoring charges will be applied also to the rest of the Ecuadorian ports. "Presumably, the private stevedoring operations are either under government regulation, or because a free market equilibrium exists for these services, the stevedoring charge per ton is fairly uniform." (Ref. 35, page 78)

Import and export stevedoring charges vary between $U.S. 2.66 and $U.S. 3.86* per ton. Turning to Table 18, we find that for our 5,000 N.R.T. liner ship stevedoring charges were on the order of $U.S.3.00 per ton (including social benefits and profit of entrepreneurs). In order to estimate the basic hourly wage it was assumed 2.5 shifts of 5 gangs of twenty persons were required to load and unload 1,000 tons during 21 hours, accordingly

$$\text{average - tons per manhour} = \frac{1000}{21 \times 100} = 0.475$$

average hourly pay per man = 0.475 x 3 = $1.425*

If we assume that the profit of the private stevedoring firm plus social benefits amount to approximately 100 per cent of the basic wage (Ref. 35, page 79) the average hourly basic wage per laborer

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*1 dollar 1970 = 24.75 sucres

would be $U.S. 0.61 equivalent to S/11.*

Port of Bolivar

Port of Bolivar ranks as the second exporting port in banana trade after Guayaquil. It is situated on the sheltered waters of the Jambeli channel, at the junction of the Guayas River and the Gulf of Guayaquil.

Capital investment in the port was increased by S/41 million in 1967 (Ref. 34, page 19) and a further capital investment of S/17 million is expected during the period 1968-1973 (Ref. 5, page 174).

The port is also expected to operate a pier for deep draft vessels (equivalent to two docks) for direct transfer of freight. In addition, the port will have adequate warehousing facilities and a 90 foot berth with floating platforms for coastal vessels. Two anchorage areas for deep draft vessels are expected to continue in operation in the sheltered waters of the port. Thus, for our purposes, four docks were considered to be at the service of ocean going vessels.

Fixed Operating Costs: It is estimated that the port authority would have to pay an annuity of S/2.8 million. At 30 equal installments at an interest rate of 2 percent over S/61 million, at 1963 prices, has been assumed.

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*The average monthly salary of a specialized industrial worker was S/1920 (S/12 per hour) in 1969 (Ref. 19, p. 112, Annex).

Port Employees and Wages: It was not possible to obtain information about the port white collar and laborer staff, so an estimate of around 208 persons was adopted on the basis that this figure represented the average number of employees per dock on the Guayas River under the Guayaquil Port Authority (52 persons per dock).

With respect to wages, the average monthly salary estimated by the Area Handbook of Ecuador (Ref. 40, page 70) was used, namely S/1,106, representing around S/7 per hour per employee on a 40 hour labor time. Therefore, a fixed operating cost of around S/1920 per dock per day at 1963 prices was estimated.

Stevedoring Charges

It is known that labor supply in this port is highly elastic and port operations are predominantly manual. It is assumed that stevedoring charges are left to private firms, as in Guayaquil. The average loading-unloading rate is estimated at 39 tons per hour per dock. This means that to load 1,000 tons would require 26 hours. Therefore, assuming 3 shifts* for five gangs of 20 men each:

$$\text{Average tons per manhour} = \frac{1000}{26 \times 100} = 0.385.$$

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*Hours of Work (Ref. 42, page 18)

8 am to 5 pm with one hour lunch
5 pm to 1 am with one hour supper
1 am to 8 am with one hour breakfast

And assuming an average stevedoring charge of $U.S. 2.66* average hourly pay per man = 0.385 x $2.66 = $1.04. Making the same assumption as in Guayaquil (100 per cent overcharge due to profit and social benefits) the hourly wage per laborer is $0.43 or 7.75 sucres at 1963 prices.

Port of Manta

Manta is a port with anchorage for the largest vessels. It has available two quays for oceangoing vessels (4 docks), two marginal wharves, each 100 meters long, for lighters and private storage for about 1,500 tons. For our purposes, and including the anchorage areas, six docks were considered as serving oceangoing vessels.

According to calculations of the national transportation planning staff (Ref. 4, page X-14) the total estimated cost of a port with deepwater terminals was around S/64,308,490 in 1963.

Fixed Operating Costs: Assuming 30 year loans at 2% interest, port fixed charges (with the addition of an annual 50 per cent capital reserve over capital costs per year) would be about 4,310,000 1963 sucres per year.

Port Employees and Wages: The number of port personnel was estimated using the same rule as for the Bolivar Port. On this basis the port would be run by a staff of approximately 364. (Assuming 52 employees per deep water dock and 52 more

*Lower level stevedoring charges in Guayaquil, 1970 prices.

for the two coastal marginal wharves.)

With respect to wages, they were assumed to come to about 1,106 sucres* per month (Ref. 40, page 70), representing around S/7 per hour per employee on a 40 hour-week labor time. Therefore fixed operating costs per day per dock were assumed to be around S/2864* per dock.

Stevedoring charges: The average loading-unloading time was estimated to be around 43 tons hour per dock. The following Table, elaborated with data supplied by the captain of the port, shows an increase in port productivity of around 10 tons-hour between 1962 and 1966, so given the lack of other information the 1966 data has been assumed as the present performance per dock.

Average Ton-Hours per Ship (estimated)

	No. of Ships	Total Throughput Metric Tons	Avg. Time per Ship in Port	Tons-Hour
1964	300	68,157	6.9	32.8
1970	361	198,435	12.7	43.3

Source: Port of Manta - Captain of the Port - January 25, 1971.

The main reason of this increase was ascribed to the activity developed on the two new deep water wharves.

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*Sucres at 1963 prices.

Stevedoring is again assumed to be under private firms. With 43.3 tons-hour per dock it was estimated that a 1,000 ton payload ship would require 23 hours and 30 minutes approximately. Therefore assuming the same basic average wages as in Bolivar Port, the hourly wage per laborer would be $0.48 or S/8.64 at 1963 prices. (The slight difference between final salaries in both ports is due to the level of productivity per man.)

Port of Esmeraldas

Esmeraldas is a lighterage port which is mainly engaged in the banana traffic. The port is situated at the south bank of the river about one mile from the entrance from the sea. The depth of the entrance channel and of the anchorage area ("La Poza"), is about 30 feet, but it is subject to the extensive shoaling. In Tables 3 and 4, show that Esmeraldas has experienced a decline with respect to the country's total export tonnage of about 4.3 per cent between 1962 and 1966. The number of ships visiting the port has declined 2 per cent in the same period. The difference may be interpreted as a reduction in the number of tons loaded per ship calling at the port.

Recommendations in major studies dealing with Ecuador's transportation problems (Ref. 4, Ref. 5) did not recommend significant improvements to this port. A simple concrete wharf with other minor improvements would have required an estimated investment of 2.2 million sucres in 1963. This figure was based on the same loan conditions which we applied to the ports discussed previously and would have resulted in a capital charge of S/132,000 a year. (Adding 50 percent over the required annuity for capital reserve.)

Port employees and wages: It was estimated that no more than 30 persons whose average monthly wage would be around S/990* (Ref. 40, page 70) were employed at the port; therefore the fixed charges of the port would be in the vicinity of S/1500 per day. Assuming two anchorage sites in the stream this would result in a charge of S/750 per dock.

Stevedoring Charges: On the average, loading operations were assumed to take approximately 24 hours per vessel. According to the same source (Ref. 34, pages 85-88) vessels anchored in the stream have been loading an average of between 300 and 700 tons. The loading of 700 tons was accomplished, on the average, in 36 hours (5 shifts of 100 men each are assumed to be working). (Ref. 34, p. 88)

Therefore:

Average tons-per man hour = $\frac{700}{36 \times 100} = 0.194$

Assuming the same stevedoring charge as in Bolivar.

Average hourly pay per man = 0.194 x 2.66 = $0.54.

Discounting 60% overcharges due to profit of private stevedoring firms and social benefits, the hourly wage per stevedore would be around $0.27 or 4.86 sucres at 1963 prices.

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* 1 U.S. dollar = 24.75 sucres (1970)

Resume of Port Data Input

Guayaquil Port - new terminal -

1. Average loading and unloading rate = 52 tons/hour
2. Number of hours payed at ordinary rate = 18 hours
3. Total working hours at the facility = 24 hours
4. Labor force:

   Stevedores, five gangs of men with 20 men to a gang 100
5. Average basic wage rate, per man hour = $0.61*
6. Fixed operating costs, per dock-day (Capital Costs + Staff Wages)

   $796 + (81 employes x $8 per man-day) = $1444.00
7. Variable Operating costs, per dock-hour (Stevedore wages + 20 percent of fixed operating costs per-hour) = $73.00
8. Overtime wage rate factor = 1.5
9. Probability of loss, according to the type of commodity handled and to the availability of warehousing facilities (fresh fruits= 0.04, general cargo = 0.02) = 0.04

10, 11, 12 and 13: are parameters associated with the type of vehicle under consideration. In table 20 a cargo vessel of 5280 N.R.T. has been considered.

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* 1963 U.S. dollars

14. Average productivity, in tons per man-hour = 0.48

15. Storage facilities, in sq. meters (At the present time there are no facilities for fresh fruit storage.) = 0.00

Bolivar Port

1. Average loading and unloading rate = 52 tons/hour

2. Number of hours payed at ordinary rate = 18 hours

3. Total working hours at the facility = 24 hours

4. Labor Force.

   Stevedores, five gangs of men with 20 men to a gang = 100

5. Average basic wage rate, per man-hour = $0.43*

6. Fixed operating costs, per dock-day

   Fixed capital costs = $707

   Fixed labor costs = $107

   Then: Fixed operating costs = $814.00*

7. Variable operating costs, per dock-hour (Stevedore wages + 20 percent of fixed operating cost per hour) = $49.70

8. Overtime Wage - rate factor = 1.5

9. Probability of loss = 0.05

14. Average productivity per man-hour = 0.39

15. Storage facilities = (fresh fruit) 0.00

* U.S. dollars 1963.

Manta Port

1.	Average loading and unloading rate =	43 tons/hour
2.	Number of hours paid at ordinary rate =	18 hours
3.	Total working hours at the facility =	24 hours
4.	Labor Force.	
	Stevedores, five gangs of men with 20 men to a gang =	100
5.	Average basic wage rate, per man-hour =	$0.48
6.	Fixed operating cost, per dock-day	
	Fixed capital costs = $865	
	Fixed labor costs = $145	
	Total fixed operating costs =	$1011.00
7.	Variable operating costs, per dock hour (Stevedore wages + 20 percent of fixed operating cost) =	$56.40
8.	Overtime wage - rate factor =	1.5
9.	Probability of loss =	0.045
14.	Average productivity per man-hour	
15.	Storage facilities =	0.00

Esmeraldas Port

1.	Average loading and unloading rate =	21 tons/hour
2.	Number of hours paid at ordinary rate =	18 hours
3.	Total working hours at the facility =	24 hours
4.	Labor force.	
	Stevedores, five gangs of men with 20 men to a gang =	100
5.	Average basic wage rate, per man-hour =	$0.27
6.	Fixed operating cost, per dock-day	
	fixed capital cost = $20 (*)(*)	
	fixed labor cots = $64 (*)(*)	
	Total fixed operating cost =	$84.00
7.	Variable operating costs, per dock-hour (Stevedore wages + 20 percent of fixed operating cost) =	$27.72
8.	Overtime wage - rate factor =	1.5
9.	Probability of loss =	0.07
14.	Average productivity per man-hour =	0.20
15.	Storage facility =	0.00

(*) Source: Table No. 4

(*)(*) U.S. dollar 1963

Table No. 16: Interface Model - Technological and Cost Characteristics for Several Interface Facilities (Sample Table)

	P A R A M E T E R S															
	1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
Facility	UNLODR	UPLODR	HRSNRM	HRSMAX	LABFOR	WARATE	FIXDOP	OPCOST	WAMUL	PROBLO	MODE	PAYLOD	VOPCST	HRSDAY	AVPRMH	STORAG
Guayaquil -Vessel Dock	-52	52	18	24	126	0.59	1444	73	1.5	0.04	1	1000	130	24	0.48	0.00
Bolivar -Vessel Dock	-39	39	18	24	85	0.36	814	49.70	1.5	0.05	1	1000	130	24	0.39	0.00
Manta -Vessel Dock	-43	43	18	24	77	0.37	1011	56.40	1.5	0.045	1	1000	130	24	0.43	0.00
Esmeraldas -Vessel Dock	-20	20	18	24	113	0.18	84	27.72	1.5	0.07	1	1000	130	24	0.20	0.00
Inland Ports -Barge Dock	- 20	20	18	24	46	0.27	40	12	1.5	0.075	4	150	13	24	0.39	0.00
Guayaquil - Truck Dock	-30	30	18	24	10	0.36	1.00	3.60	1.5	0.006	3	8.9	1.45	24	0.43	0.00

Note: The tabulated service performance and cost characteristics correspond to the operation of banana transhipment for different facility types. A complete table for all the considered alternatives has been printed out by the computer under "Print Out of Input Data" - see Appendix No. 3.

2.2.6 Part 6 - Overseas Transportation, Ocean Going Fleet

2.2.6.1 General Approach

As argued in Chapter One, integrated transport operations may be a challenging and advantageous possibility for countries like Ecuador where ownership or control over important sections of the transport process already is vested in governmental agencies. That is particularly so in respect to the National Banana Fleet and to a lesser degree with the Gran-Colombian fleet. In the case of Gran-Colombian, which is organized as a private corporation, the situation is not as simple as is the former. In spite of this, the Ecuadorian government is an important partner in the enterprise. The highly specialized banana fleet owned by the Ecuadorian government, facilitate the analysis and evaluation of this particular branch of the transport operation.

On the other hand, when dealing with the problems of coffee, cocoa and other cargo trades, usually labelled as General Cargo, additional factors must be considered. The size and volume of these trades are relatively small in Ecuador, and the assumption that private or state owned ocean going fleets will deal adequately with the total generated tonnage is unrealistic. The generalized framework of Latin American shipping and its problems is as follows:

1. It is difficult to predict the effect of the increasing participation of national flags on the balance of trade in Latin American countries. However, by following a

recently issued ECLA report, [Ref. 12] some figures and percentages related to regional import-export freight rates may explain the increasing concern for the overseas transport business among the countries of the region. In 1967 over 2.765 billion dollars in maritime freight rates were paid by the region but only 352 million dollars of this total was paid to ships under national flags. (Ref. 12, Tables 241, 242) By assuming only a 30 per cent participation on the total paid maritime freight rates, the region's total gross income would have risen to 830 million dollars for the same year (around 500 million dollars more than the amount actually experienced).

2. There seems to be a tacit coincidence of opinions among different specialized bodies in Latin America on the subject of the participation in trade by national fleets. It is argued that a 30 per cent participation of regional shipping lines in sea transportation is a realistic goal, when considering the past achievements of other nations in the world during the last twenty years. (Ref. 12, p. 343).

Brazil, for example, has put into practice a policy by which a preponderant proportion of its external trade is reserved to ships owned by the exporting and importing partners. Initially, the

Brazilians had decided that 65 per cent of the total cargo in some of their principal trade routes must be divided between their own ships and the ships of the other country with whom trade is effectuated. However, this kind of bilateral cargo allocation, while reasonable for Brazil, may not be adequate for countries with lower trade volumes or with a different commodity structure in their external trades. The negative effects over cost and quality of the service might be greater than the actual benefits derived from the necessary increase of national merchant fleets.

Ecuador meets the former conditions and in this study, we considered the approach envisioned by the ECLA staff (Ref. 12, p. 383) to be realistic. Namely, the possibility of imposing a Collective bilateral cargo reserve covering more than one country. Under this scheme, the Group of Andean Countries* might be able to reserve 30% of their cargo for transportation by the signatories' shipping lines. The formulation of negotiable conditions may impose the necessity of reserving an additional portion of the transport for the country trading with the Group. In this manner, countries might be grouped into sets and the cargo involved might be reserved bilaterally for each set. However, cargo might be distributed multilaterally within each set.

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*Andean Group: Bolivia, Colombia, Chile, Ecuador and Peru

A recent decision taken by the Colombian authorities seems to point in that direction. It was put forth by a decree of the National Government that 50 per cent of the Colombian external trade must be restricted to Colombian ships. At the same time, the government stated that equal rights be given to ALAMAR* members - provided that Colombian ships receive similar treatment from ALAMAR. (Ref. 12, p. 383)

Further considerations with respect to Ecuador's general cargo trades stems from the idea of Collective Bilateral Cargo Reserve. However, for the purpose of calculating cargo transport requirements for sizing feeder systems, several assumptions will be made. It is well known that flows from agricultural commodities fluctuate throughout the year. But it is precisely from this that the idea of the collective bilateral cargo reserve becomes rational. Once the sizing and scheduling of feeder systems, as well as the specific cargo demands for each season of the year are calculated, seasonal peaks of cargo may be absorbed by the addition of vacant ships from other shipping lines of the regional group. An analysis for establishing performance standards for the fleet follows.
It has been carried out on two separate bases according to the sea transportation patterns generated by Ecuador's trade.

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*ALAMAR = Latin American Association of Shipping Companies - private and state owned companies of LAFTA (Latin American Free Trade Association)

2.2.6.2 The National Banana Fleet

According to a National Planning Board Report (Ref. 5, p. 191) the country will have a fleet of 12 "Reefer" ships with a gross tonnage of 26,400 long tons by the year 1973. As no description of particular ships was supplied, it is assumed that the ships may be of similar characteristics and performance to others already in service for the banana trade in the Gran-Colombian fleet.

For the purpose of this study, ship characteristics and performance are the following:

Gross Tonnage	5139 Tons
Net Tonnage	2714 Tons
Speed	19 Knots
Load Draft	24 Feet
Cubic Capacity (Refrigerated)	390,630 Cubic Feet

(This description corresponds to a Gran-Colombian Reefer Ship - Ref. 45, p. 175)

<u>Cargo Accumulation and Vessel's Space Requirements</u>

It will be assumed that when a ship arrives at the loading port, the cargo accumulated at the port will exactly equal the deadweight cargo capacity of the ship.* It is also assumed that the trade routes are such that the cargo will be transported directly from the

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*see definition on Appendix IV

Ecuadorian port to the destination. Ecuador's banana trade has three major market areas: the U.S., Europe and Asia (Japan). It is obvious that an ideal fleet for this carriage would be made up of ships of a wide range of gross tonnages. The capability of maintaining speeds between 15 and 20 knots per hour also appears to be called for. (Ref. 28, p. 46) For the sake of simplicity in our calculations, we will keep the previously proposed "average ship", but divide the entire fleet into three sub-fleets each one operating exclusively in a specific trade route.

Round-trip average distances:

Ecuador (Guayaquil) - U.S. Ports	5,100 miles
Ecuador (Guayaquil) - European Ports	11,662 miles
Ecuador (Guayaquil) - Japanese Ports	16,000 miles

Steaming days per year:

Taking the information from current experience (Ref. 28, p. 47) it is assumed that an average of 110 days a year are needed for loading and unloading time in ports and layups for repairs or because of cargo unavailability. Consequently, 255 days per year of actual steaming is considered as a reasonable average for each ship.

"Sub fleet" sizes:

A cross-analysis and evaluation of Table 19 and the average distances between Ecuador and the three above mentioned market areas were used in order to apportion the entire fleet. On this basis, Europe with 54,000 million ton-miles a year will require 54% of the fleet. Consequently, it will be assumed that six ships will be assigned to this trade route. The second set of four ships will be assigned to the Japanese trade route (approximately 30% of the fleet). The remainder of the fleet, two ships, have been assigned to the U. S. trade route.

Performance standards of the proposed uniform fleet for each trade route may be set forth as follows:

1. Miles per ship per day:

   19 miles per hour x 24 hours = 468 miles ship-day

2. Miles per ships per year at 255 steaming days:

   255 x 468 = 120,000 miles per ship per year

3. Fleet miles per year:

   a. European trade - 6 ship "sub-fleet":

      6 x 120,000 = 720,000 fleet miles-year

   b. Japanese trade - 4 ship "sub-fleet":

      4 x 120,000 = 480,000 fleet miles-year

   c. U. S. trade - 2 ship "sub-fleet":

      2 x 120,000 = 240,000 fleet miles-year

4. Number of voyages per year:

   a. European trade

      720,000 fleet miles-year/11,662 miles = 61 voyages

b. Japanese Trade

480,000 fleet miles-year/16,000 miles = 30 voyages

c. U.S. trade

240,000 fleet miles-year/5,100 miles = 47 voyages

5. Assuming a 2000 ton load of fruit per voyage the transporting capacity of the fleet will be:

a. European trade

61 voyages x 2000 tons = 122,000 tons-year

b. Japanese trade

30 voyages x 2000 tons = 60,000 tons-year

c. U.S. trade

47 voyages x 2000 tons = 94,000 tons-year

So the total tonnage transported by the entire fleet will be 276,000 tons-year.

6. Round Trips per Ship per Year

a. European trade

120,000 miles/11.662 = 10.1 round trips

b. Japanese trade

120,000 miles/16.000 = 7.5 round trips

c. U.S. trade

120,000 miles/5.100 = 23.5 round trips

Table 17: Banana Exports by Destinations by Continents, Regions or Economic Areas

	1967	1968	1969	Average
Total Europe	496,637	473,442	411,123	460,400
EEM	491,920	469,165	405,464	
Belgium, Luxembourg	152,697	102,565	92,005	
France	2,778	4,077	5,178	
Germany (Fed. Rep.)	248,914	273,846	232,603	
Italy	87,531	83,464	69,450	
North America				
U. S.	477,090	393,617	303,557	391,421
South America	70,219	75,313	86,197	77,244
Chile	68,087	71,268	80,427	
Peru	2,080	70	41	
Or. Europe	19,969	62,085	90,097	
Germany (Dem. Rep.)	7,105	10,461	27,139	
Czechoslovakia	9,516	16,857	22,388	
Russia	-	3,597	15,759	
Yugoslavia	-	1,536	21,516	
Asia				
Japan	76,047	251,963	267,513	197,507
Total	1,145,296	1,259150	1,173,884	1,127,672

Source: Boletin Banco Central Ecuador, Junio-Julio 1970.

2.2.6.3 General Cargo Fleet

A "sub-fleet" of four Gran-Colombian vessels is assumed to be operating in the U.S.-Canada and European trades. They are registered respectively with the Association of West Coast Steamship Companies and the European-South Pacific and Magellan Conferences.*

Cargo Accumulation and Vessel's Space Requirements

It must be realized that the results of this analysis may vary according to the service parameters selected. The following performance parameters have been chosen:

a. Payload:

The net cargo tonnage of the average ship is 2818 tons, but the reserved cargo capacity for Ecuador's ports will be assumed to be equal to 1000 tons per call.

b. Speed: 17 knots

c. Number of port calls: 8 (4 and 4)

1. Four on the South American Pacific Coast and four ports of call in the North American Atlantic, Pacific and/or Gulf Coast.

2. Four ports of call on the South American Pacific Coast and four ports of call in Continental Europe, the United Kingdom and/or Scandinavia.

d. Frequency of Service:

For the apportionment of the four vessel fleet, the

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*Routes are described in Appendix 4.

same method as used for the banana fleet was followed.

1. Average distances:

   Ecuador to Europe = 11,000 nautical miles

   Ecuador to U.S.-Canada = 6,180 nautical miles

2. Number of vessel per trade route:

   Table 22 shows that the average cocoa and coffee export tonnage between Ecuador and Europe during the five year period was around 20,900 tons, or an equivalent 229.9 million ton-miles, which represents 43.5 per cent of the total ton-mileage in both trade routes (524.7 million ton-miles). Obviously, ships exist only in discrete units and the required round-off for such a small number of vessels will not affect significantly the frequency of service. It is then assumed that two ships serve each one of the trade routes.

e. Steaming days per year:

1. Port time: An average port time of 24 hours at each port of call on the U.S.-Canada and the West Coast of South America is assumed. For the European trade, in spite of the fact that a wide range of port productivities exist, it was decided to assume the same average port time. Hence, the number of port days per round trip equals the number of port calls independent of

the amount of cargo handled.

2. Average Repair time: An average repair time of fifteen days, per year per vessel is assumed, making the total operating days per year equal to 350 days. (Ref. 13, p. 69)

3. Time at sea: It is given that each ship of the fleet serves eight ports on each round trip of the route. For our calculations, the port of Valparaiso becomes the extreme port of call for both trade routes.*

3.1 Time at Sea US-Canada Trade: Round trip distance = 11.200 nautical miles, 11.200/468 = 24 days per ship

3.2 Time at Sea - European Trade: Round trip distance = 15042 nautical miles, 15042/468 = 32 days per ship

f. Total Operating days per round trip per ship:

In the US-Canada trade - 31 days

In the European trade - 39 days

g. Round trips per ship per year:

In the US-Canada trade - 350 days/31 days = 11.2

In the European trade - 350 days/39 days = 9

h. Number of voyages per year (Sub-fleet)

US-Canada trade - 2 ships x 11.2 = 22.4 voyages

European trade - 2 ships x 9 = 18 voyages

i. Yearly cargo capacity of the fleet:

Assuming 1000 tons load of general cargo at the Ecuadorian port of call, the transport capacity of the fleet will be:

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*Four principal ports on the South America West Coast: Buenaventura (Colombia), Guayaquil (Ecuador), Callao (Peru), Valparaiso (Chile).

US-Canada trade - 22.4 voyages x 1000 = 23,4000 tons/year

European trade - 18 voyages x 1000 = 18,000 tons/year

Fleet's total cargo capacity per year = 40,400 tons

j. Average interarrival time between ships:

350 days/40.4 voyages = 8.4 days

Assuming a schedulling in which ships' arrivals are distributed uniformly during the year.

The average cargo reserve per ship and the bilateral cargo reserve of 30 per cent. In order to maintain coherence with the introductory arguments of this section, the tonnage claculation in part (d) will be broken down in the following manner:

Based upon 30 per cent of the average exports the following tonnages are arrived at:

1. Cocoa and coffee (Table 18) for the US-Canada and European trade 20,400 tons.
2. Other general cargo loads (balsa wood, canned food,) (Ref. 37, pp. 51-81) 5,000 tons.
3. Fruits (bananas, pineapples) 15,000 tons.

It must be pointed out that the proposed apportionment of the total annual transport capacity of the fleet follows a very simplistic approach. The 30 per cent bilateral cargo reserve may be interpreted in a more complex and perhaps more realistic way, nevertheless the chosen simplification avoids difficult alternative analyses, which are out of context for this study.

It must be pointed out that the proposed apportionment of the total annual transport capacity of the fleet follows a very simplistic approach. The 30 per cent bilateral cargo reserve may be interpreted in a more complex and perhaps more realistic way, nevertheless the chosen simplification avoids difficult alternative analyses which are out of context for this study.

Table 18: Coffee and Cocoa Exports Permits by Continents, Regions, Economic Areas or Continents

	Years					
	1965	1966	1967	1968	1969	Average 1965-69
	Tons	Tons	Tons	Tons	Tons	Tons
U. S. and Canada	56,763	45,667	56,304	51,087	29,111	47,700
Total Europe	27,866	22,577	20,712	16,074	17,572	20,900
Total Asia	1,644	2,492	14,831	8,636	4,957	6,500
Others	371	4,603	11,085	38,448	19,921	14,870
Total Export Permits	86,844	75,339	102,933	114,245	70,561	89,970

Source: Data derived from the Boletin del Banco Central del Ecuador Nos. 522, 523, and 524, 1971 (pages 203 to 212).

2.2.7 Part 7 - Coastal and Waterways Submodel

2.2.7.1 The Inland Waterway System

In spite of its past influence on Ecuadorian transportation patterns, the National Planning Board Staff appears to have made no major provisions for improving coast and inland waterway transport. On the contrary, the statement was made that highway improvements for 1973 through 1983 would almost completely replace some existing waterway movements. (Ref. 4, page xvi). Inland waterways continue to provide low-cost but slow transportation for bulk shipments, and the exclusion of this mode would distort the interpretation of usage patterns of the Ecuadorian transportation network.*

Data Collection

It has been almost impossible to obtain information pertaining to inland waterways transportation from public sources; rather, some data were obtained in response to personal letters directed to exporters and to port authorities. Although some cross-calculations and guesses were necessary in order to obtain average and unitary prices, their accuracy is considered to be adequate for the purposes and scope of this study. However, their validity for other purposes might require more specific research.

Operating Costs

The Operating costs** and charactistics arrived at for tugs

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* According to estimates of the Minister of Production (Ref. 44) ten per cent of the total banana export was transported within the country by boat in 1971.

** 1963 prices.

and barges are as follows:

Tug - (at US $123 per hour)

average speed = 3 knots[1]

power = 800 HP

Barges -

100 tons deadweight - US $0.17/hour

150 tons deadweight - US $0.26/hour

400 tons deadweight - US $0.51/hour

Tow operating cost per ton (assuming 70% load factor)

600 tons tow (4 barges of 150 tons + tug) = 0.11 per ton - Naut. Mile.

1200 tons tow (3 barges of 400 tons + tug) = 0.06 per ton - Naut. Mile

Average cost per ton = $0.66 per ton - Naut. Mile.

2.2.7.2 The Coastal Barge Feeder System

The proposed Coastal Feeder System is exogenous to the present Ecuadorian transport system; it is a consequence of an hypothesis developed during this study. The present section is a discussion of the analytical approach for sizing a coastal barge feeder system. This approach stems from the concept of an integrated transportation operation and has been designed to test not only its feasibility but also the advantages of a more efficient use of existing transportation assets.

(1) 3 knots = 5.4 km/hour.

In Part 6, the cargo momentum problem was analyzed for a set of ships operating on the banana and general cargo trade routes. The importance of the relationship between the number of ships available and the use that can be made of improved feeder transportation and advance cargo information was also expressed. In this section, the sizing of an integrated coastal feeder barge system will be analyzed, assuming that it will be coordinated with the previously calculated ocean going fleet. The analysis is made separately to evaluate the barge system capital and operating costs required for the operation of the banana trade first. Later the general cargo trade is examined, and finally an "average" barge fleet able to operate as a coastal feeder system for all the commodities considered is analyzed.

The reasoning applied is that of cargo momentum which basic meaning is that it will be assumed that when a ship arrives at the loading port, the amount of cargo accumulated will be exactly the vessel's reserved cargo payload.

The Elements of the System

Tow: The dimensions of a tow are generally limited by the dimensions and draft of channels as well as port facilities (docks, locks, etc.). The tow consists of a number of barges propelled by a single independent power unit (tug or tow-boat).

Barge: The barge is the cargo unit and may be of different sizes and characteristics according to cargo requirements. Barges serve the dual purpose of cargo box (container) and ship hull.

Operative Aspects: The turnaround time depends very much on the operating conditions. It is possible to think in two distinct measures of port time:

1. Port time for barges, i.e. time expended in port loading or unloading or as a "warehousing" unit.
2. Port time for the tow-boat, as determined by the time spent in fueling and preparing crews and stores for return trip. However, two other subalternatives are possible:
   a. The tow-boat is scheduled to make the round trip with the same tow. Then port time is directly connected with loading and unloading operations.
   b. The tow-boat leaves a tow and picks up another one already loaded and ready to go; the port time is determined by the period of time the tow-boat spends waiting for barge exchanges or in servicing the tow-boat itself.

Routing: The route of each tug is assumed to be "circular", - it calls at the feeder ports once on every round trip. In the case of more than one terminal, the tug may call twice at each of the terminals. Routing is closely tied to scheduling analysis. However, this study concentrates on the sizing and cost evaluation of a fleet and disregards such aspects as optimal assignment of vessels, minimal idle times in port, stocastic cargo generation, etc. The latter points have been fully studied in an MIT Report by Hughes, Seibold and Frankel (Ref. 39) and in a Research Report from Northwestern University (Ref. 49).

Cargo Generation: The daily rate at which cargo appears at a feeder port for shipment is a direct consequence of hinterland size, which, among other factors, depends upon inland transport system characteristics and interface costs. This topic is analyzed in Chapter Three, where an integration of the whole set of transportation modes as well as their interaction in the flow movement through the entire network is tested and the effective port throughput for each commodity group is evaluated. For the moment, the accumulation rate is considered sufficient to meet the cargo momentum requirements for the entire set of ports.

Cargo availability: It is assumed that cargo availability is a function of tug round trip time.

Variation of Cargo Type: For the purpose of determining the volume required for storage cargoes have been divided into two main groups: special cargo (fresh fruit, bananas, etc.) is assumed to require 167 cubic feet per long ton, while general cargo (coffee, cocoa, light machinery, etc.) is assumed to require 75 cubic feet per long ton.* Both of them are ordinarily considered "measurement cargo."

Operating Policy**: It is assumed that the transport of commodities will be effectuated between two zones: Zone A represents a set of six feeder ports with daily throughput of M

* See Appendix IV.

** In general, the method follow Ref. 53, page 27-35.

long tons; Zone B is a maritime terminal where vessels arrive at a scheduled time. The vessel's deadweight cargo at the main terminal is C and their interarrival period is designated by I.

Maximum tow capacity = c

Average round trip speed = V

Round trip time in days = T

The cargo momentum equation is m = MT (1)

given that m = n.c. (2)

Where n = number of tows we may write: nc = MT (3)

We must verify any limitations in the barge operation parameters imposed by the 100 per cent use of the cargo deadweight reserved for the main terminal, then

$$c \cdot \frac{I}{i} \geq C \qquad (4)$$

Where, tow interarrival time, i, is given by

$$i = \frac{I}{n} \qquad (5)$$

The problem may have different alternative solutions, depending upon the conditions under which the system operates. In the present study, the operation is constrained by the following environmental conditions:

a) No storage at the loading port, i. e. cargo is loaded directly into barges.

b) No storage facilities at unloading port, i.e. loading vessels is made directly from barges.

c) An empty tow is waiting at unloading port.

d) A tow of loaded barges is waiting at loading port.

For these conditions (3) becomes

$$nc = M\left(\frac{D}{24V} + N_p k\right) \qquad (6)$$

Where:

Average time spent in port operations per round trip = k

Round trip distance = D

Total number of ports = N_p

The total capacity of barges (T_{BC}) is given by

$$T_{BC} = c \cdot (n + r) + C \qquad (7)$$

T = extra number of tow boats

The total number of tow boats (R) is given by

$$R = n + r \qquad (8)$$

where r is the number of auxiliary tugs provided in the system.

Total Annual Operating Costs

Unit costs for the several factors involved in this type of problem were taken from references 50, 51, and 52. It was necessary to adjust the available data to costs for a common base year to account for changes in cost figures. All the prices and costs are referred to in US dollars of 1963 to maintain consistency with cost evaluations in the other sections of the general model.

I. Integrated Tow - 20 year operating life and zero scrap value are assumed -

Group A - Costs dependent on the number of vessels.

Amortization of principal - 5.0%

Interest - 3.5%

Insurance - 1.0%

Crew Wages, subsistence overhead, stores and miscellaneous - 13.0%

Maintenance and repair - 4.5%

Total - 27.0%

Group B - Costs dependent on ton-miles of cargo transported.

Diesel oil consumption. From Reference 53 we have the following approximate relation: 17.3 long tons of diesel oil are consumed per million long ton miles of cargo carried.

II. Extra Barges - Costs for extra barges comprise the following percentages of construction costs:

Amortization of principal - 5.0%

Interest - 3.5%

Insurance - 0.5%

Maintenance and Repair - 1.0%

Total - 10.0%

III. Auxiliary Towboats

Amortization of principal - 5.0%

Interest - 3.5%

Insurance - 1.0%

Crew wages, subsistence, stores, overhead, miscellaneous, and port fuel oil - 15.0%

Maintenance and repair - 5.5%

Total - 30.0%

IV. Tug Performance and Characteristics

Coastal and Harbor Tug (Data from Ref. 51, page 175)

Diesel, 2000 SHP, Steel construction.

Length	107'
Beam	26'6"
Light Displacement	295 L.T.
Max Draft	12'2"
Fuel Capacity	20,768 gallons
Speed	12 knots
Cruising Range	3,000 nautical miles
Crew	16 persons

"A scrutiny of successful application indicates that good performance has been obtained in ocean coastal voyages with a 16:1 ratio between barge and tug displacement." (Ref. 50, page 275)

Auxiliary Tug (Main Terminal Operation)

Diesel, 600 SHP., Steel construction

Length	70'
Beam	19'6"
Light Displacement	100 LT
Max Draft	8'3"
Fuel Capacity	5,850 gallons
Fuel Consumption (per hour)	41 gallons

Speed 12 knots

Cruising range 1.700 nautical miles

Crew 5 persons

The auxiliary tugs are assumed to be capable of short ocean passages under own power (Ref. 51, page 175).

1. A barge feeder system for the banana trade.

Problem Data:

$T = 2.6$ days

$m = 2,000$ tons*

$M = 765$ tons a day*

$D = 1000$ nautical miles

$V = 10$ knots

$k = 3$ hours (average)

$c = 1000$ tons*

$N_p = 7$ ports

$r = 2$ auxiliary tugs (1)

Number of tows:

Substitution of the above quantities into Eq. (6) yields

$$n = \frac{765}{1000} \left(\frac{1000}{240} + 7 \times 3 \right) = 4$$

Total Number of Tugs:
$R = 6$

Total Barge Capacity - Cargo Deadweight:

Substitution of these values into Eq.7 yields

* Long tons

(1) Two alternative main terminals are considered, then two auxiliary tugs are necessary - (Main terminals: Guayaquil and Manta).

T_{BC1} = 1000 (4 + 2) + 2000 = 8000 tons*

Construction Costs:

a. Tugs (4 units) 200 x 360 x 4 = $2,800,000

b. Barges, Special Cargo Space (Double Skinned, Insulated and Ventilated). Calculated on the basis of 1000 ton deadweight barge - see Figure No. 7, in 1963 U. S. dollars, at $945 per ton - 4000 x 945 = $3,780,000

c. Auxiliary tugs (port service), 600 SHP - 2 x 600 x 360 = $532,000

Annual Operating Costs:

I. Integrated tow

Group A (Amortization of principal, interest charges, etc.)

6,580,000 x .27 = $1,775,000

Group B (Diesel oil consumption, at 360 working days)

At sea time per tow round trip: 1000 naut. miles x $(11.6 \text{ miles/hour} \times 24 \text{ hours})^{-1}$ = 3.6 days

Total port time per tow (k = 3 hours) = 21 hours = 0.95 days

Total round trip per tow = 4.55 days

Total fleet ton-mileage: According to the already developed evaluation of cargo for the banana fleet (Part 6), the total tonnage would be around 276,000 tons/year. Then the total fleet ton-mileage would be: 276,000 long tons x 1000 nautical miles = 276 million ton-miles.

Diesel Fuel Consumption: For this mileage 276 x 17.3 = 4,800 long tons of diesel oil will be used. The total cost of the diesel

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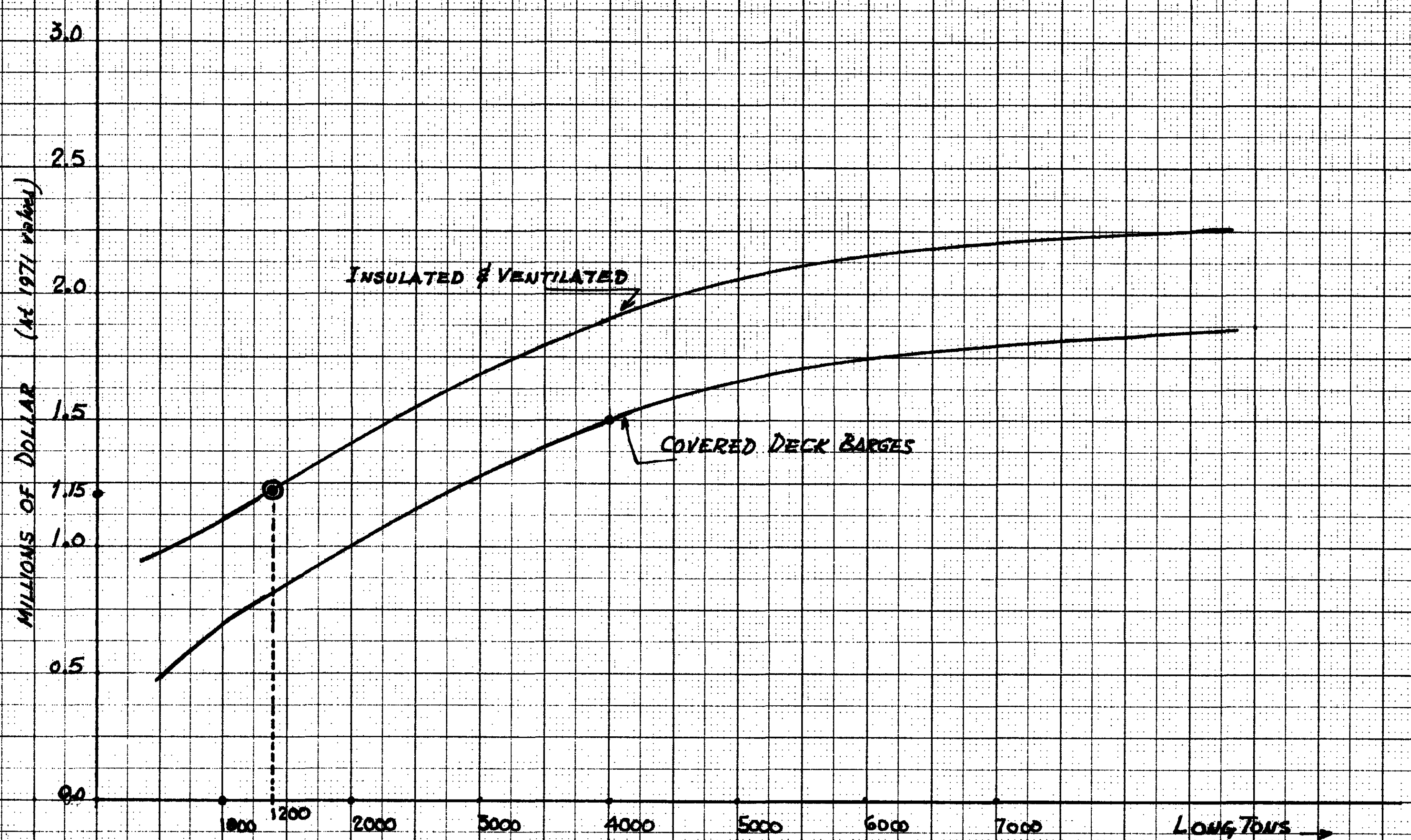
* long tons

FIGURE 7

ESTIMATED CONSTRUCTION COSTS FOR OCEANGOING BARGES



oil (at US $0.16 per liter in Ecuador and 44 liters per ton) is 4,800 x 44 x 0.16 = $34,000.

II. Extra Barges

(4 tows carrying 100 tons each = 4,000 tons). Then, from Eq. (7) we derive: extra barge capacity T_{BC1} - 4,000 = 4,000 tons.

Annual Operating Costs (10 per cent of construction costs): 4,000 x 945 x .10 = $378,000.

III. Extra Tow-boats

(Operating Costs: 30 per cent of construction costs): 532,000 x .30 = $160,000.

IV. Total Operating Costs: $2,347,000.

V. Operating Costs Per Ton

O_{CT} = 2,347,000/276,000 = $8.50.

VI. Operating Cost per Ton-Nautical Mile

2. <u>A barge feeder system for the general cargo trade.</u>

Problem Data:

T = 8.4 days

m = 1000 tons

M = 120 tons per day

D = 1000 nautical miles

V = 10 knots

k = 3 hours

c = 500 long tons

N_p = 7

r = 2

Number of Tows:

$$n = 120 \left(\frac{1000}{24 \times 11.6} + 1.75 \right) 0.0002 = 1.28$$

Total Barge Capacity: - Cargo deadweight -

$T_{BC2} = 500\ (1.28 + 2) + 1000 = 2640$ tons

Total Number of Tows: R = 3

Construction Costs:

a. Tugs (1 unit) 2000 x 360 = $720,000

b. Barges - Covered Cargo Deck -:

Calculated by interpolation on the basis of 500 ton dead weight barge (Figure No. 7) at 1963 U.S. dollars at $900 (1) per ton deadweight. 640 x 900 = $576,000

c. Auxiliary Tugs (Port Service) - 600 SHP - $532,000

Annual Operating Costs:

I. Integrated Tows

Group A: $350,000

Group B: In the analysis of cargo for the ocean going fleet, an annual total tonnage of 40,400 tons was estimated; the total ton-mileage carried by the large fleet is then 40 million ton miles.*

Diesel fuel consumption: 40 x 17.3 = 692 tons

Total cost of diesel oil = 692 x 44 x 0.16 = $4,450

II. Extra Barges

T_{BC2} - 640 tons = 2000 long tons

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(1) This amount must be considered an order of magnitude value valid for purposes of planning estimates.

* Assuming average vessel's round trip each 2.6 days, barge system capacity 2640 long-tons and D = 1000 nautical miles.

Annual operating costs: 2000 x 900 x 0.10 = $180,000.

III. Extra Tow-Boats

(2 units) $160,000

IV. Total Operating Costs: $694,450

V. Operating Cost/Ton

O_{CT} = 694,450.40,400 = $17.5

VI. Operating Cost/Ton-Mile: $0.017.

General Observations:

It is apparent that no practical justification exists for evaluating cargo space requirements and fleet sizing for each separate commodity. The inherent flexibility of tows and barges facilitates several combinations within the same tow, while at the same time adequate barge design permits the maximum utilization of its cargo deadweight. This maximum utilization would require extensive market analysis, as well as actual and up-to-date knowledge of technological improvements in barge operation. Among them we mention:

1. Barges can be used as storage facilities as they supply a flexible and versatile warehousing system. That warehousing system should be located at different geographical points according to seasonal changes in demand. This system may prove particularly useful in countries in preliminary stages of development where seasonal changes in the demand of warehousing facilities, and changes in local or regional patterns of production frequently occur.

2. After a certain amount of time, fixed warehouse space may be built. Once the demand for such a space is supplied by these fixed facilities, a portion of auxiliary barges formerly required for warehousing may be freed for other purposes.

3. Being a completely new fleet, it would take advantage of the new techniques without conflicting with existing business interests. (Push Tow, Deep Notch, etc.) Of course, all these advantages must be weighed carefully against the disadvantage of greater amounts of capital tied up in extra barges.

Although this study is limited to the Ecuadorian interport trade, it is possible that the major potential for a coastal barge system would be found in applying the system to trade among the countries of the Andean Group which:

1. Share a common coastline.
2. Lack adequate international inland transport.
3. Have inadequate conventional ships to provide convenient schedules for the relatively small local generation of cargo and intertrade among ports of the area.
4. Have industrial possibilities for constructing parts or entire vehicles in their shipyards and factories.
5. Have inherent advantages derived from a diversification of trade among these countries.
6. Already have legislation or trade agreements on matters related to the Latin American Common Market (LAFTA), and the more specific agreements with respect to shipping and

ocean trade (ALAMAR).

Obviously, all of these topics cannot be considered herein, however, their presentation has been considered a sort of inevitable and fundamental background for the evaluation of the Ecuadorian system. This is why the scheme of a double main terminal has been proposed (Guayaquil and Manta) in this study when evaluating the banana and the general cargo barge fleets. Evidently, it is thought that the proposed scheme is also more effective and well permit greater flexibility in response to local movement of goods, as might be required to meet seasonal demands of cargo space.

The particular situation of cargo generation at Ecuador's ports would favor a type of barge capable of carrying special cargo, such as fresh fruits, vegetables, meat, and fresh fish, as well as general cargo, such as coffee, cocoa, and light machinery. Likewise, it should be possible to combine several ocean going barge types in a single tow. For example:

a. tanker barges (petroleum products, sugar molasses, etc.)

b. deck cargo barges (forest products, heavy machinery)

c. bulk cargo barges (ore, cereals)

d. 'reefer' barges

In spite of the fact that no antecedent exists concerning "reefer" barges, it is thought that no technological or economic obstacles will exist for their construction and operation. The latest developments in the area of barge carrying ocean ships, for example,* clearly indicate that sooner or later these types of barges will be needed.

Moreover, in spite of the indicated cargo carrying potentialities of ocean going barges, the final step in the analysis of a barge feeder system for Ecuador will deal with the sizing of an average fleet capable of carrying special and general cargo in the same tow. The operating costs of such a fleet will be calculated in order that we may introduce it into the analytical evaluation of flow patterns for the whole country.

3. Barge feeder system, special and general cargo trade.

Problem Data:

$T = 2.6$ days[1]

$m = 3000$ long tons[2]

$$M = \frac{3000}{2.6} = 1{,}120 \text{ long tons per day}$$

$D = 1000$ nautical miles

$V = 10$ knots

$c = 1200$ long tons

$N_p = 7$ ports

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* i.e., "LASH" System

(1) Turnaround time: The turnaround time for barges of the banana fleet, was taken as the average T.

(2) Assuming for bananas, 800 long tons; coffee and cocoa, 175 long tons; light machinery-145 long tons, per day.

$r = 2$ (Auxiliary tugs)[1]

Number of tows:

$$n = 1{,}120 \quad (\frac{1000}{24 \times 11.6} + 1.75) \cdot 0.00083 = 4$$

Total Barge Capacity:

Considering the total barge capacity, as calculated in Sections I and II:

$$T_{BC} = T_{BC1} + T_{BC2}$$

$$T_{BC} \sim 12{,}000 \text{ long tons}$$

Total Number of Tugs: (one for each integrated tow and two auxiliary tugs)

$R = 4 + 2 = 6$

Construction Costs:

a. Tugs (4 units) 2000 x 360 x 4 = $2,800,000

b. Barges, special cargo space (Double Skinned, Insulated and Ventilated). Calculated by interpolation for a 1200 ton barge (Figure 7) US $960 per ton at 1971 prices, applying the price indices to convert to 1963 prices the cost per ton is $864. (Ref. 52). 4000 x 864 = $3,460,000

General Cargo Space (simple covered deck): 2000 long tons per tow, at $610 per ton*, 1000 x 610 = $610,000.

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(1) Two alternative main terminals are considered, one port-tug per terminal (Guayaquil and Manta).

* Dollars as of 1963.

Auxiliary Tugs (Port Service) 600 SHP each: 2 x 600 x $360 =

$532,000

Annual Operating Costs(*):

I. Integrated Tow - Barge with special cargo and general cargo compartments -

Group A: $6,748,000 x .27 = $1,820,000

Group B: Fleet total number of voyages: 316 voyages

Annual cargo breakdown:

Exporting fresh fruits - 276,000

Exporting general cargo - 41,000

Importing light machinery - 2,800

Total: 319,800 long tons

Round trip: 1000 nautical miles

Ton-mileage per year: 320 million ton-miles

17.3 long tons diesel oil x 320 million ton-miles = 5,546 tons

Cost per liter in Ecuador: $0.16 (at U.S. 1963)

Total cost of diesel oil: 5,546 x 44 x 0.16 = $39,000

II. Extra Barges

4 tows carrying 1200 long tons = 4800 long tons

Then, extra barge tonnage 10,600-4,800 = 5,800 long tons

Assuming 4000 tons special cargo barges (Section I)

1800 tons general cargo barges (Section II)

(*) All money values at 1963 prices.

4000 tons x \$864 = 3,550,000

1800 tons x \$610 = 1,100,000

Total \$4,650,000

Operating costs = \$465,000.

III. Extra Tow Boats

Operating costs = \$160,000 (30 per cent, construction cost).

IV. Total System's Operating Costs per Annum

\$2,484,000

V. Operating Cost Per Ton (O_{CT})

O_{CT} = 2,484,000/320,000 = \$7.75 per ton

VI. Operating Cost per Ton-Nautical Mile

O_{CM} = \$0.0077

Chapter III

3.1 The Network Model

A linear programming technique has been adopted for the study of the efficiency of commodity flow patterns, where the efficiency criterion is concerned with predicting the least cost flows in a capacitated (*) network. It is agreed that the different sub-networks of an entire regional or national system are not mutually exclusive sets, and that the interactions between them must be considered in a wider context than the simple origin and destination environmental conditions (Ref. 59, p. 410).

Minimum Cost and the Capacitated Transportation Problem:

In the classical Hitchcock-Koopmans formulation where the overall cost is to be minimized we assume that $C_{ij} \geq 0$, where C_{ij} is the cost of moving one unit flow form origin $\underline{i}$ to destination $\underline{j}$ and is known for all i,j pairs. If we assume that the cost of sending more units is directly proportional to the corresponding C_{ij}, the analytical formulation is as follows:

$$\text{minimize } z = \sum_i \sum_j c_{ij} x_{ij} \qquad (1)$$

where x_{ij} is the number of units moved between the i,j pairs subject to the conditions:

(*) The idea of capacitated network, is a derivation of the use of capacity restriction on the links - See Ref. 30, page 170-171.

$$\sum_j x_{ij} = a_i \; ; \quad a_i > 0; \quad i = 1, \ldots, m \tag{2}$$

$$\sum_i x_{ij} = b_j; \quad b_j > 0; \quad j = 1, \ldots, n \tag{3}$$

$$x_{ij} \geq 0 \qquad \text{all } i, j \tag{4}$$

$$x_{ij} \leq u_{ij} = \min [a_i, b_j] \tag{5}$$

where u_{ij} is the upper bound capacity of the link i, j. However, the above fomulation does not consider the existence of upperbounds in some or all of the link flows. In this case, the analytical formulation of the capacitated problem is analogous to the previous one with the exception of the definition of u_{ij} which now becomes the actual link capacity, therefore, the problem takes the form:

$$\text{minimize} \sum_i \sum_j c_{ij} \, x_{ij} \tag{6}$$

subject to:

$$\sum_j x_{ij} = a_i; \quad a_i > 0 \quad i = 1, \ldots m \tag{7}$$

$$\sum_i x_{ij} = b_j; \quad b_j > 0 \quad j = 1, \ldots n \tag{8}$$

$$x_{ij} \leq u_{ij} \tag{9}$$

$$x_{ij} \geq 0 \; ; \qquad \text{all } i, j \tag{10}$$

This problem can be solved using the method described by Ford and Fulkenson in the Journal SIAM, Vol. 9, No. 1 (March, 1961) pp. 18-27, for which a computer program written by R. J. Clasen is available through SHARE for use in IBM installations (Ref. 60).

3.1.1 Problem Formulation

For our study, the network consists of:

1. A collection of links connecting all cantons having a projected urban population of 15,000 or more in 1973. Each canton is represented by at least one node.
2. A set of links providing connections between a canton with an important urban population and an international ground transport network or an ocean port engaged in international trade.
3. Links providing reasonably direct outlets for agricultural exports from areas of production concentration.

The list follows some of the recommendations of the National Transportation Planning staff for the period (1963-1973) covered by their plan. Data input for the program has been selected on the following basis. Maps No. 7 and 8 are a representation of the entire national network, nodes and arcs for each of the modal sub-networks analyzed are schematically presented.

Each arc is an ordered pair of nodes, with which are associated four quantities:

c_{ij} = cost of shipping one unit of flow from node i to j

x_{ij} = number of flow units to be shipped from i to j

u_{ij} = upperbound capacity of arc between i and j

l_{ij} = lower bound capacity of arc between i and j

If two nodes are connected by more than one transportation mode they are inputed independently and the previous data collection is inputed more than once for the same ordered pair of nodes. Interface nodes are introduced into the general network as an independent "mode," i.e., a dummy node is added and a fictitious link of length equal to unity is introduced to connect the dummy "nodes" into the network. Then:

c_{ij} = total transhipment cost per unit flow

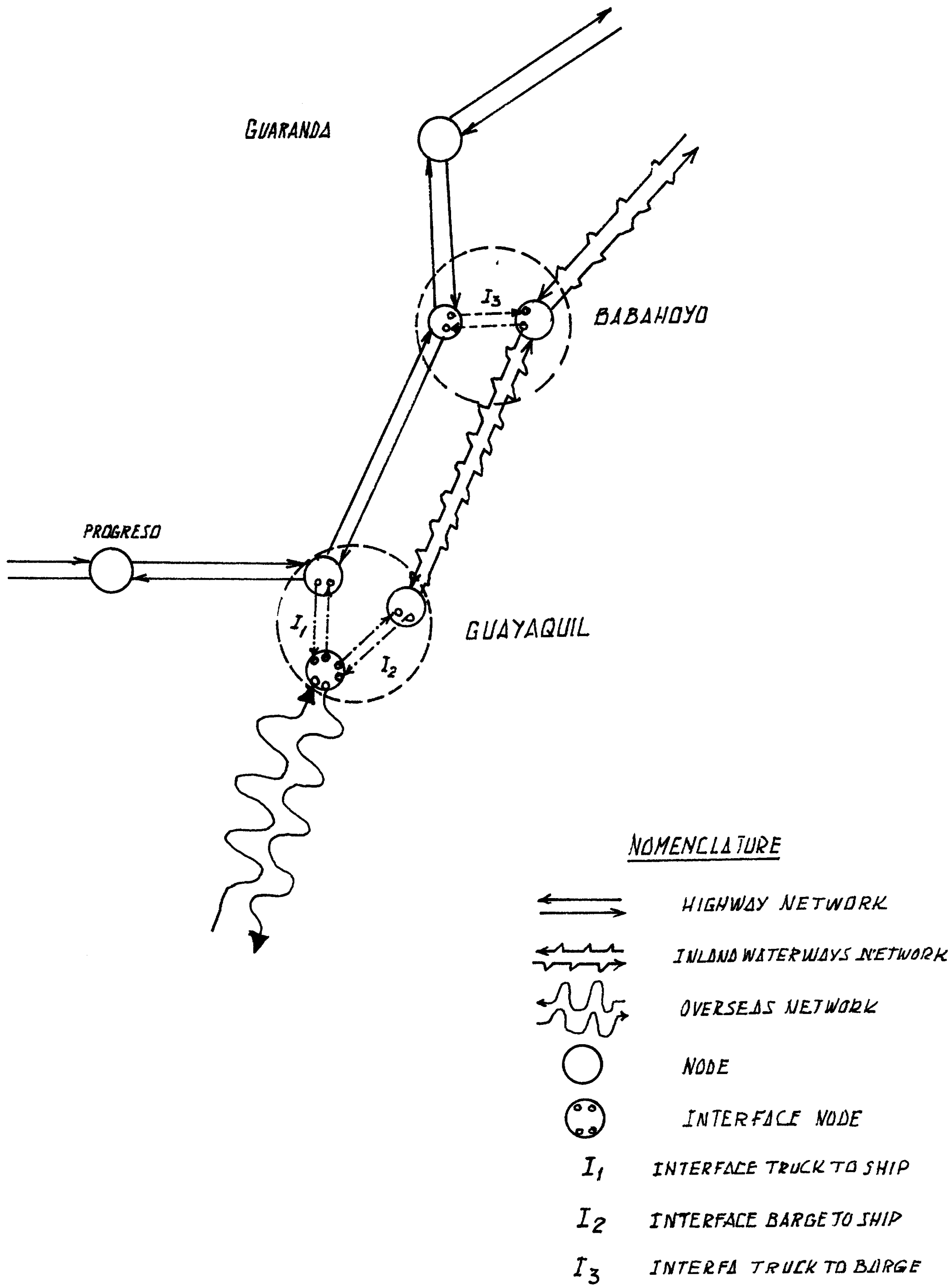
x_{ij} = average number of units moved through the facility

u_{ij} = upperbound capacity of the facility

l_{ij} = lowerbound capacity of the facility

The following figure which represents a portion of Ecuador's network, is a schematic representation of a set of nodes connected by different transportation nodes and illustrates how they are inputed to the model.

FIGURE B


GUARANDA
BABAHOYO
I_3
PROGRESO
GUAYAQUIL
I_1
I_2
NOMENCLATURE
HIGHWAY NETWORK
INLAND WATERWAYS NETWORK
OVERSEAS NETWORK
NODE
INTERFACE NODE
I_1 INTERFACE TRUCK TO SHIP
I_2 INTERFACE BARGE TO SHIP
I_3 INTERFA TRUCK TO BARGE

3.2 Data Input for the Model

3.2.1 Commodity Supply and Demand

The compilation of commodity tonnages by provinces and by node of origin is presented in Table 19. This table synthesizes the estimates of the maximum daily average tonnages that would be dispatched by different production areas toward the ports. Raw data has been taken from Tables 7, 8, 9, and 10. The resulting figures are order-of-magnitude values only suitable for planning purposes, more precise figures would require specific research designed to locate the areas of production and their respective production per year. As indicated in Chapter 2, this level of information was not available for this study.

With respect to imported commodities, a broad criteria has been adopted. The total import tonnage for the year 1969(*) has been divided by the total urban population (*)(*) and the resulting ratio, in tons per head, has been multiplied by the population of each one of the network's nodes. Again, figures are rough average approximations and do not take into account income differences among regions. The lack of regional income distribution data justifies the adoption of the described arithmetic approach. The requirement of the minimum cost and capacitated network algorithm, makes the distribution of commodity flows a matter of final

(*) Ref. 47, pages 152, 153

(*)(*) Projected: using 1962 census data and assuming a 3 per cent annual rate of growth for the total population, Ref. 4, page iii.

adjustment between cost and link capacity available to accommodate the actual flow demand. In average terms the overall capacity of the network may exceed actual flow demand but overflows may occur in some of the links feeding the main terminals. This possibility is taken into account in the computer model and causes, when required, a flow reorientation. Although network overloading would have the most critical effect under conditions of seasonal demand, this study is concerned with average flow demand given that any analytical sophistication in this direction would require a specific study of the affected links. Such a goal is beyond the context of the present study.

3.2.2 Highway Transport Costs

Table No. 20 presents highway operating costs for a truck having a payload of 8.9 long-tons.* Transport costs between nodes have been derived on the basis of these costs, according to the road type, and distance between nodes. The highway configurations, tested in this study, are shown in maps number 7 and 8. They are a synthesis of the proposals taken form the National Transportation Plan (Ref. 4), the National Planning Board (Ref. 5) staff's proposals, and a discussion of the roads feeding the ports as described in a U.N. Technical Report by M. V. Ubierna (Ref. 12).

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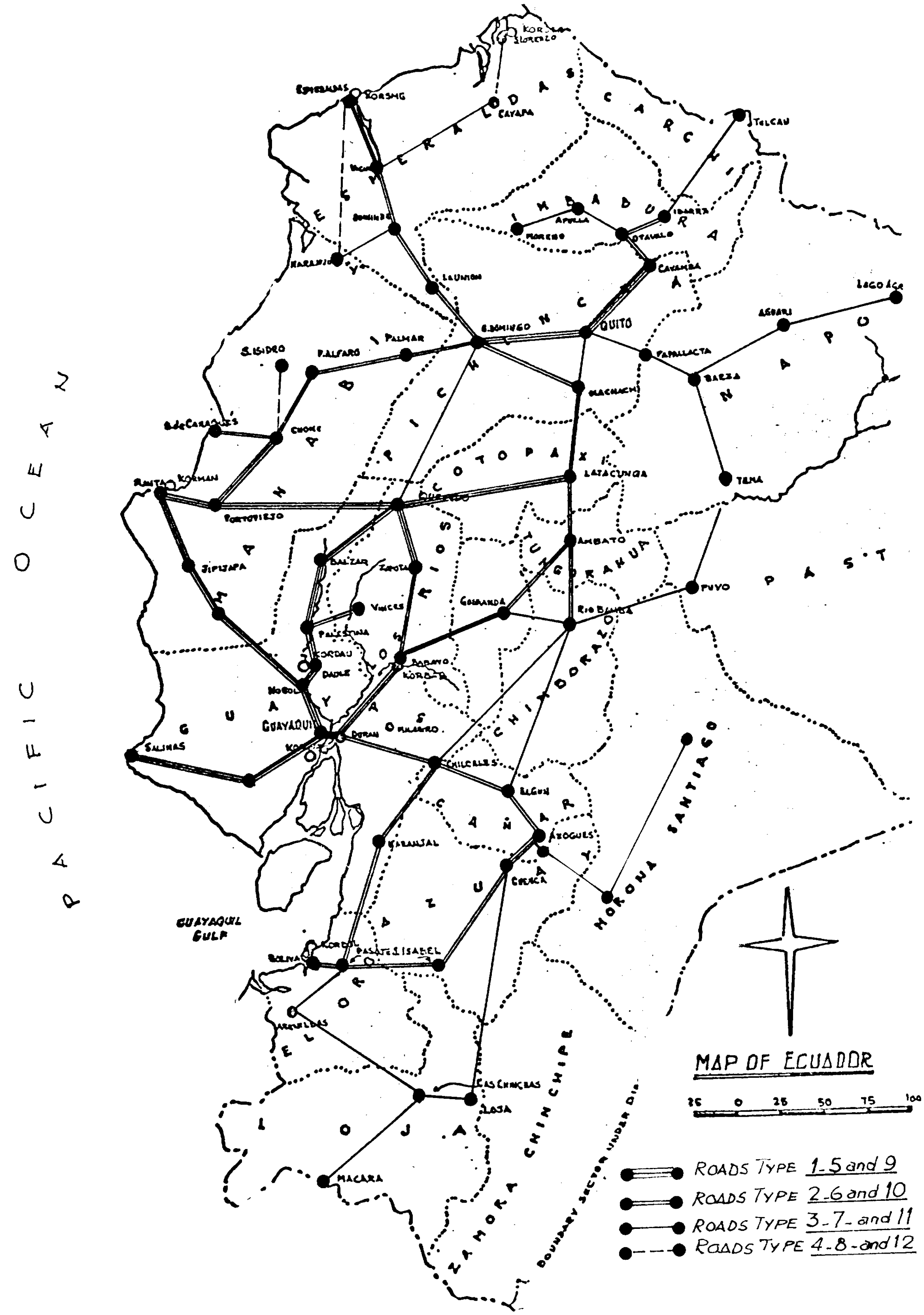
* A sample of the computer output printout for the different vehicle types and road conditions tested in the highway and user cost submodel is shown in Appendix 3.

THE HIGHWAY NETWORK FOR 1973

MAP No. 7



THE HIGHWAY NETWORK FOR 1983 - MAP No. 8

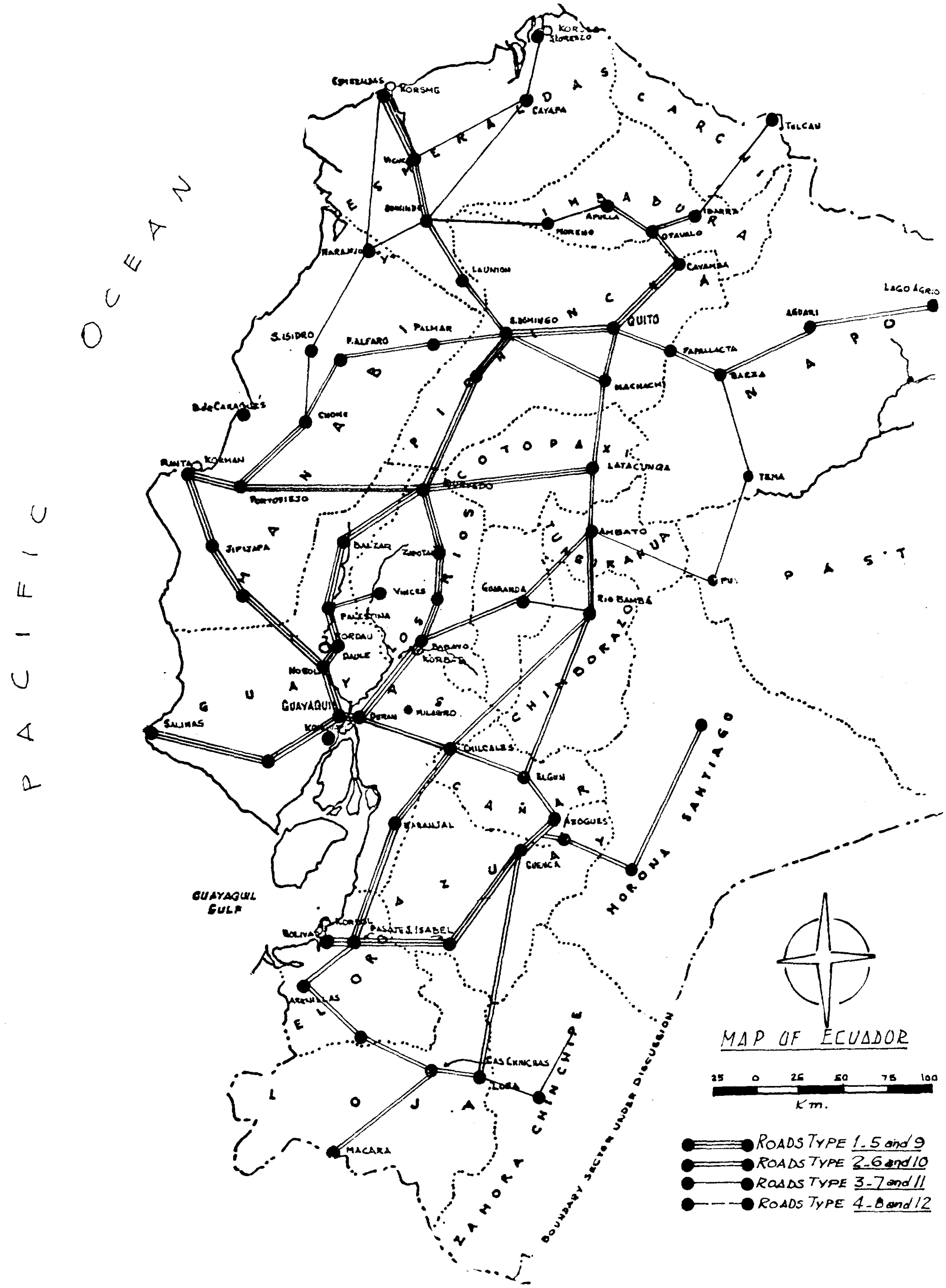


Table No. 19: Export Commodity Supply per Provinces and Nodes, Bananas + Coffee and Cocoa

Province	Node of Origin	Daily Exporting Flows(1) 1968 tons	1973 tons	1983 tons
Azuay	S. Isabel	.80	.88	1.07
Bolivar	Guaranda	50.00	54.00	64.00
Carchi		16.00	17.60	23.00
Canar	Chilcales	136.00	163.00	219.00
Cotopaxi	Valencia	236.00	281.00	376.00
Imbabura	Moreno	2.50	3.30	5.20
Loja	Las Cinchas	59.14	63.70	75.40
	Zaruma			
Picincha	S. Domingo	603.00	831.00	1133.00
	P. Ila	329.50	416.50	580.50
	La Palma	190.00	209.00	240.00
Esmeraldas	Quininde	115.00	139.00	202.30
	La Union	80.00	90.00	102.00
	Viche	140.00	165.00	219.00
	Esmeraldas	48.50	108.40	131.20
	Cayapa	17.50	19.70	24.50
	S. Lorenzo	26.00	34.50	53.60
El Oro	Pasaje	186.00	213.00	293.00
	Arenilla	166.00	234.00	358.00
	Pinas	83.80	91.00	105.00
	Bolivar	84.00	92.10	112.00

Table No. 19: Continued

Province	Node of Origin	Daily Exporting Flows (1) 1968 tons	1973 tons	1983 tons
Guayas	Balzar	117.00	126.00	157.00
	Palestina	54.00	61.80	75.00
	Daule	176.40	226.00	355.00
	Nobol	112.00	124.00	151.00
	Progreso	32.50	35.70	41.20
	Naranjal	223.00	261.00	351.10
	Duran	114.60	121.00	141.20
	Milagro	86.30	104.60	184.60
Los Rios	Quevedo	420.40	462.00	571.00
	Zapotal	419.30	493.00	658.20
	Catarama	277.00	329.00	438.00
	Babahoyo	616.50	685.00	895.30
	Vinces	282.20	310.00	434.70
Manabi	Portoviejo	21.50	20.50	25.00
	F. Alfaro	89.50	132.00	188.00
	Chone	100.00	162.00	156.00
	S. Isidro	30.00	32.00	48.50
	Naranjo	32.50	36.50	45.50
	Pajan	48.00	59.00	66.00
M. Santiago	Limon	43.00	48.50	59.00
	Macas	8.50	9.60	11.60
Napo	Papallacta	15.00	18.00	24.00
	Baeza	10.00	12.60	13.70

Table No. 19: Continued

Province	Node of Origin	Daily Exporting Flows (1) 1968 tons	1973 tons	1983 tons
Pastaza	Puyo	25.00	27.40	31.60
Z. Chinchipe	Zamora	36.00	39.50	45.70
Total Country		6,500.00	7,800.00	10,250.00

Source: Elaborated with data from Tables 7, 8, 9, and 10.

(1) It is assumed that the total production is leaving its respective production area toward port cities for warehousing and packaging.

Table No. 20: Operating Vehicle Costs, for an 8.9 Long-Ton Truck

- in dollars of 1963 -

Road Type No.	Character	Operating Costs Per Ton-km
1	Asphalt Mountainous	.039
2	Gravel Mountainous	.064
3	Earth Mountainous	.129
4	Earth Mountainous (*)	.170
5	Asphalt Rolling	.032
6	Gravel Rolling	.060
7	Earth Rolling	.0785
8	Earth Rolling (*)	.132
9	Asphalt Rolling	.025
10	Gravel Rolling	.044
11	Earth Rolling	.082
12	Earth Rolling (*)	.11

(*) Less than 3.00 meters width

3.2.3 Interface Cost Operation

In order to describe the multiple combinations involved in the interface operations in the context of a general network model a specific node-link nomenclature must be established to identify each possible alternative. The following dictionary describes the meaning of each alternative, as used throughout the model:

BOLIVA-PORBOL GUAYAQ-PORGUA MANTA-PORMAN ESMERA-PORSME	Interface cost for unloading truck and loading an oceangoing ship.
BOLIVA-WORBOL GUAYAQ-WORGUA MANTA-WORMAN ESMERA-WORSME	Interface cost for unloading a truck and loading an inland waterway barge or lighter.
BOLIVA-KORBOL GUAYAQ-KORGUA MANTA-KORGUA ESMERA-KORSME	Interface cost for unloading a truck and loading a coastal barge.
WORBOL-PORBOL WORGUA-PORGUA WORMAN-PORMAN WORSME-PORSME	Interface cost for unloading an inland waterway barge and loading an oceangoing ship.
KORBOL-PORBOL KORGUA-PORGUA KORMAN-PORMAN KORSME-PORSME	Interface cost for unloading a coastal barge and loading an oceangoing ship in an integrated operation.

The cost of these combinations has been compiled in Table 21, using the output of the Interface Model.* However, in order to equate the average interface costs to the actual port configuration

* Printouts are included in Appendix 3.

another set of calculations must follow. These calculations are oriented toward an average cost of the coexistent technologies in each one of the ecuadorian ports. Technologies currently used are a combination of lighterage and pier ports. Consequently, successive computer runs consider an initial situation in which interface costs are the average cost described above and a final situation in which lower interface costs for each port are assumed. The last case is equivalent to assuming that a certain amount of investment would be needed in order to create the required homogeneous technological conditions in each port. The following calculations, though, are made for obtaining an average of the interface costs for each technology and each port.

Table No. 21: Interface Operation Costs (In dollars of 1963)

PORTS	EXPORTING COMMODITIES BANANAS	COFFEE & COCOA	AVERAGE COST	IMPORT COMM. LOCAL	IMPORT COMM. OVERSEAS
BOLIVAR:					
BOLIVA-KORBOL	2.46	2.78	2.62		
KORBOL-BOLIVA				2.62	4.62
BOLIVA-PORBOL	7.33	8.23	7.78		
PORBOL-BOLIVA					11.33
BOLIVA-WORBOL	3.24	3.70	3.47		
WORBOL-BOLIVA				3.47	6.80
WORBOL-PORBOL	7.77	8.69	8.23		
PORBOL-WORBOL					12.07
GUAYAQUIL:					
GUAYAQ-PORGUA	7.29	7.42	7.35		
PORGUA-GUAYAQ					9.12
GUAYAQ-KORGUA	2.79	2.93	2.81		
KORGUA-GUAYAQ				2.81	4.32
KORGUA-PORGUA	5.97	6.22	6.09		
PORGUA-KORGUA					7.29
WORGUA-GUAYAQ				3.70	5.85
GUAYAQ-WORGUA	3.64	3.76	3.70		
WORGUA-PORGUA	7.81	7.94	7.87		
PORGUA-WORGUA				9.91	

Table No. 21: Continued

PORTS	EXPORTING COMMODITIES BANANAS	COFFEE & COCOA	AVERAGE COST	IMPORT LOCAL	COMM. OVERSEAS
MANTA:					
MANTA-KORMAN	2.50	2.96	2.73		
KORMAN-MANTA				2.73	3.90
MANTA-PORMAN	7.13	8.38	7.75		
PORMAN-MANTA					10.12
KORMAN-PORMAN	5.11	5.55	5.33		
PORMAN-KORMAN					6.84
MANTA-WORMAN	3.24	3.70	3.47		
WORMAN-MANTA					
ESMERALDAS:					
ESMERA-KORSME	2.45	3.06	2.75		
KORSME-ESMERA				2.75	5.65
ESMERA-WORSME	2.00	3.10	2.55		
WORSME-ESMERA				2.55	8.21
WORSME-PORSME	9.99	11.75	10.87		
PORSME-WORSME			13.43		18.05
BABAYO-KORBAB	2.45	3.06	2.75		
DAULE-KORDAU	2.45	3.06	2.75		
SLOREN-KORLOR	2.45	3.06	2.75		

According to the particular technological configuration of each port and based upon Table 21 the weighted average interface cost are calculated in the following:

WEIGHTED AVERAGE INTERFACE COSTS - In 1963 Dollars -

PORT OF GUAYAQUIL

(5 alongside berths + 2 anchorage areas)

	BANANAS	COFFEE & COCOA	AVG. EXPORT COMM.
From truck to dock & dock to ship	7.29	7.42	7.35
Truck to dock-Dock to lighter-Lighter to ship	11.45	11.70	11.57
Weighted average interface cost			8.57

	IMPORTED COMMODITIES
From ship to dock-dock to truck	9.12

PORT OF BOLIVAR

(2 docks along a pier + 2 anchorage areas)

	BANANAS	COFFEE & COCOA	AVG. EXPORT COMM.
From truck to dock-dock to ship	7.33	8.23	7.78
From truck to dock-dock to lighter-lighter to ship	11.01	12.39	11.70
Weighted average for interface cost			9.74

	IMPORTED COMMODITIES
From ship to dock-dock to truck	11.33

PORT OF MANTA

(4 docks + 2 anchorage areas)

	BANANAS	COFFEE & COCOA	AVG. EXPORT COMM.
From truck to dock-dock to ship	7.13	8.38	7.75
From truck to dock-dock to lighter-lighter to ship	10.38	12.08	11.22
Weighted average for interface cost			8.90
	IMPORTED COMMODITIES		
From ship to dock-dock to truck	10.12		

PORT OF ESMERALDAS

(1 anchorage deepwater site)

	AVG. EXPORTING COMMOD.	AVG. IMPORTING COMMOD.
From ship to lighter-lighter to dock-dock to truck		18.05
From truck to dock-dock to lighter-lighter to ship	13.43	

3.2.4 Coastal and Inland Waterways Systems

The coastal and inland waterway systems have been described in Chapter 2 and no further changes have been introduced to the estimated transportation costs. In Maps 9 &10, the basic network is presented along with the corresponding nodes and terminals.

3.2.5 Oceangoing Transport-Costs

In spite of the fact that oceangoing transport costs may have a major weight in the final transport cost of each commodity the influence of these costs on hingerland configurations and inland commodity flows is limited. Consequently, and for the purpose of the present study, only one of the multiple overseas links will be analyzed and inputed to the network model. The following calculations correspond to the New York-Santiago de Chile trade route, and for a 5800 N.R.T. charter vessel. Cost per day is calculated on the basis of charter rates (Ref. 13) for a 5000 ton payload charter vessel, plus fuel cost and Panama channel tolls.

Then:

a. Charter rates for 5000 ton payload and 19 knot speed vessel taken as $1700 per day.

b. Panama channel tolls, at $1.40 per N.R.T. (Ref. 13, p. 87 or $8150 one way

c. Lubricants and fuel costs of $20.30/ton of consumption for round trip distance of 9500 nautical miles* = $15,000

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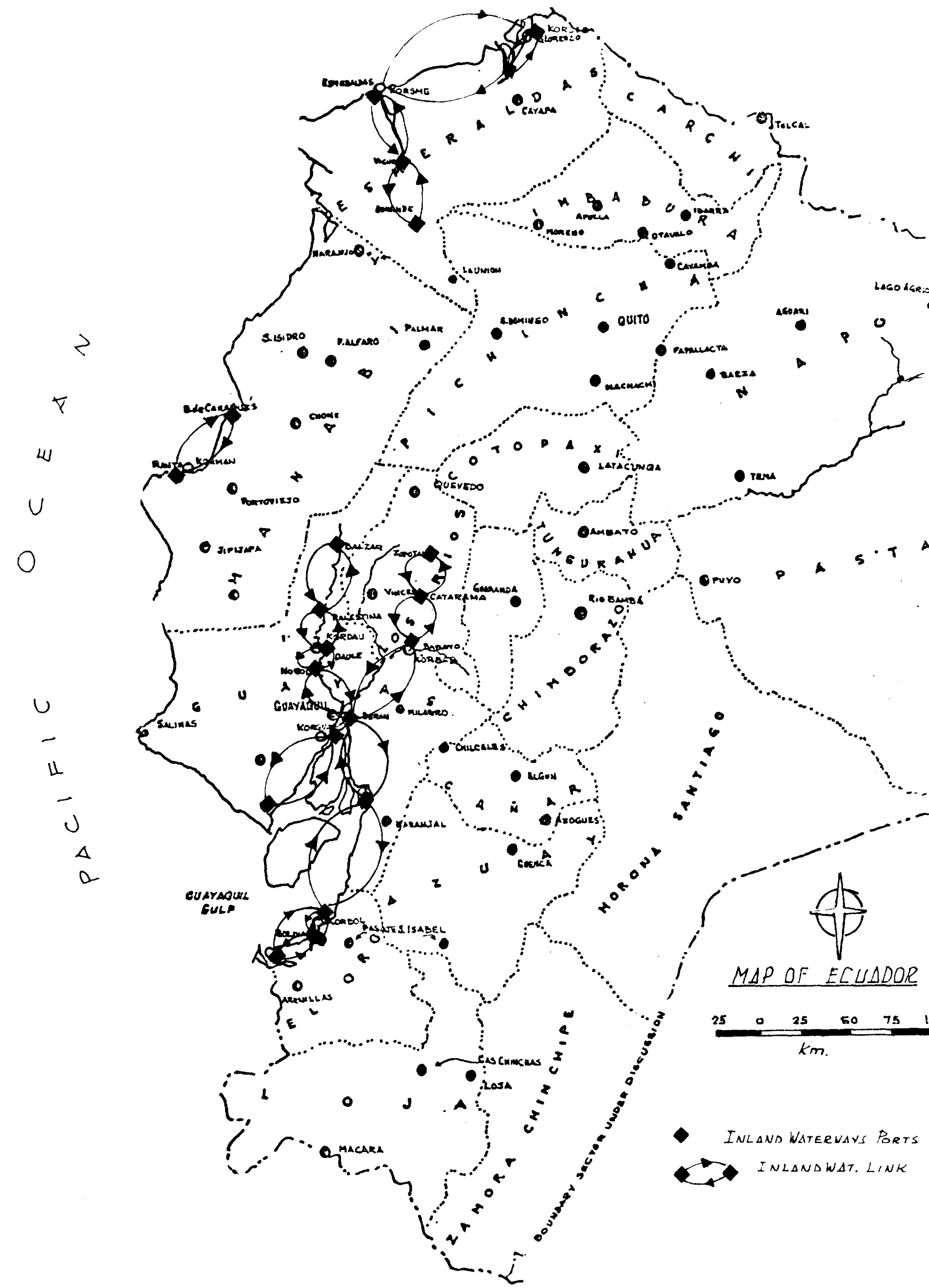
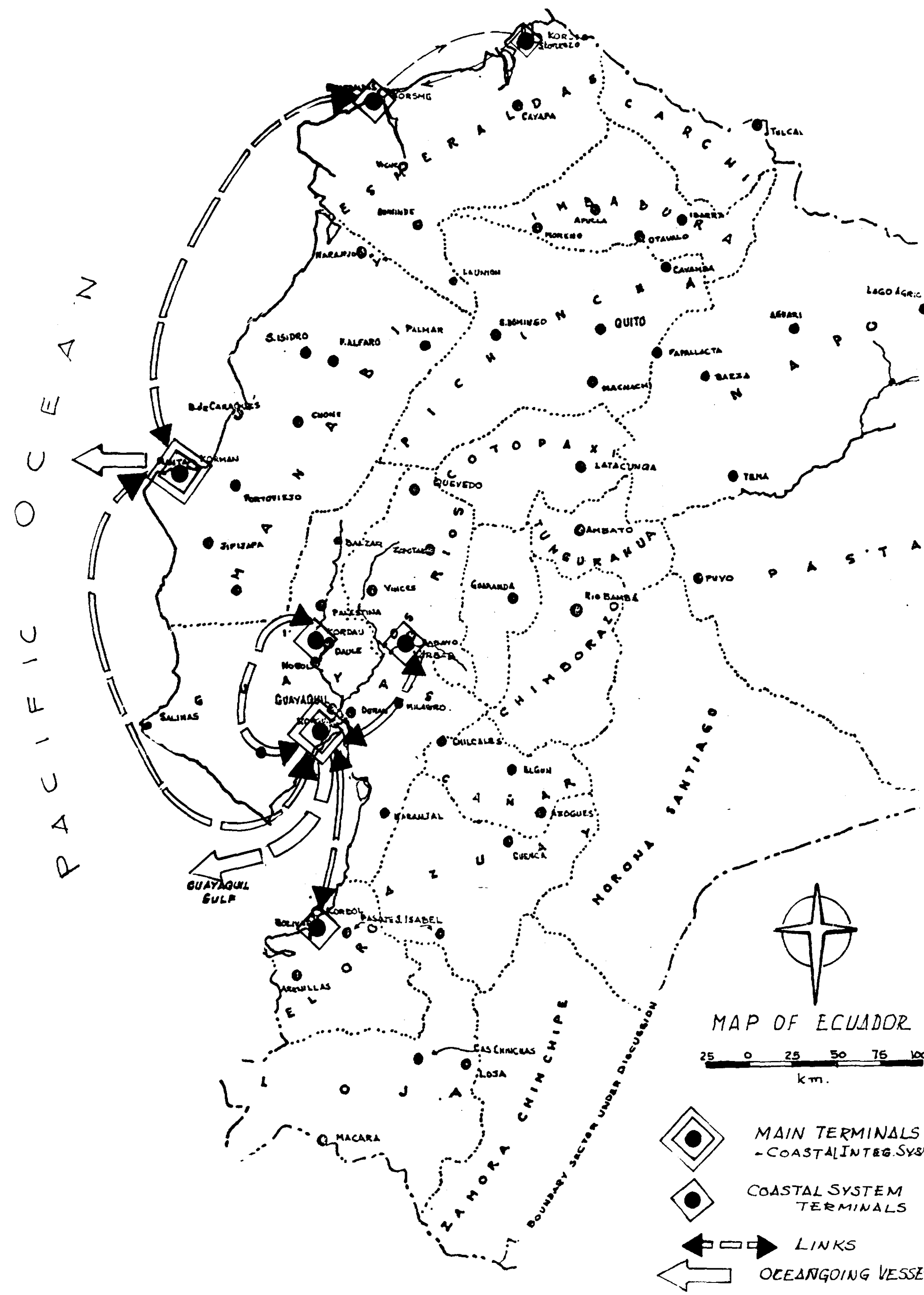
* Assuming 740 tons of fuel per round trip.

INLAND WATERWAY NETWORK MAP No 9



COASTAL FEEDER SYSTEM'S NETWORK MAP No 10



Cost per nautical mile = \$15,000/9500 = \$1.58

d. Panama channel tolls reduced to basis of cost per nautical mile for trip = \$8150/4750 = \$1.71

e. Charter costs per day on per mile basis equals \$1700/18.1 x 24 = \$3.90 per nautical mile

f. Average operating costs per nautical mile = 1.58 + 1.71 + 3.90 = \$7.19*. In 1963 prices** this figure is equivalent to \$6.10.

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* 1970 U. S. dollars

** Rate of depreciation according to the New York Times, Encyclopedic Almanac 1971, p. 634.

Chapter IV

4.1 Commodity Flow Simulation

The behavior of flows throughout the network will be tested in order to measure the impact of alternative transport policies. Through a sequence of computer experiments, it is expected that the simultaneous effects of currently more or less separated decisions might be evaluated in a more comprehensive fashion.*

The main parameters used in this general simulation model are:

a. The 1967 highway system (Ref. 5, p. 81)

b. The 1973 highway system (Ref. 4, Ref. 5)

c. The 1983 highway system (Ref. 4, Ref. 5)

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* Although no consideration has been devoted to the railway system, its exclusion may not restrict seriously the scope of the findings of the present study.

d. The 1967 port configuration (Ref. 12)

e. The 1973 proposed port configuration under two alternative conditions:

e_1 Interface costs are assumed to be the average cost of current coexistent port technologies in each port, i.e., lighterage and on pier loading-unloading

e_2 Interface costs are assumed to be the lowest of the existent port technologies in each port. (See Table 23)

f. The current inland waterway system

g. The integrated coastal feeder system.

h. The projected production of Bananas-Coffee and Cocoa by the year 1973.

i. The projected production of Bananas-Coffee and Cocoa by the year 1983.

Consequently, under the heading of Hinterland Configuration, a diverse set of parameter combinations will be analyzed in the following order:

1. Hinterland Configuration Number 1, year 1968

   Including parameters a, d, and f, its purpose is to supply a base of comparison between the model output and actual statistical data.

2. Hinterland Configuration Number 2, year 1973

   Parameters, b, e_1, f, and h

3. Hinterland Configuration Number 3, year 1973

   Parameters b, e_1, f, g, and h

4. Hinterland Configuration Number 4, year 1973

   Parameters b, e_2, f, and h

5. Hinterland Configuration Number 5, year 1973

   Parameters b, e_2, f, g, and h

6. Hinterland Configuration Number 6, year 1983

   Parameters c, e_1, f, and i

7. Hinterland Configuration Number 7, year 1983

   Parameters c, e_1, f, g, and i

8. Hinterland Configuration Number 8, year 1983

   Parameters c, e_2, f, and i

9. Hinterland Configuration Number 9, year 1983

   Parameters c, e_2, f, g, and i

4.2 Presentation of Results from Computer Models

4.2.1 Extent of Port Hinterlands Under Environment Condition 1

The geographical extent and shape of the Ecuadorian port hinterlands for 1968 as derived from computer outputs, is a reasonable reproduction of the real-world configuration*. Table 22 at the end of this chapter summarizes the results from the computer models, while in map 11 a graphical interpretation of the computer results for the year 1968 is presented. The main reason for presenting this map is to provide a basis against which

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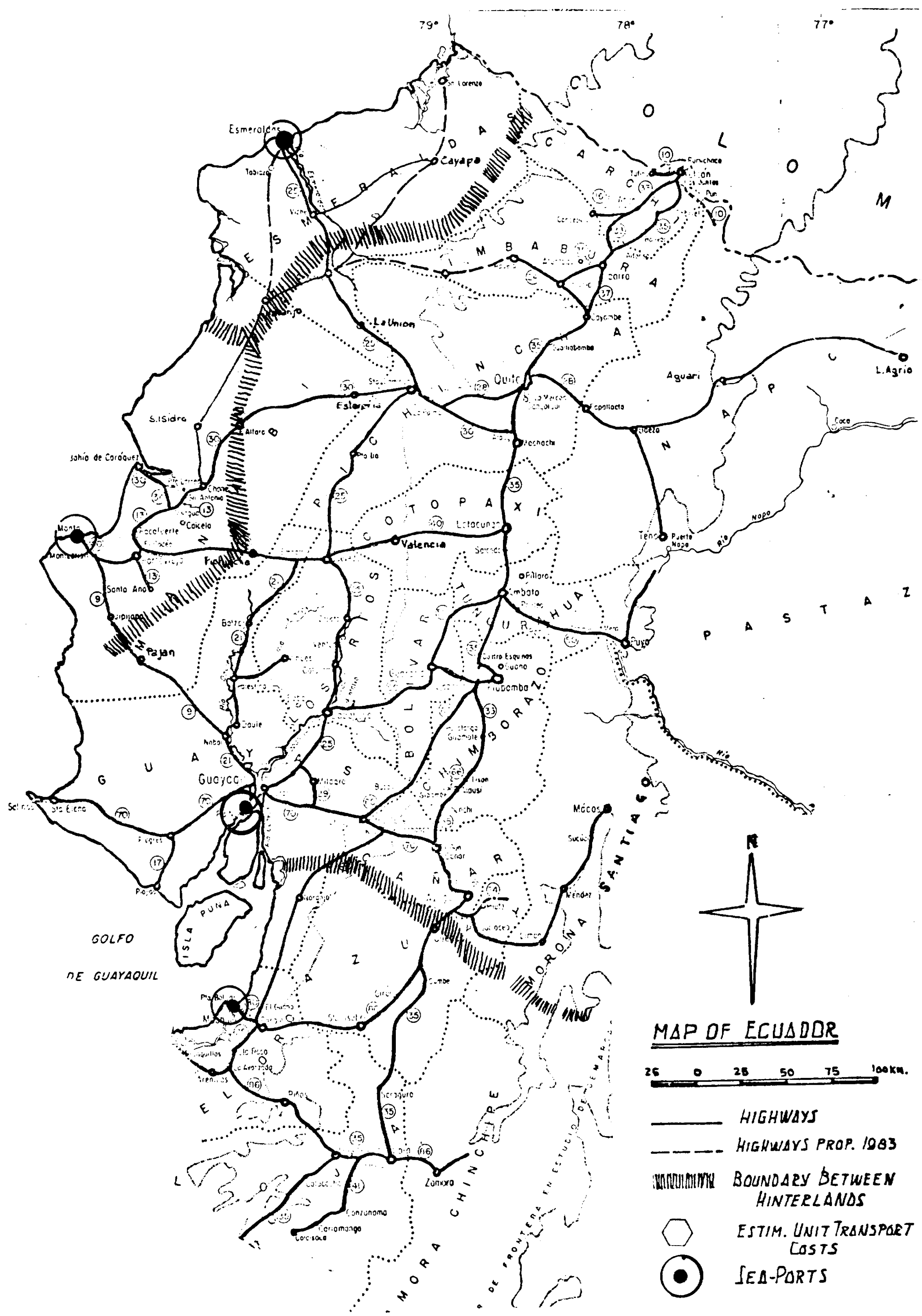
* Described in Refs. 4, 6, 7, and 15.

MAP No. 11 - EXTENT OF HINTERLANDS .. ENVIRONM. COND. 1



changes in hinterland configuration resulting from the transport and port parameters can be appraised. Furthermore, results in connection with the production assigned to the nodes in each hinterland area and, the actual port throughput in 1968, also show reasonable numerical consistency, though this conclusion cannot be derived merely by examination of the figures.

In the case of Ecuador, banana marketing and processing patterns will suffice to explain the differences between the total estimated flow toward port cities, the estimated exports and the actual tonnages exported in 1968. As was indicated in Part 1 of Chapter 2, statistics reporting banana exports do not represent the effective flow toward port cities. An approximate 10 per cent allowance for shrinkage and rejection (Ref. 29, p. 80), plus another 10 to 15% for local consumption and processing results in a total flow toward the port cities of 20 to 25% more than the actual exported tonnage.**

With respect to the traffic through Guayaquil, Bolivar, and Esmeraldas the results are conclusive. In the case of Manta, the results are also reasonable although the principal commodity was coffee rather than bananas. Moreover, port statistics* for the years 1969 and 1970 show a heavy increase in the banana traffic through this port and close similarities to the other

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* Answers to a questionnaire submitted in April, 1971, to the Port Authority.

** 6 per cent is assumed to be rejected in plantation areas before shipping toward port cities.

ports' flow patterns. It was assumed also that flows toward port cities from Pichincha, Cotopaxi, Bolivar, El Oro and Manabi provinces will be 15% less than the estimated production listed in Table 7. This deficiency provides for internal consumption within the Sierra provinces.

4.2.2 Extent of Port Hinterlands Under Environment Condition 2 Parameters

b. By the end of 1973 the Highway System plan as recommended by the National Transportation Plan and the National Planning board staff has been implemented. The system is shown on Map. No. 7.

e_1. The proposed port configuration has also been implemented by 1973. It is also assumed that port interface costs are the average cost of current coexistent technologies.

f. The current inland waterway system is maintained.

h. The production of Bananas, Coffee and Cocoa follow the 1973 properties.

A geographic expansion, with respect to 1968, of the Manta and Esmeraldas hinterlands seems to be the most apparent impact of the assumed set of parameters. With the exception of one small "invasion" of the Guayaquil hinterlands* the area under the influence of Bolivar may be reported as stable.

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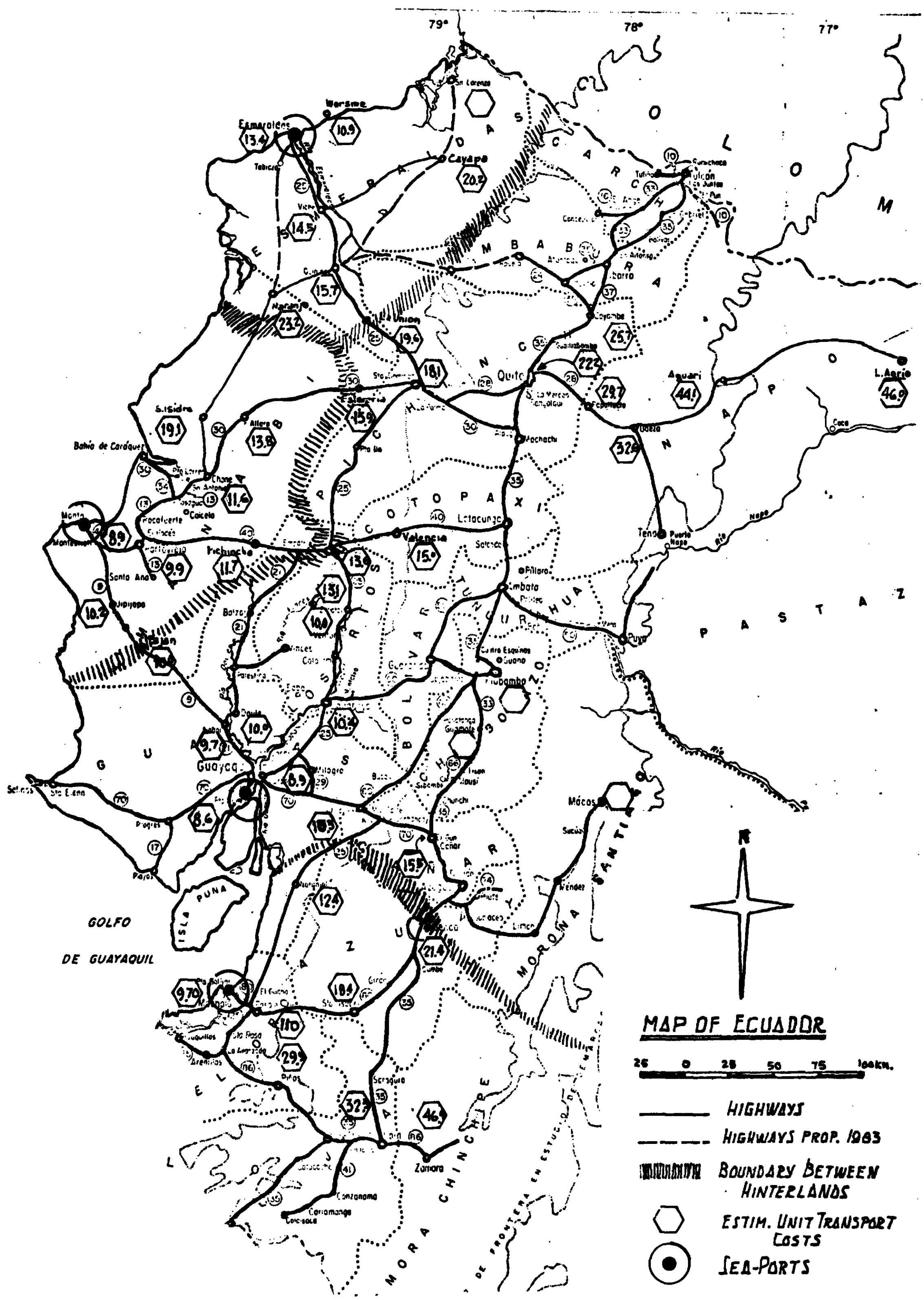
* South of Canar province.

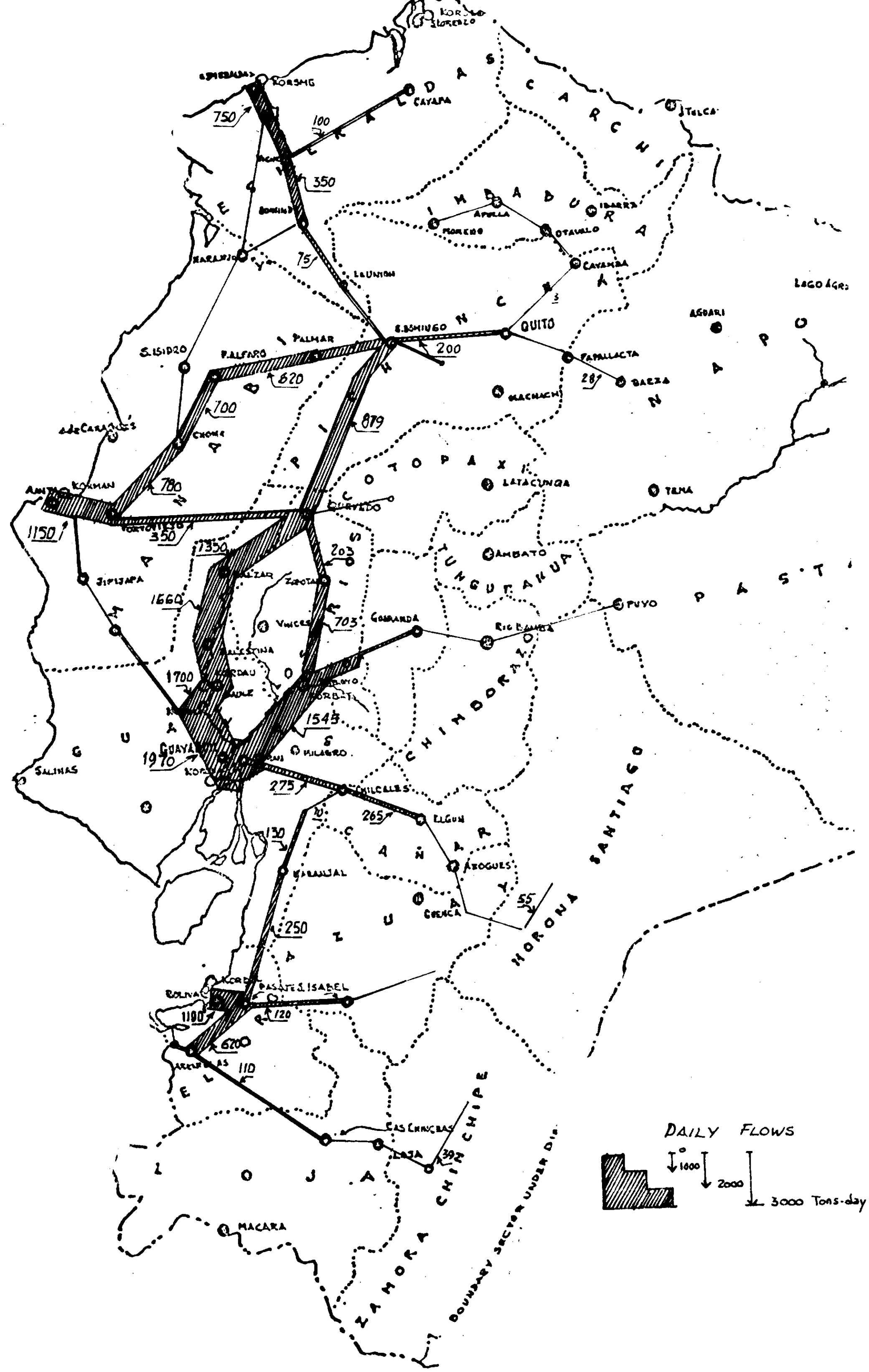
It is estimated that in terms of annual exporting flows toward port cities, Guayaquil's share will drop to approximately 66 per cent of the total. Yet, in absolute terms, exporting tonnages through Guayaquil would still keep the same levels as in 1967. (Table 22) It is also likely that under the assumed combination of parameters Manta and Esmeraldas would increase their respective participation in total exporting tonnages by around 9.5 and 6 per cent.

The major daily concentration of flows are expected to occur along the Santo Domingo - Nobol - Guayaquil and Santo Domingo - Quevedo - Manta Corridors. Quevedo city appears as an important flow distributor node, from that point unit transport costs toward the Guayaquil and Manta terminals are equal. In map No. 13, flow distribution has been assumed to be proportionate to the estimated port throughput at each end of the respective corridors. Inland waterway traffic would continue to represent a relatively important mode along the Esmeraldas River and for local movements toward Guayaquil along the Babahoyo River. An interesting finding of the current experiment was that the lower cost route from Quevedo City to Guayaquil would be from Quevedo to Zapotal and thence to Guayaquil via the Babahoyo River. However, given the existing facility constraints only a portion of the total potential flow would be expected to follow this route.

MAP No. 12 – EXTENT OF PORT HINTERLANDS – ENVIR. CONDITION 2 –



ESTIMATED FLOW ORIENTATION - ENVIRONM. CONDIT. 2 - MAP No. 13



4.2.3 Extent of Port Hinterlands under Environment Condition 3

Parameters: b - e_1 - f and h - (the same as in Section 4.2) plus:

g. An integrated coastal feeder system, as described in Sections 6 and 7 of Chapter 2, has been introduced. The system consists in a coordinated coastal feeder subsystem operating with a scheduled fleet of oceangoing vessels. The ports of Guayaquil and Manta have been assumed to be the main terminals while Bolivar, Daule, Babahoyo, San Lorenzo, and Esmeraldas operate as feeder ports. The operation of the coastal feeder system, even in those cases in which total transport costs are lower, does not necessarily mean the elimination of existing operational patterns. The system is assumed to participate only in 30% of the total movement of exporting commodities.

In geographical terms, the coastal system has caused no significant changes with respect to the hinterland area extent described in Section 4.2.3*. However, the impact of the coastal system is qualitatively relevant. 1.) Two inland cities, Santo Domingo and Quevedo, each located at hinterland boundaries, might play a key role in determining the distribution of flows to the ports of Esmeraldas, Manta and Guayaquil. 2.) In all the ports, the integrated coastal system would represent a less expensive

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* Map No. 16

mode of transportation for the export commodities analyzed. Despite the differences in unit costs favoring the coastal system only a third of the total exporting flow has been channelled toward this system.* Flows throughout the coastal system itself have been distributed in proportion to the number of docks supposed to be working in each port facility. By comparison with the median transport costs estimated in Section 4.2.2 for each hinterland, a reduction of 4.5% in Guayaquil, 1.5 in Bolivar, 6.5 in Manta and 3.5% in the Esmeraldas influence areas is likely to occur.** More equitable distribution of flows among regions, lower backhauls distances and more efficient use of the existing highway inventory and facilities may be predictable consequences. The expected inland flow distribution is shown in Map No. 13.

An estimated annual saving of around 2.9 million dollars*** with respect to the environment condition 2 might be expected with the introduction of a Coastal System. On the other hand the estimated total operating costs for the system is 2.4 million dollars per year. Consequently, the benefits might approach 500 thousand dollars per year.

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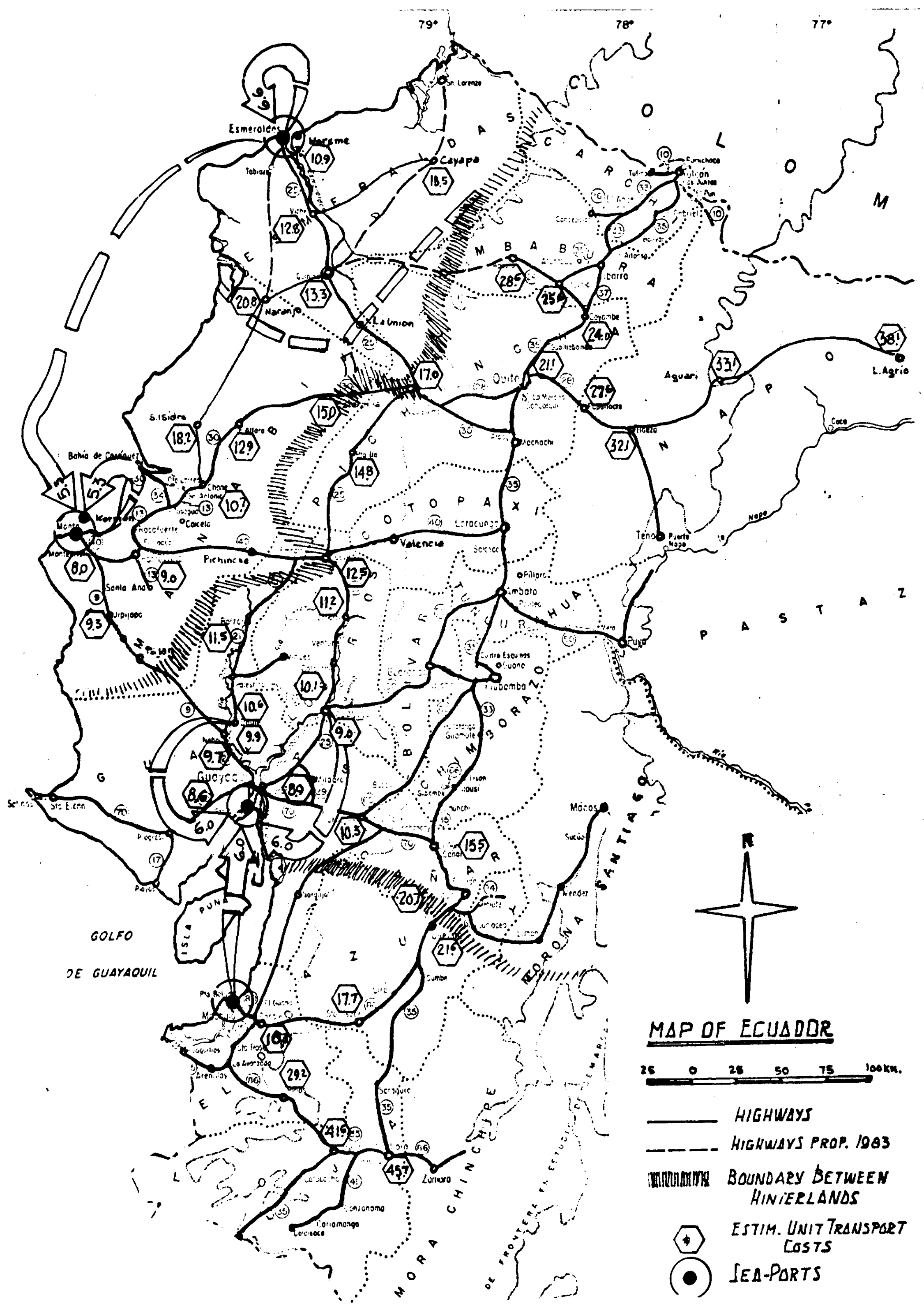
*This question was already discussed in Chapter 2, Part 7

**Indicated in Table 22, Map No. 14

***At 1963 dollars

MAP No.14 _ Extent of Port Hinterlands, Environm. Cond. 3



4.2.4 Extent of Port Hinterlands under Environment Condition No. 4

Parameters: b, f are the same as in Section 4.2.3.

e_2. It is proposed that the ports are utilizing the less expensive of the technologies currently coexisting. If a port, for example, is operating lighterage docks and alongside berths, the interface costs assigned to the port will be the lower of the two technologies. In the Ecuadorian case, the ports of Guayaquil, Bolivar, and Manta will be assumed operating only as alongside berth ports while Esmeraldas will remain as a lighterage port.

The major impact of the assumed port technology with respect to the 1968 hinterland's configuration is indicated by the expansion of the Manta and Esmeraldas hinterlands. No strong changes would occur for the Bolivar port with the exception of the one small "invasion" of the Guayaquil hinterland in the southern part of the Canar province. (Map No. 15) It is estimated that in terms of total flows toward ports, Guayaquil will continue to be in a leading position with an approximate 70 to 75% of the total exporting flows of the country. Bolivar will keep the same 13 to 14% of the total exports as in 1968 while Manta and Esmeraldas would increase their relative participation from 1.4 to approximately 5% and from 3.5 to 10% respectively.

A comparison of the Condition No. 4 results for 1973 with the 1973 conclusions of Section 4.2.2 as indicated in Table 22, shows that the lower port costs associated with Condition No. 4 result in:

1. An increase of about 6% in the exporting flows through Guayaquil along with a nearly equal reduction of the exports through Manta.
2. A reduction in the median unit transport costs of 7, 12 and 12 per cent for the Guayaquil, Bolivar, and Manta hinterlands respectively.

The major concentration of flows would occur along the corridor Santo Domingo, Quevedo, Balzar, Guayaquil and Quevedo, Babahoyo, Duran, Guayaquil. Changes of relative prices in tolls for the Guayaquil-Duran bridge may cause some readjustment in the traffic between the two routes south of Quevedo City. For the daily flows indicated in Map No. 16, no resistance to the traffic movement is expected to occur along the corridors' roads. The road between Nobol and Guayaquil for example, may concentrate 300 to 400 trucks a day while its estimated maximum capacity would be on the order of 600 trucks per day. Traffic 'resistance' along local streets and avenues has not been evaluated, however, it may be of significant relevance in the case of neighboring ports like Guayaquil and Manta where small changes in operating costs may induce shifts in flow orientation.

As expected, inland waterways provide a clearly advantageous mode of transport to lighterage ports. According to the computer outputs, only for the port of Esmeraldas would the continued use of small barges be more convenient. In the Guayaquil and Bolivar port areas, the service of inland barges on the Daule, Babahoyo Rivers and on the Guayaquil Bay appears to play a secondary role, they would not be able to compete with trucks.

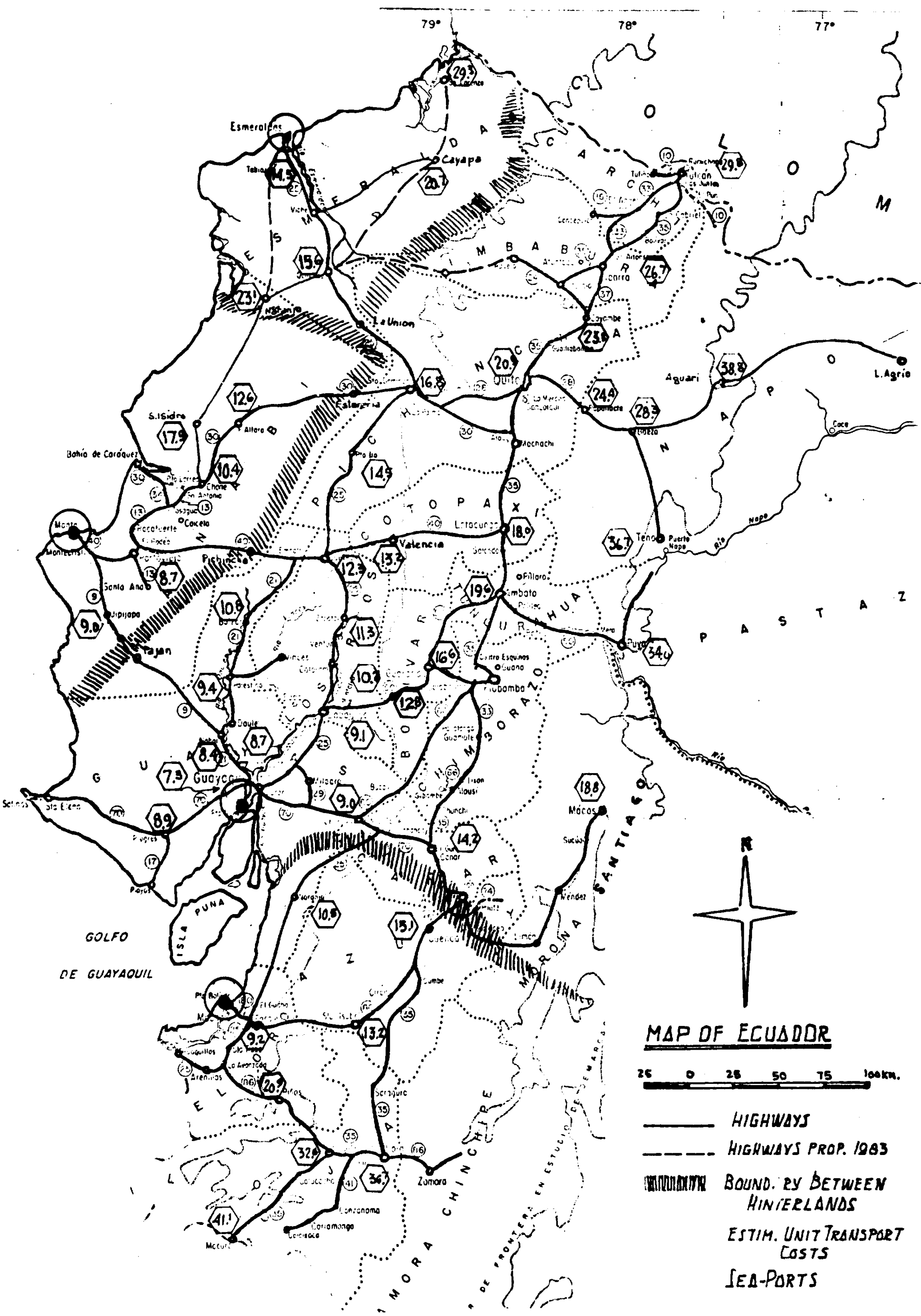
An estimated annual saving of around 1.7 million dollars with respect to the environment condition no. 2 might be expected from the operation of the proposed port configuration. The cost of implementing the new installations (*) was estimated in 7.2 million dollars. If this amount were to be repayed in 30 equal installments with an interest of 3 per cent (**) the annual payments would be 367 thousand dollars.

Thus the actual benefit for the economy might be around 1.3 million dollars per year.

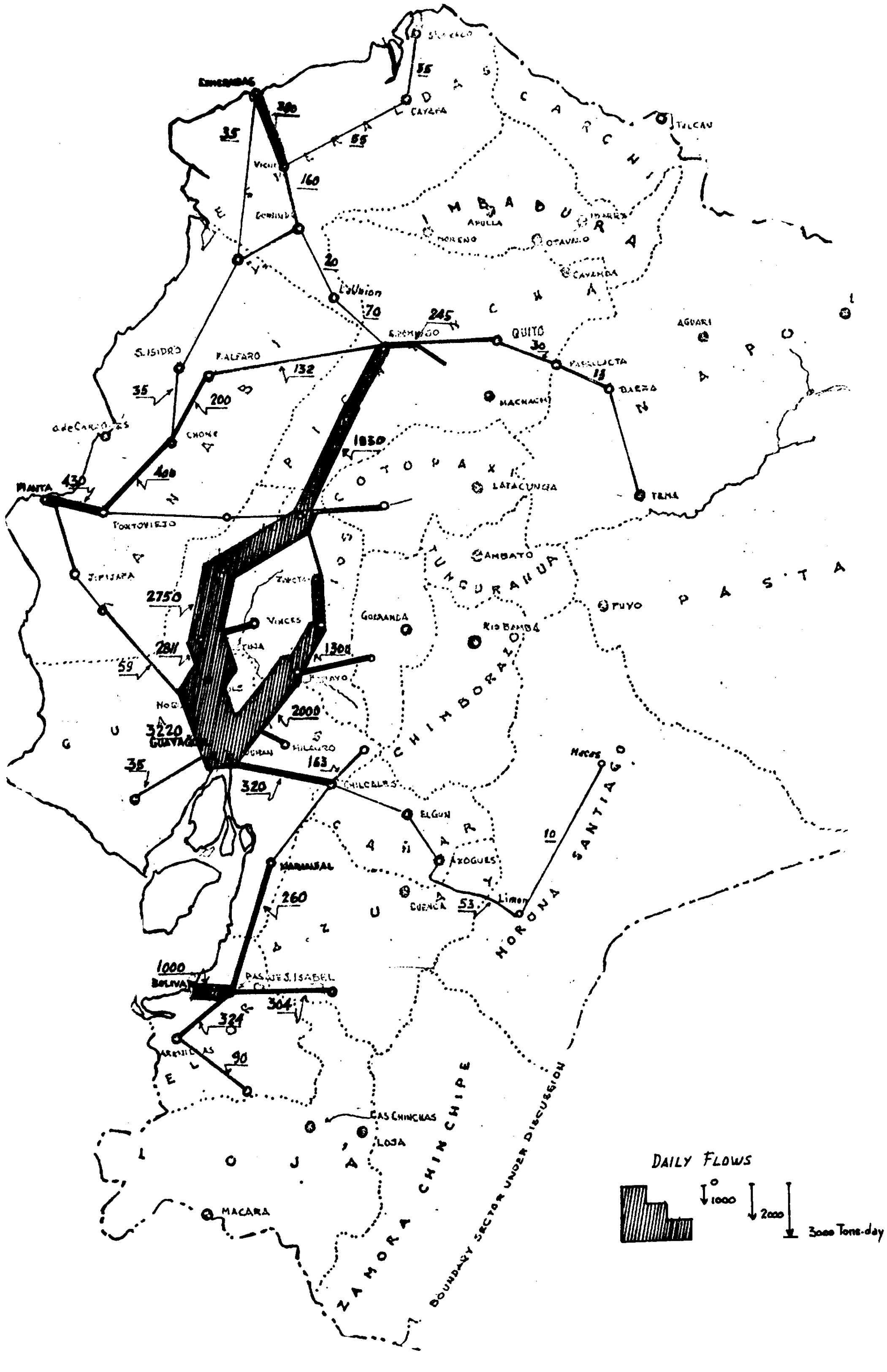
(*) Two docks are assumed to be constructed in Guayaquil, Manta and Bolivar respectively. The estimated cost per dock is 1.2 million dollars - cost of water side and inland facilities per dock.

(**) A higher interest rate with respect to previous port construction loans has been assumed because of current higher capital cost at the present time, however it is thought that this interest might be too low.

MAP No. 15 EXTENT OF PORT HINTERLANDS – ENVIRONM. CONDIT. 4



ESTIMATED FLOW ORIENTATION _ ENVIRONM. CONDITION 4 _ MAP No. 16



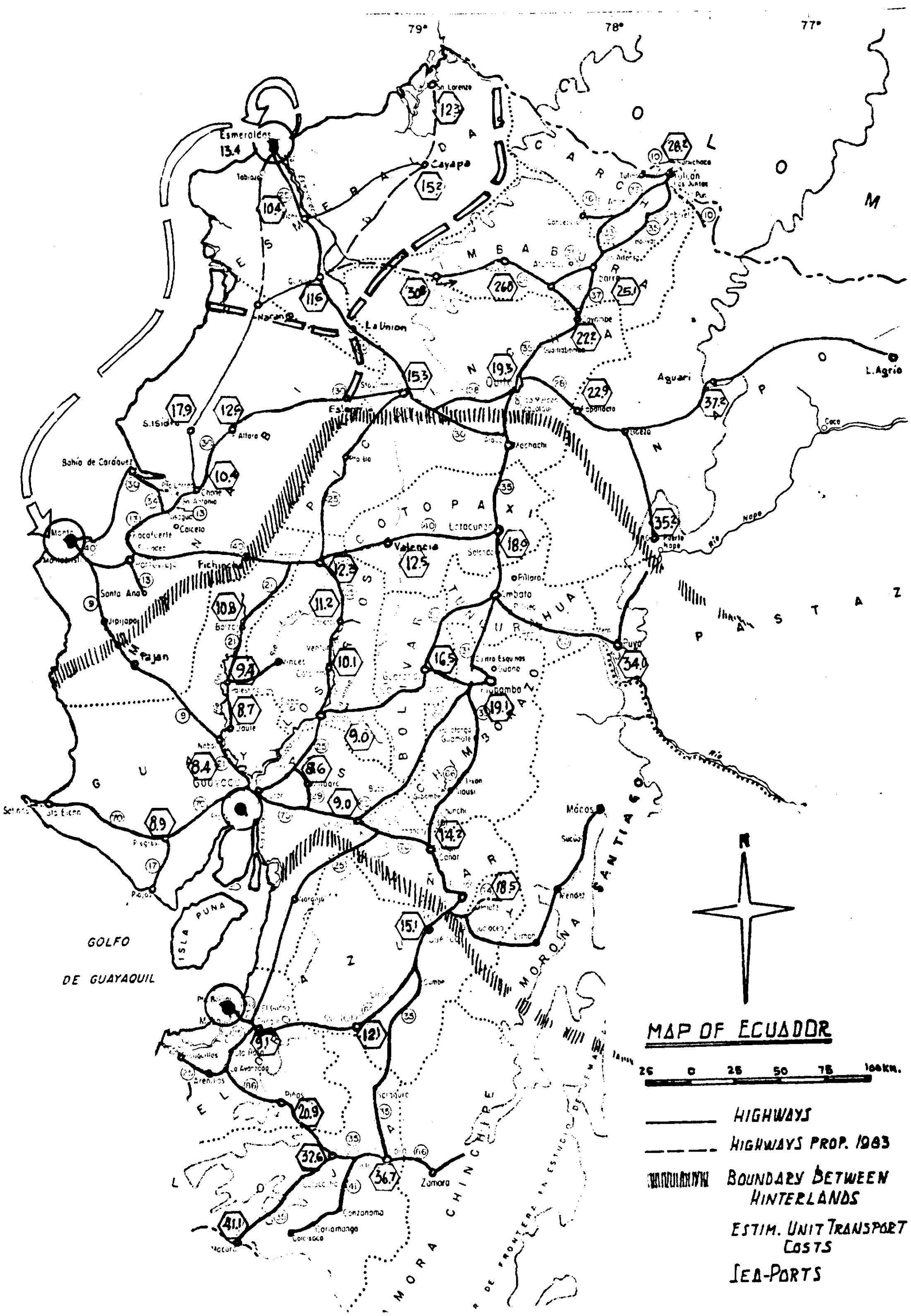
4.2.5 Extent of Port Hinterlands under Environment Condition 5

Parameters: b, e_2, f, g and h.

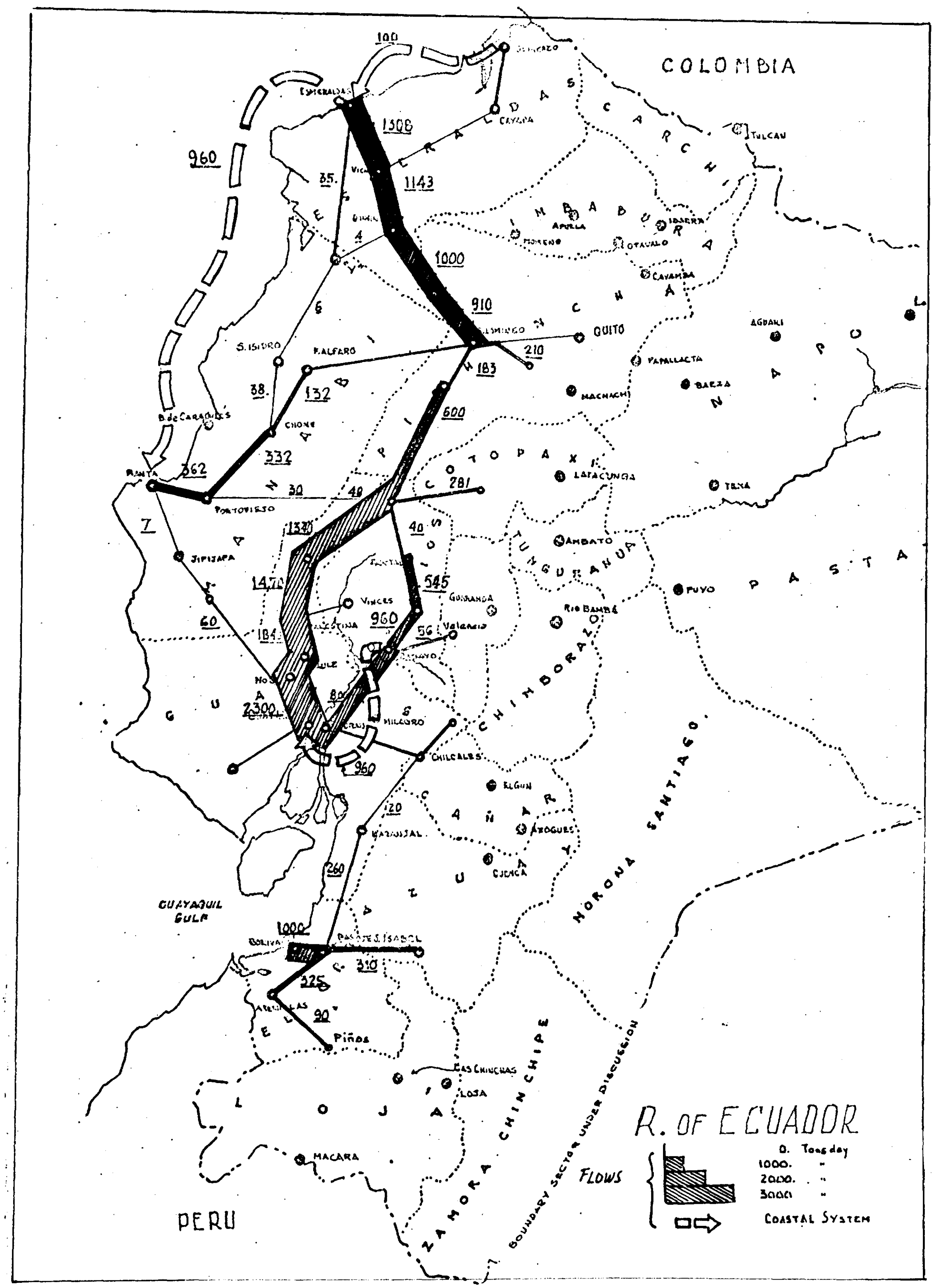
The introduction of the coastal system results in expansion of the Manta Hinterland. All the northern provinces in the Costa, the Sierra and the Oriente region would fall into the dominance area of Manta. Nevertheless, three main questions have to be considered:

1. The proposed system has been assumed to operate only one dock in the feeder port of Esmeraldas whose maximum daily throughput is in the order of 960 tons.
2. The new system seems to be competitive with the assumed existing handling and transport technologies only in the Esmeraldas and Babahoyo hinterlands. Yet, the case of the Babahoyo hinterland may require more careful research, the small advantage in total costs verified for the coastal system may be highly dependent on the estimated bridge tolls in the Guayaquil-Duran link.
3. With a potential participation of scarcely 15% in the total exporting capacity estimated for the year 1973, the coastal system would not be in condition to operate with economic efficiency. With only one feeder port sharing the potential for economical operation, the whole integrated system would not be practical, since the coastal system would merely play the role of an advanced lighterage system. At the same time it would not be reason for the existence of the integrated marine terminal in Manta.

MAP No.17 - EXTENT OF HINTERLANDS UNDER ENVIRONM. COND. 5



ESTIM. FLOW ORIENTATION UNDER ENVIRONM. CONDITION No. 5 _ MAP No. 18



If the problem is examined considering seasonal flow demands and their relationship with points 2 and 3, an unbalanced regional demand for transport services may provoke serious bottlenecks in certain areas while in others vehicles and port facilities would remain idle. The adoption of the coastal feeder system simultaneously with the more advanced port technologies proposed for Guayaquil, Manta and Bolivar does not seem justified, as compared with the results of Section 4.2.4 median unit transport cost in other than the Esmeraldas hinterland remain unchanged. (Table 22.)

A reduction of 2 to 3 per cent in median unit transport costs in the northern provinces might not be a sufficient incentive for the required investments. Since a saving of 2 per cent in the transport cost for the goods transported through Esmeraldas would only be reflected in a slight saving of around three thousand dollars per year for the whole country.

4.2.6 Extent of Port Hinterlands under Environment Condition 6 Parameters:

c. The highway system proposed for the year 1983 is assumed to exist. Road improvements are shown in Map 8 , no major changes would occur in the central region of the country with respect to the 1973 highway system. On the contrary in the north and southern regions changes would be significant.*

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* Maps 10 and 11 as well as Table 23 will give a more complete background of the changes tested in the following set of experiments.

i. The projected production of Bananas-Coffee and Cocoa by 1983
Parameters e_1 and f have the same values as in Section 4.2.2.

The major geographical impact of the proposed combination of parameters seems to be a reduction of Guayaquil's hinterland area. The construction of a new link between Apuela City in the Imbabura province and Quininde might be considered the causal factor. Practically the whole territory of Imbabura and Carchi provinces would fall into the Esmeraldas hinterland. Reductions in unit transport costs might be on the order of 12 (Tulcan), 20 (Apuela) and 54 (Cayambe) per cent if comparisons are made with the esimtated 1973 unit transport costs described in Section 4.2.2 - Maps 12 and 19.

The southern boundaries of the Guayaquil hinterlands remain relatively stable, with the exception of towns like Macas and Limon, in the Morona Santiago province, which might be oriented toward Bolivar. Yet, this would depend on the type of cargo involved.

In terms of flow orientation toward port cities and in comparison with similar conditions tested for 1973, the impact of the new highway structure would produce:

1. A reduction of 8 per cent in the Guayaquil exporting throughput. At the same time Manta and Esmeraldas would increase their throughputs by 5 and 2.5 per cent respectively.
2. Median unit transport costs would be reduced by 7.2 (Esmeraldas), 1.2 (Manta), and 21.6 (Bolivar) per cent while no changes

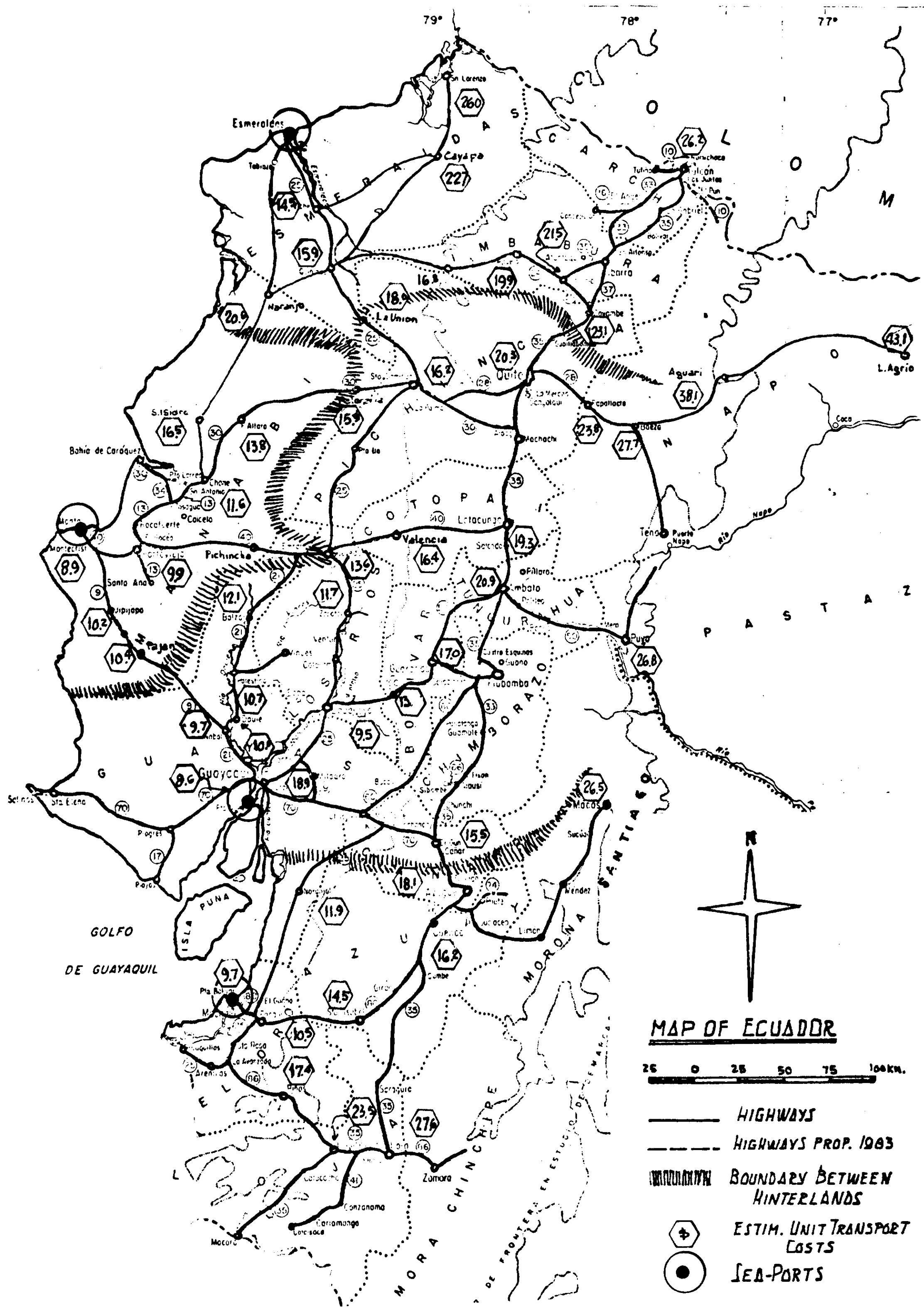
would occur in the Guayaquil hinterland median unit transport cost.

A cross analysis between environment conditions number 2 and 6 in Table 22, shows that Guayaquil would experience a reduction of around two hundred thousand tons with respect to the expected 1973 estimates. Esmeraldas would probably experience congestion problems in their port facilities.

The dramatic reduction of 21.6 per cent in median unit transport costs for the Bolivar area might be the most significant result of the present experiment. With the proposed highway improvements and the existing port facilities the model shows that the transport system should handle the expected growth of three per cent per year in agricultural exports.

The median unit transport cost remain essentially the same as for the corresponding environment conditions for the year 1973. Major highway improvements in 1983 would occur in areas which are now producing only marginal quantities of exports.

MAP No. 19 - EXTENT OF HINTERLANDS - ENVIRONM. CONDIT. 6 -



4.2.7 Extent of Port Hinterlands Under Environment Condition 7

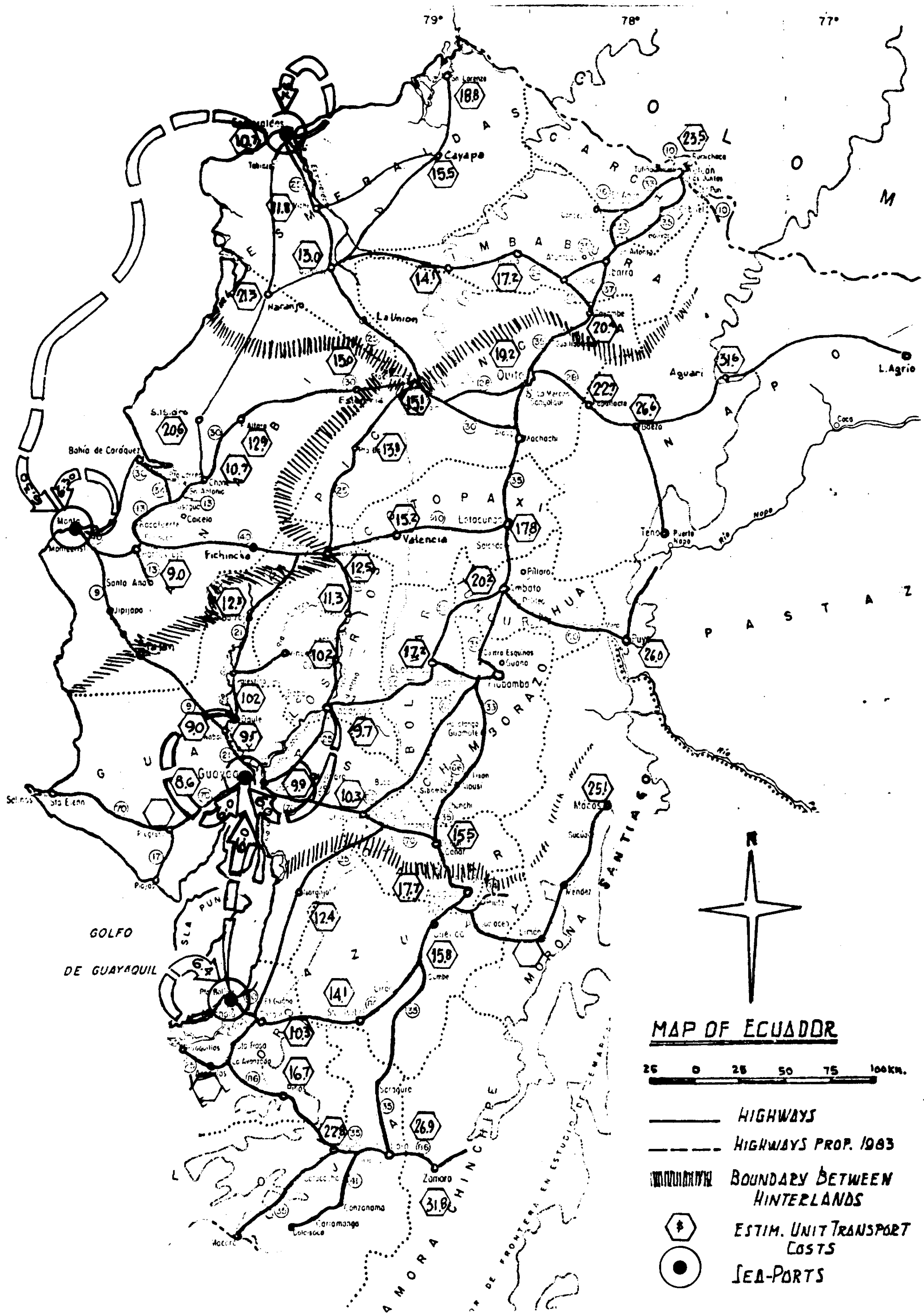
Parameters: c - e_1 - f - i and g

A cross examination with the figures under environment condition 6, in table 22 shows the following:

1. Reductions on the order of 8, 5.3, 3.3 and 1 per cent in the median unit transport costs, for Esmeraldas, Guayaquil, Manta and Bolivar hinterlands respectively.
2. The strategic position of the cities of Santo Domingo Quevedo as distribution centers is again emphasized, as in Section 4.2.3 each city appears located at a point of equal transport cost with respect to two influence areas. (Map No. 20)

In spite of these conclusions the expected results for the economy as a whole seems negative. With an estimated saving of around 1.5 million dollars per year over environment condition 6, the coastal system would require 2.4 million dollars per year for capital amortization, interest and operation.

MAP No. 20 EXTENT OF HINTERLANDS . ENVIRONM. CONDIT. 7



4.2.8 Extent of Port Hinterlands under Environment Condition 8

Parameters: c, e_2, f, i

Although a consequence of highway improvements would be a geographic reduction in the size of the Guayaquil hinterland, the area under its influence will continue to be the most productive of the country and commodity flows from this hinterland will maintain the leading role of Guayaquil. Results for our Condition 8 indicates that 71% of the total projected flows of bananas, coffee and cocoa will be attracted by this port.

If the estimates for the years 1968, 1973*, and 1983 are compared (see Table 22) the flows toward Bolivar will maintain a 13 to 14 per cent participation with respect to the country's total. This fact seems to be the result of proximity of the port to local production areas, a rather sustained rate of production increase, and particular geographical conditions which annul the relative cost advantage of Guayaquil port.

The estimated flow distribution shown in Map No. 22 repeats the same concentration pattern described in Section 4.2.4, along the Santo Domingo, Quevedo, Balzar, Guayaquil Corridor. (See Map No. 16.). An approximate increase of 25% in the average daily flow, may total an average of around 450 to 500 trucks per day. This conclusion indicates that on peak days, an approximate flow of 600 to 700 trucks per day serving the banana, coffee, and

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* Table 22.

cocoa traffic will circulate along the Nobol - Guayaquil link.

It is likely that under these conditions, a reorientation of flows might occur in Quevedo City, depending upon the relative difference between bridge tolls, the cost of moving the cargo toward Manta and the actual operating costs along the Nobol-Guayaquil link. More conclusive answers to this question would require an extension of the scope of this study.

By comparison, with the results derived from Section 4.1.6, it is possible to foresee the impact of relative changes in port technologies. A reduction of 15% in interface costs in the port of Guayaquil might induce the following effects:

a. An expansion of this hinterland at the expense of the Manta and Esmeraldas hinterlands.

b. An increase of around 13% in the volumes shipped toward this port city.

c. A reduction of approximately 13% in the hinterlands' median unit transport cots (see Table 22).

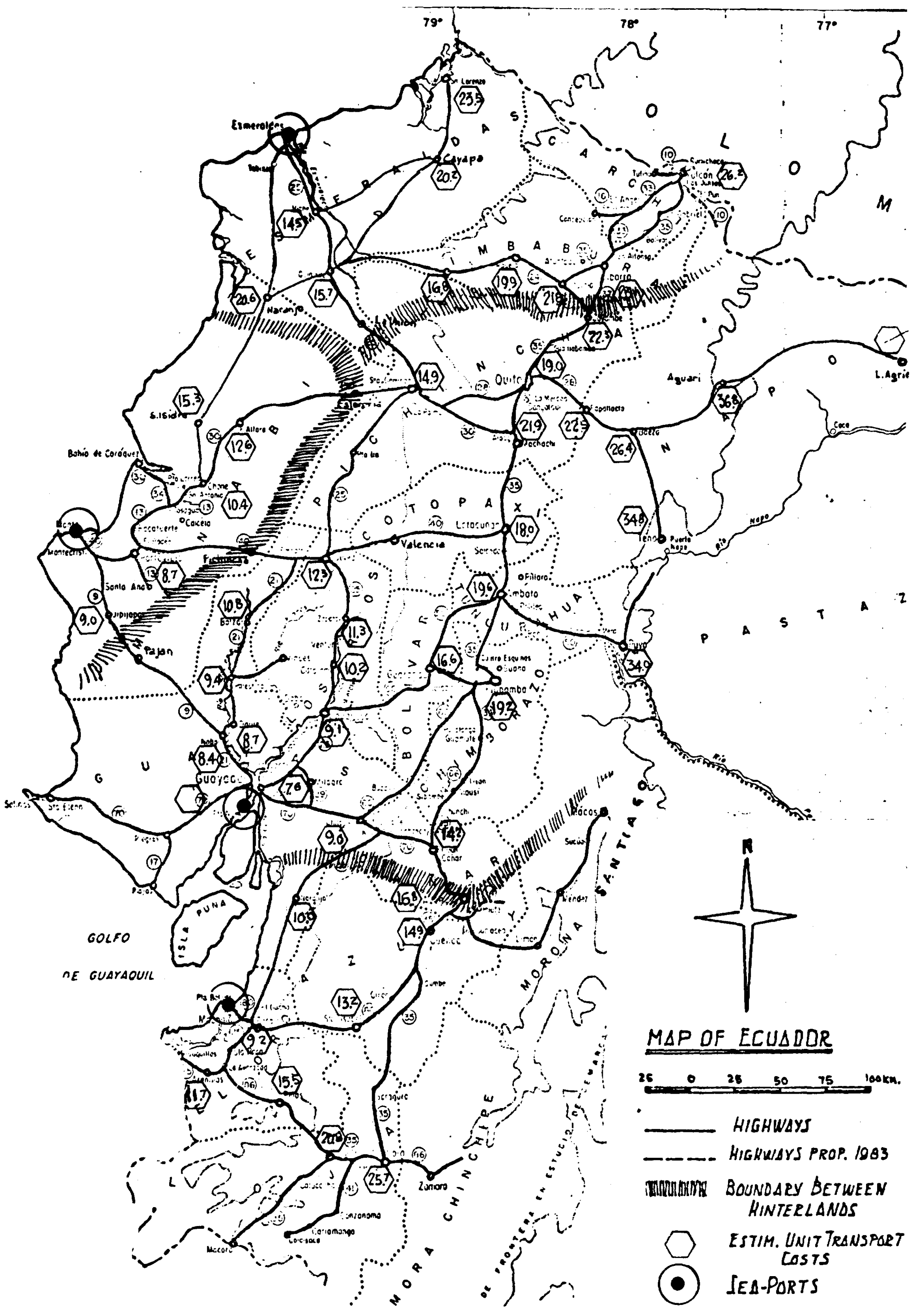
In the Manta and Esmeraldas hinterlands median unit transport costs might drop. The causes however are a consequence of:

a. The reduction of their influence areas.

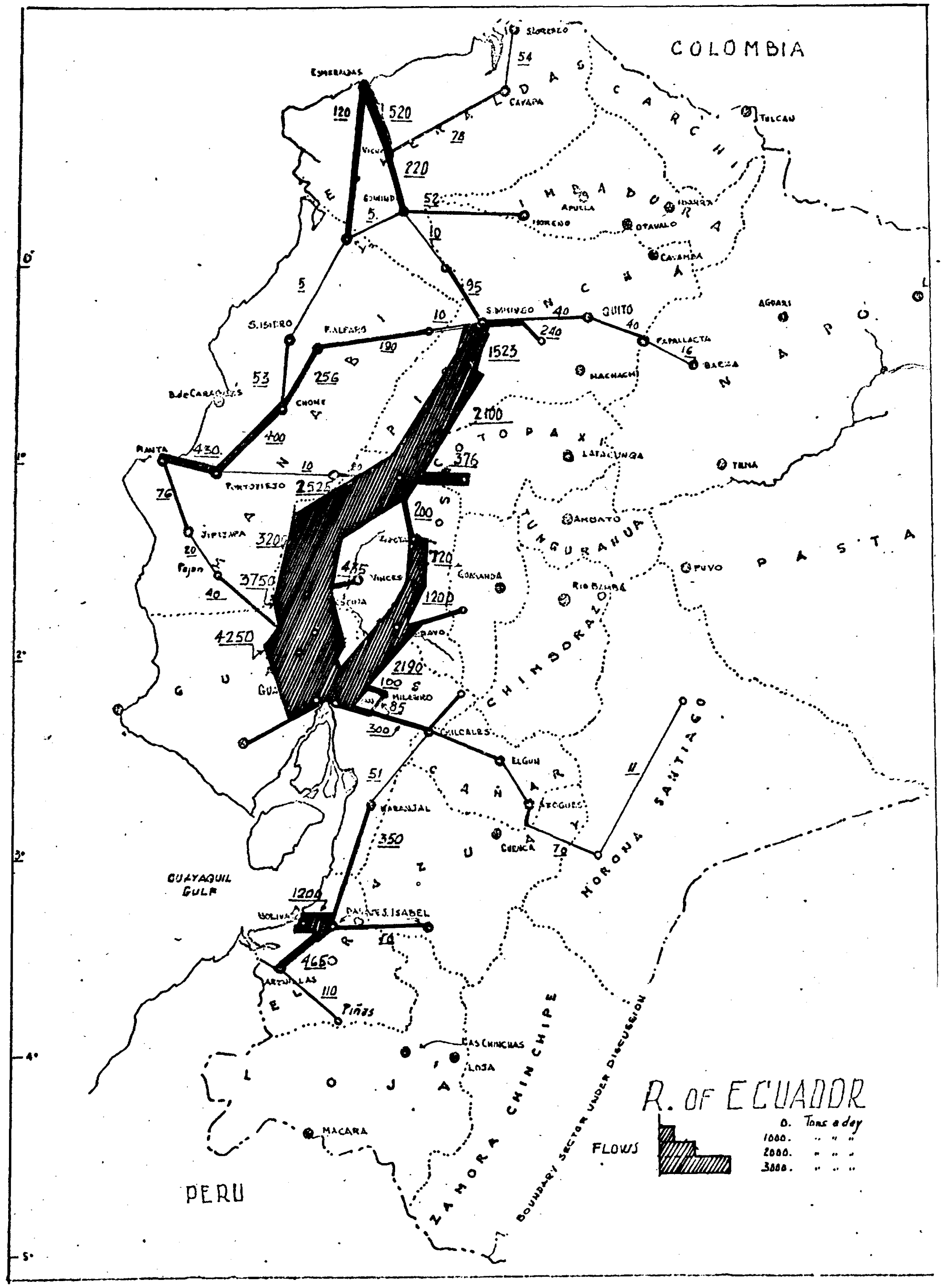
b. The shortening of average distances from production areas to ports.

In Bolivar, the median unit transport cost reduction might be the highest, around 15%, however, the area under its influence would remain constant. Some conclusions are:

EXTENT OF HINTERLANDS _ ENVIRONM. CONDITION 8 _ MAP 21



ESTIMATED FLOW ORIENTATION UNDER ENVIRONM CONDITION 8 _ MAP 22



a. Facility improvements might have more immediate impact on its area of influence, due to the geographical characteristics of the area.

b. The interaction of highway and port improvements seems to be the major determinant for the indicated drop in median transport costs.

The introduction of a unique along-the-berth port technology in Guayaquil, Bolivar and Manta, might result in a savings of around 7.3 million dollars per year. On the other hand, the expected amortization of capital, interest and operating costs would be in the vicinity of 3.9 million dollars. Consequently, the benefits for the country might be expected to amount to 3.4 million dollars per year.

The higher expected benefits with respect to the similar port configuration for 1973 are certainly a consequency of the production estimates and the assumed location of production centers with respect to ports.

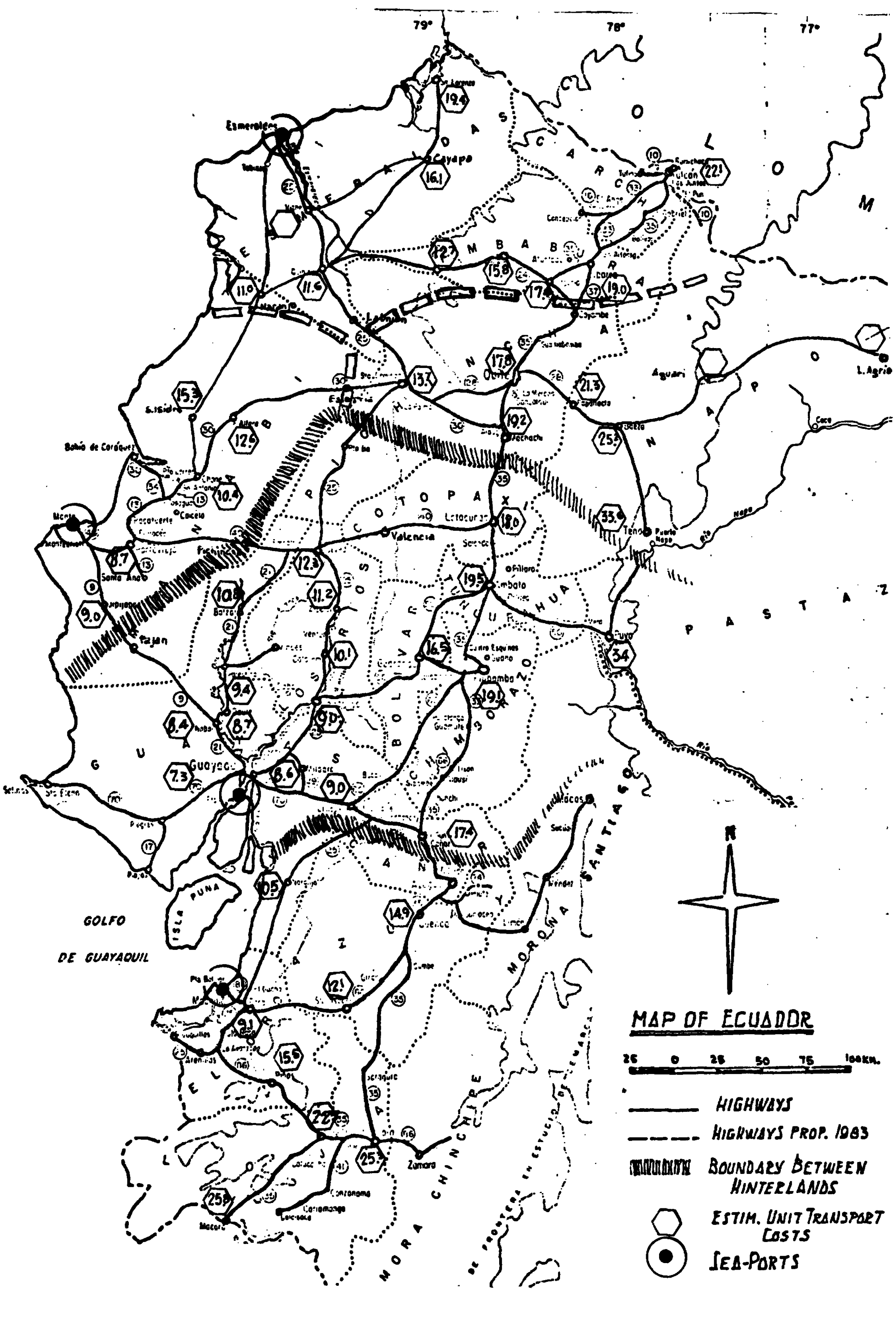
4.2.9 Extent of Port Hinterlands under Environment Condition 9

Parameters: c, e_2, f and i, and g. The integrated coastal feeder system.

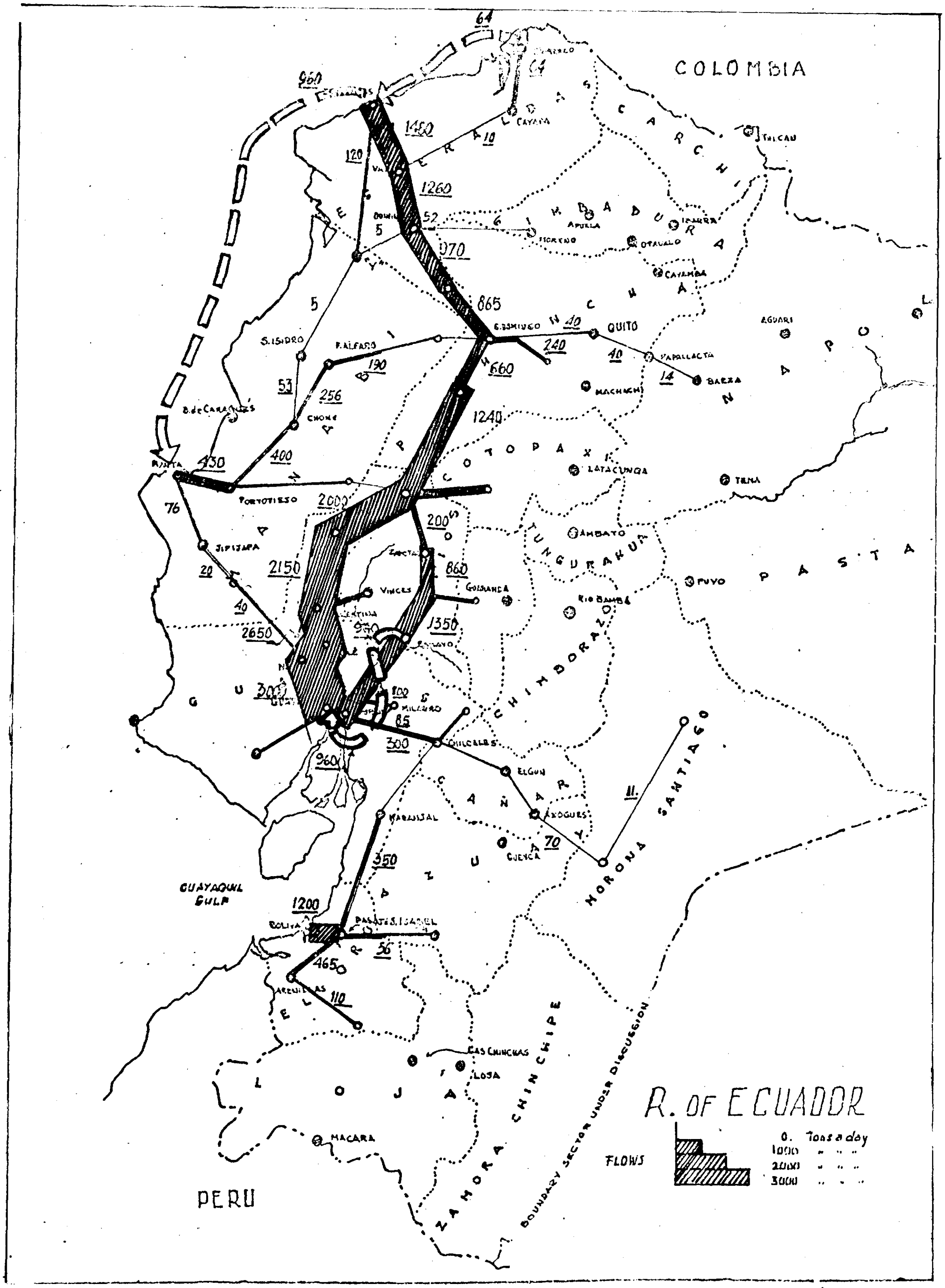
As Section 4.2.3 verified, the most apparent result of the introduction of the coastal system would be the expansion of Manta's hinterland and a correlative reduction of the Guayaquil influence area. However, given the assumed capacity of the coastal system to serve Esmeraldas, a considerable part of the production in the north of Pichincha province will continue to flow toward the port of Guayaquil.

According to the estimates for the year 1983, sixty per cent of the total exporting flows would be directed toward Guayaquil while 15.8% would be exported through the Manta facilities (10.2% through the Esmeraldas coastal feeder branch). With the exception of the ports of Esmeraldas and Babahoyo, the coastal system seems to be competitive with other transportation modes in no other area of the country. The findings for the conditions of this section show no major deviations from those of Section 4.2.3. The postulated changes in the highway system do not represent any significant alteration in the distribution of influence areas derived for 1973. This conclusion indicates that if significant changes did occur, they would be entirely dependent on the relative differences between interface costs in alternative port operations. The new system seems to offer an economic benefit of 2.7 million dollars per year. However, this significant benefit cannot be considered an inherent advantage of the coastal system. Rather it is a consequence of the lowering of interface costs in the port of Esmeraldas. This conclusion clearly indicates that, under the assumed levels of production in the northern area of the country, the construction of adequate facilities in the Esmeraldas port would offer significant economic advantages for

MAP No. 23 EXTENT OF HINTERLANDS – ENVIRONM. CONDITION 9



FLOW ORIENTATION UNDER ENVIR. CONDIT. 9 - MAP No. 24



the country and for the Esmeraldas region. The Integrated Coastal System would not appear to be economically justified under the conditions here postulated.

4.2.10 Extent of Port Hinterlands for Imported Commodities

A set of four experiments using computer models was made in order to evaluate the distribution pattern of imported goods throughout the country. Needless to say, however, the obtained results have inherent limitations.

An adequate calibration of the model would certainly require the availability of a more sophisticated economic analysis for the country. The absence of such background information has limited this portion of the search although the results of the group of experiments described should have considerable value for hypothesis building purposes.

4.2.10.1 Extent of Port Hinterlands for Imported Commodities, Environment Condition 1

Parameters: The proposed highway system for 1973.

The proposed highway system for 1983.

The current inland waterway system.

j. The system of importing ports constituted by Guayaquil, Manta and Bolivar. These parameters, while apparently arbitrary, are a direct consequence of the Interface Submodel hypothesis described in Chapter 2. The cost of transfer operations are inversely proportional to the existence of adequate storage facilities in port, while directly proportional to the cost per ton of the commodity involved. The non-existence of warehousing facilities in one port increases automatically the transfer costs to such an extent as to eliminate the affected port from any regular inward flow. The case previously described applies to the port of Esmeraldas.

With the exception of some reduction in unit transport cost in those sections where road improvements would take place, no major changes in the general hinterland structure of the country would be expected between 1973 and 1983. (Map No. 25). The influence area of Guayaquil would continue to cover the major and economically most active part of the Ecuadorian territory. By the same token, Manta's hinterland would remain limited to the coastal strip of the Manabi province.

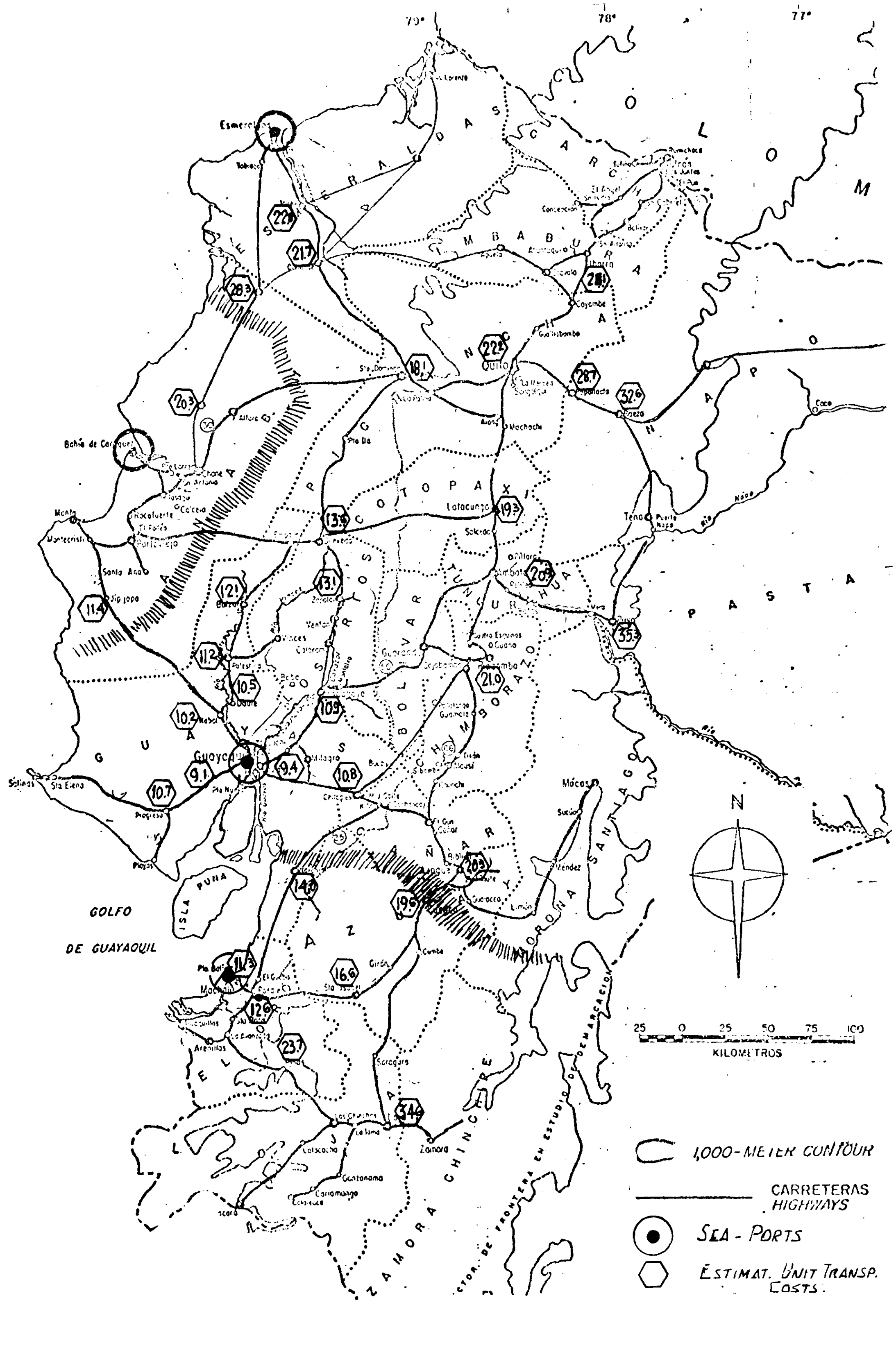
According to the model's output, the southern part of the country would find importing through the Bolivar port advantageous.

4.2.10.2 Extent of Port Hinterlands for Imported Commodities, Environment Condition 2

Parameters: The same parameters as in Section 4.2.10.1, plus the coastal feeder system.

g. Under the conditions created by the addition of the coastal system and the proposed Highway System for 1973, the port of

MAP No. 25 EXTENT OF HINTERLANDS - ENVIRONM. CONDITION 10 - IMPORTS.



Esmeraldas would become more attractive for imports in its immediate area inside the province of Esmeraldas. (Map No. 26) The advantages of the coastal system addition are basically due to the fact that the provision of storage space in a port is inherent in the system itself.* In spite of effective unit transport cost reduction, again, rewards must be made with respect to a final conclusion on this basis. Under the resulting scheme, Manta would have to be come a leading managerial center controlling the northern coastal area.

The arguments can be repeated for the case in which the coastal system might operate in combination with the 1983 proposed highway system. (Map No. 27) In this case, the results are geographically more dramatic, the opening of a new road between Quininde - Moreno - Apuela, would certainly reduce significantly the estimated transport costs. At the same time, and as one consequence, Quininde City would assume a locational advantage with respect to the Guayaquil, Manta and Esmeraldas hinterlands. The case of Quininde brings a new perspective to the locational advantages of intermediate urban centers like Santo Domingo, Quevedo and Quininde itself. Each of these cities seems to be located in a strategic position among ports and the leading developmental poles in the Sierra** and the Costa Regions***.

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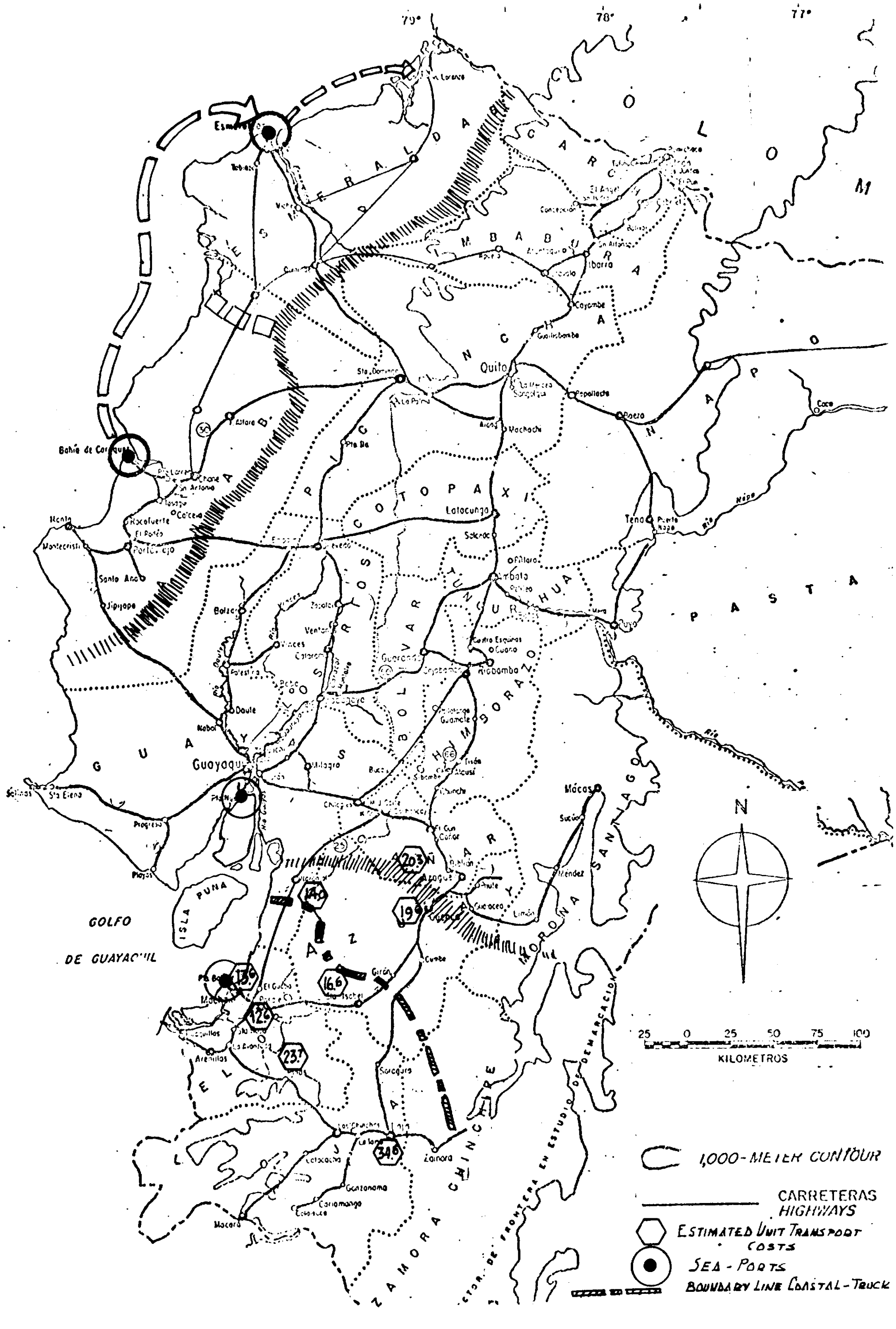
* See Chapter 2, Part 7.

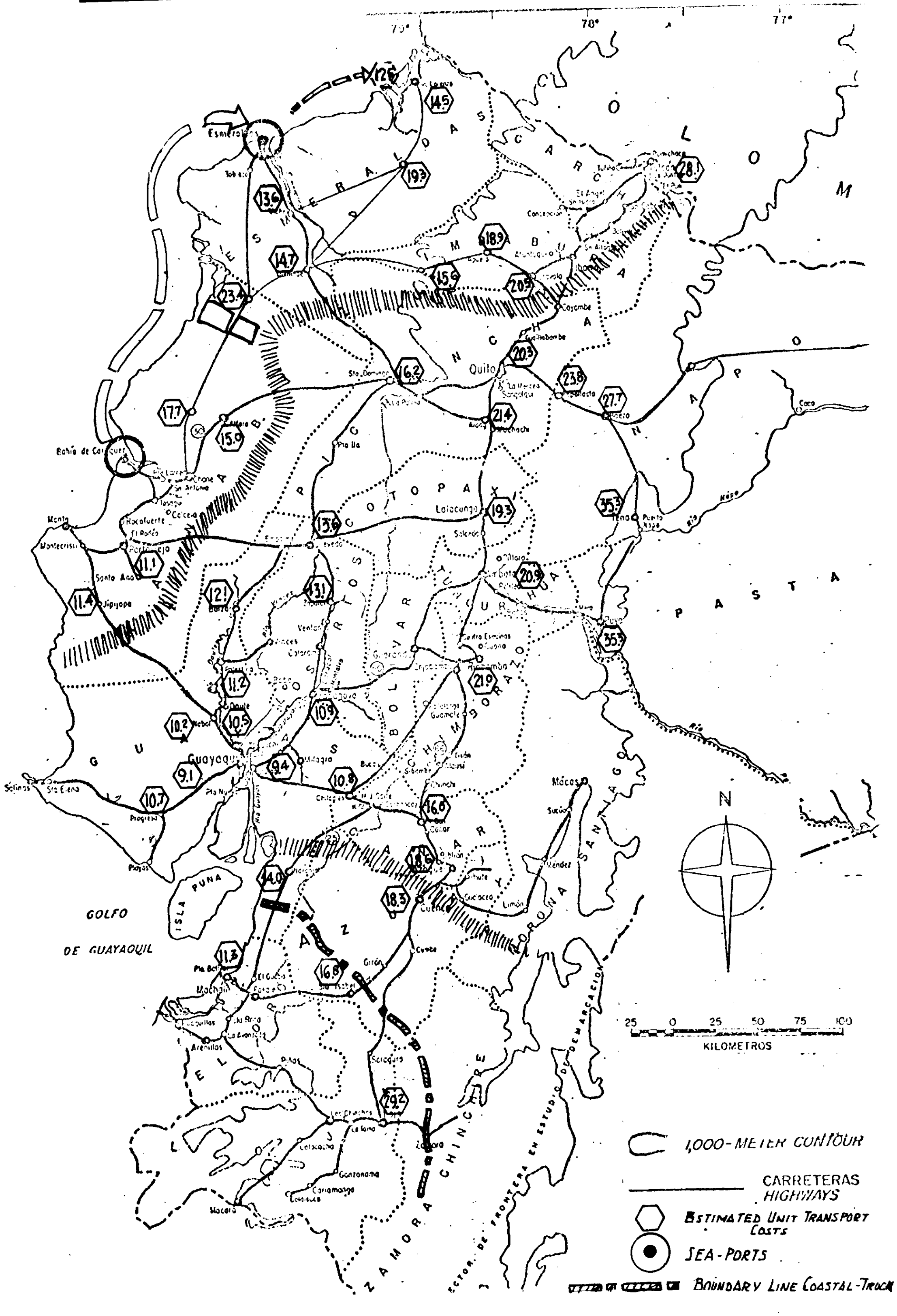
** Quito, Latacunga, Ibarra

*** Guayaquil and Manta

MAP No.26 _ ENVIRONMENT CONDITION II _ IMPORTS _



MAP. No.27 EXTENT OF HINTERLANDS _ ENVIRONMENT CONDIT. 12 _ IMPORTS_



The role that Quevedo and Santo Domingo would play with respect to exporting flows was discussed in Sections 4.2.2 and 4.2.7, and it is possible to hypothesize that the importance of these cities would increase following an overall analysis of interregional flows.

Maps 26 and 27 also show the minimal cost boundary line for goods shipped from Guayaquil to Bolivar. An all truck feeder system, and the combination of the coastal system and trucks feeding inland centers was tested.

Table No. 22:

Estimated Flows Toward Port Cities and
Exporting Annual Tonnages*
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 1, Year 1968

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.25		
Bolivar	18.42			
Carchi	5.90			
Canar	49.50			
Cotopaxi	86.50			
Imbabura	0.80			
Loja		21.80		
Pichincha	409.00			
Esmeraldas	199.80			46.00
El Oro		186.00		
Guayas	242.80	80.00		
Los Rios	680.00			
Manabi	57.60		31.40	29.00
M. Santiago	19.00			
Napo	9.60			
Pastaza	9.80			
Z. Chinchipe		13.50		
Total Est. Demand	1,788.72	291.55	31.40	75.00
Total Est. Exports	1,343.00	218.00	22.60	55.00
Percent. Distrib.	82%	13.3%	1.4%	3.3%
Annually Exported	1,373.24	236.55	28.50	52.00

* In thousands of tons

Table No. 22:

Estimated Flows Toward Port Cities and
Exporting Annual Tonnages *
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 2, Year 1973

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.32		
Bolivar	20.00			
Carchi	6.40			
Canar	59.40			
Cotopaxi	102.40			
Imbabura	1.23			
Loja		23.40		
Pichincha	342.50		179.00	
Esmeraldas	50.00			230.00
El Oro		231.00		
Guayas	285.00	95.00		
Los Rios	829.00			
Manabi	19.20		120.80	9.50
M. Santiago	21.00			
Napo	11.00			
Pastaza	10.00			
Z. Chinchipe		14.40		
Total Est. Demand	1,757.33	364.12	299.80	239.50
Est. Median Unit Cost	13.0	17.9	15.8	17.7
Total Est. Exports	1,317.00	273.00	217.00	179.00
Percent Distrib.	66%	13.7%	10.9%	9.4%
Est. Median Unit Cost Whole Country			14.4	

* In thousands of tons

Table No. 22:

Estimated Flows Toward Port Cities and
Exporting Annual Tonnages*
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 3, Year 1973

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.32		
Bolivar	20.00			
Carchi	6.40			
Canar	59.40			
Cotopaxi	102.40			
Imbabura	1.23			
Loja		23.90		
Pichincha	208.00		222.00	91.00
Esmeraldas				280.00
El Oro		231.00		
Guayas	285.00	95.20		
Los Rios	829.00			
Manabi			140.00	9.60
M. Santiago	21.00			
Napo	11.00			
Pastaza	10.00			
Z. Chinchipe		14.40		
Total Est. Demand	1,553.43	364.72	362.00	380.60
Est. Median Unit Cost	12.4	17.7	14.3	17.3
Sub-Total for Exp.	1,168.00	273.00	271.00	246.00
Total Est. Exports	1,249.50	191.50	352.50	165.50
Percent. Distrib.	64%	9.7%	18%	8.3%
Est. Median Unit Cost Whole Country		13.3		

* In thousands of tons

Table No. 22:

Estimated Flows Toward Port Cities and
Exporting Annual Tonnages *
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 4, Year 1973

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.32		
Bolivar	20.00			
Carchi	6.40			
Canar	59.40			
Cotopaxi	102.60			
Imbabura	1.23			
Loja		23.40		
Pichincha	521.50			
Esmeraldas	25.00			255.00
El Oro		231.00		
Guayas	285.00	95.00		
Los Rios	829.00			
Manabi	19.20		130.30	
M. Santiago	21.00			
Napo	11.00			
Pastaza	10.00			
Z. Chinchipe		14.40		
Est. Median Unit Transport Cost	12.5	16.4	12.9	17.4
Total Est. Demand	1,911.33	364.12	130.30	255.00
Total Est. Export	1,416.33	273.00	98.00	189.00
Percent. Dist.	71.5%	13.5%	5.3%	9.5%

Est. Cost Whole Country (median unit cost) 13.4

*In thousands of tons

Table No. 22:
Estimated Flows Toward Port Cities and
Exporting Annual Tonnages *
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 5, Year 1973

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.32		
Bolivar	20.00			
Carchi				6.40
Canar	59.40			
Cotopaxi	102.40			
Imbabura				1.23
Loja		23.90		
Pichincha	147.90			373.40
Esmeraldas				280.00
El Oro		231.00		
Guayas	285.00	95.20		
Los Rios	829.00			
Manabi	19.00		130.30	
M. Santiago	21.00			
Napo				11.00
Pastaza	10.00			
Z. Chinchipe		14.40		
Est. Median Unit Transp. Cost	12.5	16.4	12.9	17.1
Total Est. Demand	1,493.70	364.72	130.30	672.03
Sub-Total for Exp.			98.00	494.00
Total Est. Export	1,123.00	273.00	363.00	189.00
Percent. Dist.	57.8%	13.9%	18.8%	9.5%
Est. Cost Whole Country (Median unit cost)		13.3		

* In thousands of tons

Table No. 22:

Estimated Flows Toward Port Cities and
Exporting Annual Tonnages *
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 6, Year 1983

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.39		
Bolivar	22.35			
Carchi				8.40
Canar	79.20			
Cotopaxi	137.30			
Imbabura				1.96
Loja		27.60		
Pichincha	372.00		320.00	8.00
Esmeraldas				374.00
El Oro		310.00		
Guayas	408.00	126.00		
Los Rios	1,053.00		84.00	
Manabi			170.00	34.00
M. Santiago		25.00		
Napo	13.50			
Z. Chinchipe		16.70		
Est. Median Unit Transport. Cost	13.0	14.0	15.6	16.4
Total Est. Demand	2,096.85	505.69	574.00	426.36
Total Est. Export	1,571.00	388.00	430.00	318.00
Percent. Dist.	58%	14.4%	15.9%	11.7%
Est Cost Whole Country (median unit cost)			14.0	

*In thousands of tons

Table No. 22:

Estimated Flows Toward Port Cities and Exporting Annual Tonnages *
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 7, Year 1983

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.39		
Bolivar	22.35			
Carchi				8.40
Canar	79.20			
Cotopaxi	137.30			
Imbabura				1.96
Loja		27.60		
Pichincha	402.00		216.00	150.00
Esmeraldas				374.00
El Oro		310.00		
Guayas	408.00	126.00		
Los Rios	1,053.00		84.00	
Manabi			170.00	34.00
M. Santiago		25.00		
Napo	13.50			
Pastaza	11.50			
Z. Chinchipe		16.70		
Est. Median Unit Cost	12.3	13.9	15.1	15.9
Total Est. Demand	2,026.85	505.69	470.00	599.56
Sub Total for Exp.	1,600.00	373.00	353.00	450.00
Total Expect. Exp.	1,706.00	257.00	499.00	314.00
Percent Dist.	63%	9.5%	16.5%	11%

Est. Cost Whole Country (median unit cost) 13.4

*In thousands of tons

Table No. 22:

Estimated Flows Toward Port Cities and Exporting Annual Tonnages *
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 8, Year 1983

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.39		
Bolivar	22.35			
Carchi				8.40
Canar	79.20			
Cotopaxi	137.30			
Imbabura				1.96
Loja		27.60		
Pichincha	684.00			16.00
Esmeraldas	50.00			324.00
El Oro		310.00		
Guayas	408.00	126.00		
Los Rios	1,137.00			
Manabi			204.00	
M. Santiago		25.00		
Napo	13.50			
Pastaza	11.50			
Z. Chinchipe		16.70		
Estim. Median Unit Cost	11.4	12.0	11.4	14.7
Total Est. Demand	2,542.85	505,69	204.00	350.36
Total Expect. Exp.	1,907.00	388.00	163.00	263.00
Percent Dist.	71%	13.2%	6%	9.8%
Est. Cost Whole Country (median unit cost)		12.1		

*In thousands of tons

Table No. 22:

Estimated Flows Toward Port Cities and
Exporting Annual Tonnages *
(Bananas + Coffee + Cocoa)

HINTERLANDS UNDER ENVIRONMENT CONDITION: No. 9, Year 1983

Provinces	Guayaquil	Bolivar	Manta	Esmeraldas
Azuay		.39		
Bolivar	22.35			
Carchi				8.40
Canar	79.20			
Cotopaxi	137.30			
Imbabura				1.96
Loja		27.60		
Pichincha	363.50			336.50
Esmeraldas				374.00
El Oro		310.00		
Guayas	408.00	126.00		
Los Rios	1,137.00			
Manabi			170.00	34.00
M. Santiago		25.00		
Napo				13.50
Pastaza	11.50			
Z. Chinchipe			16.70	
Est. Median Unit Cost	10.2	12.0	11.2	15.5
Total Est. Demand	2,184.85	505.69	170.00	738.36
Sub-Total for Exp.	1,623.00	388.00	127.00	569.00
Total Expect. Exp.	1,623.00	388.00	423.00	263.00
Percent Dist.	60%	14.4%	15.8%	9.8%
Est. Cost Whole Country (median unit cost)		11.3		

*In thousands of tons

Table No. 23:

DAILY MAXIMUM FLOW CAPACITY IN ROADS*

Road Type	Estimated Maximum Tonnage Per Day**
1	2670
2	1105
3	205
4	54
5	4000
6	1210
7	290
8	89
9	5320
10	2220
11	445
12	110

*One way

** Long Tons

Chapter V

5.1 Findings

The analysis of flow movements in a national context may involve a very wide and heterogeneous set of factors so the interactions among them may become very complex. In this study, however, the attention has been focused on the movement of commodity flows between the system of ports and the rest of the economic space in which they operate.

The interaction among developmental policies and their influence on the location of economic activities and on the transport system itself have been analyzed in this study. Though limited, the conclusions derived from a study of this type may have diverse connotations.

The first group might relate to the behavior of the system in its national or regional context and in relation to the role of the interacting subsystems. A second group of conclusions might focus on the particular aspects of some of the subsystems. While a third group might deal with the theoretical and instrumental aspects of the approach utilized in this study.

Since the goal of this thesis was to examine the economic influence of alternative port, transport and production policies only the conclusions which relate to the behavior of the system in its national or regional context will be developed here. Although the computer results would permit relatively detailed development of conclusions of the second group, there is little practical purpose in presenting such results before national policies on the overall transport system are established. In the second place, the limited data base available for this study would not permit the drawing of significant outcomes relating to the details of the subsystem.

In relation to the third type of conclusions, the modelling techniques used for this study appear to be reasonable and consistent with the requirements of transport system planning. It is felt that a reasonable and useful pattern has been developed and providing the required data are available, positive results may be expected. In many instances in this study, estimates of particular costs as well as the location of commodity production centers had to be approximate rather than derived from actual data, however, as better data are available they could easily be fed into the model.

One of the important conclusions of this study has been the identification of the specific data required to appraise transport system costs. It is felt that the subsystem models are adequate but certain shortcomings do exist in the Interface submodel, although they appear to be unimportant for this study. For example, some aspects of the analysis of queuing in terminals might require additional refinements. In conclusion, the particular approach for developing an overall model for a complex transport system as a series of interacting submodels has been found to greatly facilitate the effort. Furthermore, the submodels are useful by themselves and some of them are adequate for more detailed studies.

Experience has shown that once the model was running and if the data required for a completely different situation is available, it should be possible to execute a representative series of computer experiments in a period of approximately two to three weeks. It is estimated that the time required to execute the series of runs described could total approximately one hour on a 360/65 IBM computer.

5.2 Some Conclusions with Respect to National Port Policies, Transport and the Economic Space.

5.2.1 Development of a Unique Ocean Terminal

The set of experiments performed in Chapter 3 repeated showed that the cost of interface operations between along-the-berth port configurations and truck feeding lines is certainly the lower than interface costs when lighters are required or transfer is between ships. No matter what kind of highway facilities, inland waterway system or coastal system is employed, the truck-along the berth configuration is certainly, in absolute terms, the least expensive port technique. Thus, the adoption of such configuration seems to be recommended in the development of any main and unique ocean terminal.

In the Ecuadorian case, it is obvious that the selection of Guayaquil as the principal port is the most appropriate. This conclusion might be demonstrated by the analysis in Sections 4.2.4 and 4.2.8, and by the cross analysis of unit transport costs attached to Maps 15 and 21 and synthesized in Maps 28 and 29 for the years 1973 and 1983. The total throughput for the commodities analyzed would be in the vicinity of 1,976 and 2,720 thousand tons of bananas, coffee, and cocoa for the years 1973 and 1983 respectively. These figures show that, in average terms, the port would require five to six docks* operating exclusively for this trade. Assuming that the commodities analyzed would represent 60 per cent of the total throughput of the port, the total number of required docks, in average terms, would be in the vicinity of 10 to 11 by 1983. Under this condition an extra daily flow of 7,000 to 8,400 tons** would be entering the city.

The concentration of fruits coming from all over the country would certainly require, apart from highly efficient feeding lines, appropriate warehousing facilities in order to preserve the product and making possible effective coordination between the intervening transport modes.

Consequently, and in terms of port investment, 5 to 6.3 million dollars would be required for construction of new docks,*** and

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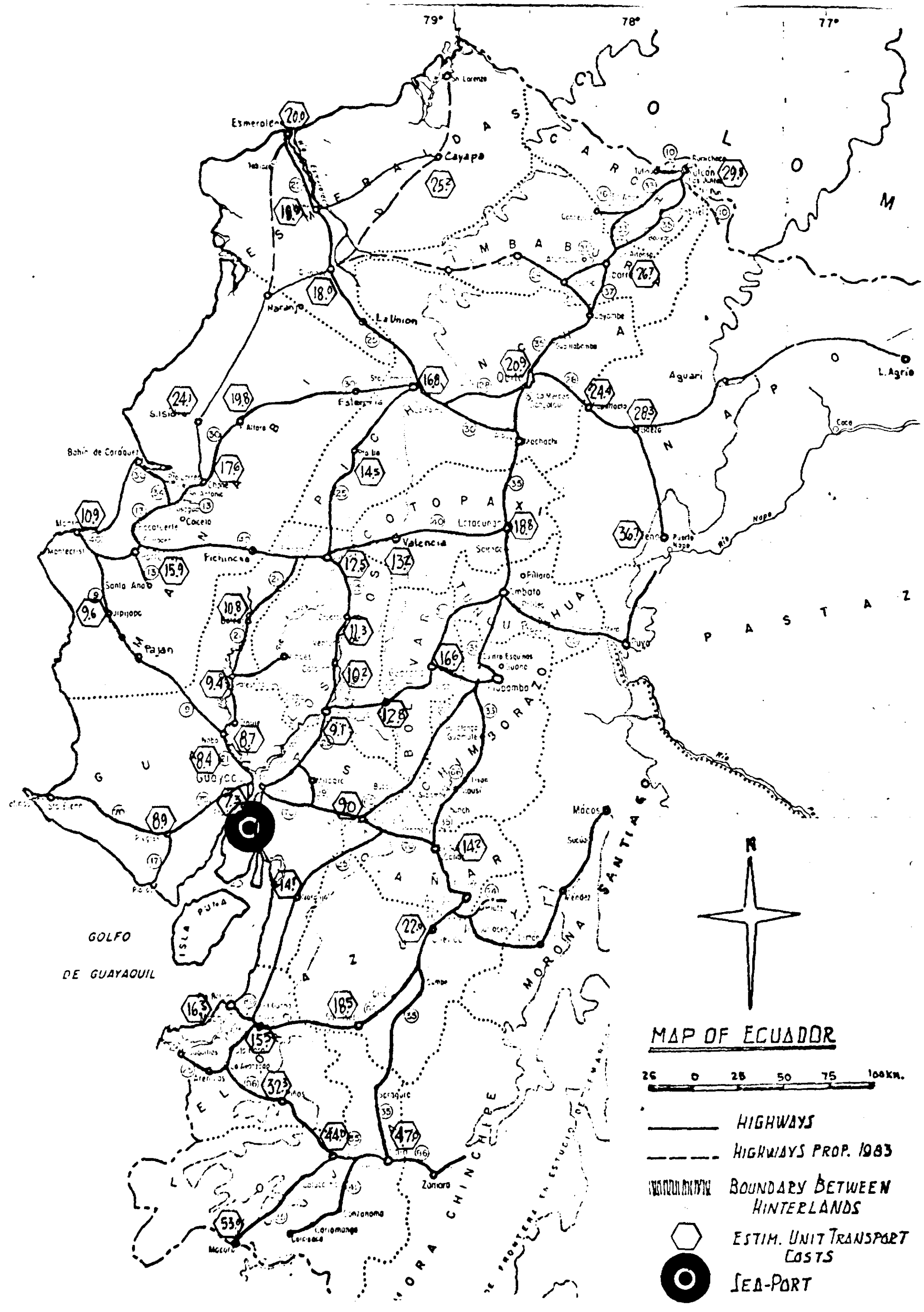
* Assuming that they would handle an average of 60 tons per hour per dock.

** Assuming 1,400 tons per day per dock.

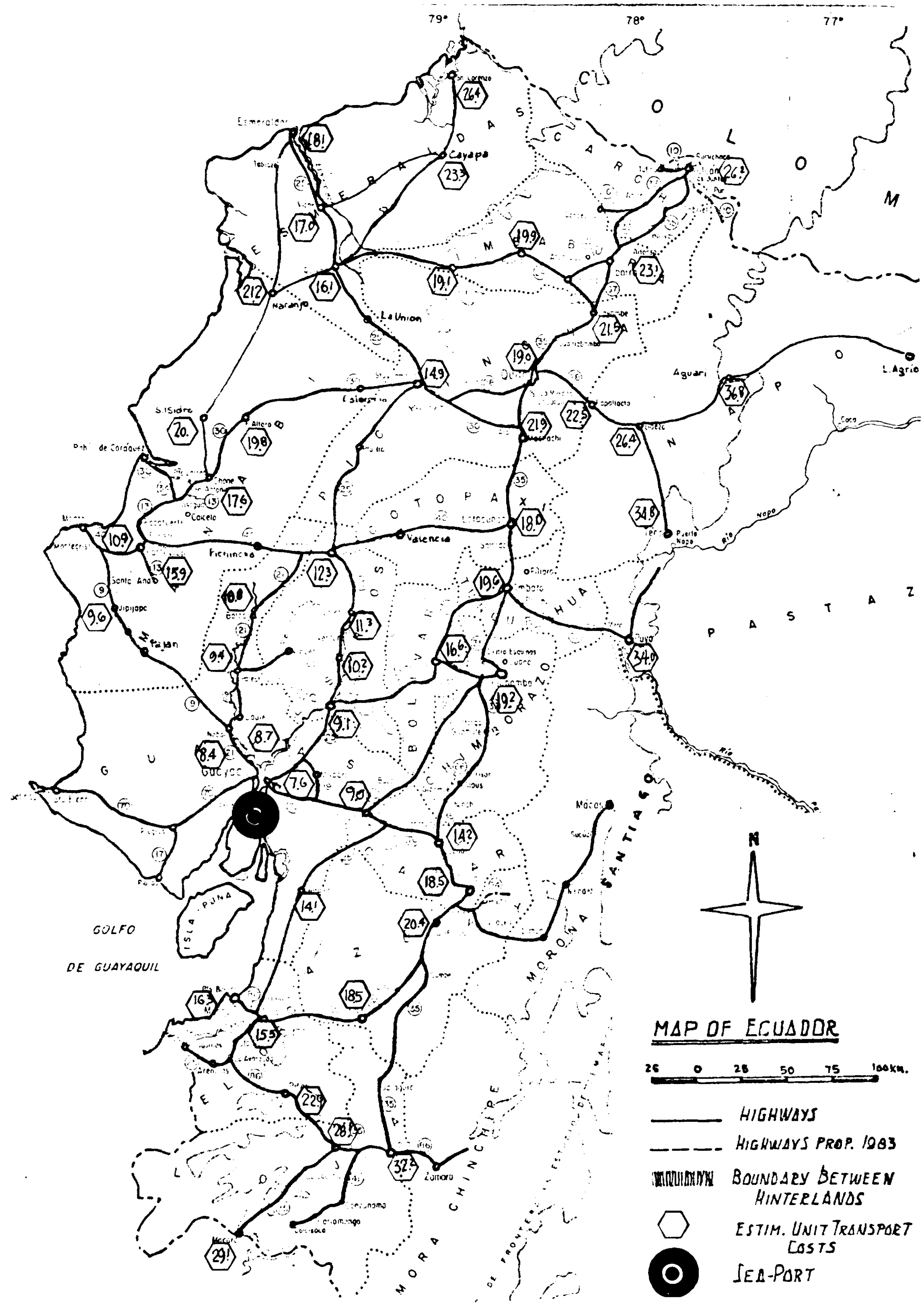
*** Cost of additional docks on the water side and land side for general cargo $1,050,000 each (Ref. 36, p. 107) at 1963 dollars.

ESTIMATED TRANSPORT UNITARY COSTS ASSUMING ONE OCEAN TERMINAL - MAP No. 28
- YEAR 1973 HIGHWAY SYSTEM -



ESTIMATED UNITARY TRANSPORT COSTS ASSUMING ONE OCEAN TERMINAL. MAP No. 29

— Year 1983 Highway System —



around 3 million for the construction of refrigerated warehousing facilities (3 to 4 hundred thousand tons total capacity).*

As the total scheme is oriented toward the concentration of all the cargo engaged in external trade, it is reasonable to assume that no operations would be effectuated through the rest of the ports. Consequently, the economy would have to continue paying the loans and interest subscribed by those ports. According to estimates made in part five, Chapter 2, these charges would represent an amount of 1.58 million dollars per year plus a rough 1.5 to 2 million dollars per year which would correspond to the amortization of principal, interest and operating costs of the new facilities.

Looking at the rest of the system, it is quite predictable that an increase of 7,000 to 8,400 tons in the daily flow toward the city would require additional capacity in some links. The Nobol-Guayaquil route and the accesses throughout the city would suffer from the effects of overflows. The first one, for example, with an estimated maximum capacity of 5,200 tons per day (Table 23) would be receiving more than this volume in average terms, and probably saturated badly if peak seasonal days are considered.

Unless significant additional investment is made in the inland waterway system - inventory and facilities - it is not expected that inland waterways would be able to alleviate highway saturation.

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* Calculated using data from Ref. 28, p. 46.

Under the proposed scheme of one main ocean-terminal, the estimated hinterland median unit transport cost would be on the order of $19.1 dollars per ton.* If this cost is compared with the highest median unit transport cost of $14.4 estimated for the whole country in Chapter 3**, the inadequacy of the one main ocean-terminal alternative for Ecuador is clearly evident.

It can be argued however, that a port concentrating all the operations related to the country's external trade would exhibit increased productivity levels. Capital intensive techniques might be emphasized in order to achieve that goal. Yet it is clear that a reduction of 13% in the median unit transport cost of export-import commodities is not an exclusive port problem. A program for increasing the carrying capacity and reducing transport cost toward Guayaquil might have to be faced.

Thus, the conclusion derived from the model is that the idea of a <u>unique ocean-terminal in Ecuador, does not represent a positive economic advantage for the country</u>. In terms of the spatial organization of the country, the proposed idea would certainly emphasize the present over-concentration of activities in Guayaquil. This would not contribute to the achievement of a more balanced regional development.

5.2.2 Development of a System of Regional Ports

Conclusions have been drawn in relation to the two planning

* This cost has only a comparative interest throughout this study. This cost cannot be strictly identified with actual costs of transport in Ecuador.

** Section 3.4.4, shown in Table 22 under environmental condition No. 2.

periods starting in 1973 and 1983.

The first group of conclusions relates to the final resume of the results of Sections 4.2.2, 4.2.3, 4.2.4 and 4.2.5. The second group encompasses the rest of the sections dealing with export commodities thus far analyzed. Conclusions with respect to import flows are implicit or explicitly mentioned inside each group.

5.2.2.1 For the Period 1973-1983

It is likely that the completion of the proposed highway system would motivate a slight redistribution of flows among the northern ports. Guayaquil might experience a relative reduction of 15% with respect to 1968. The indicated changes would be a consequence of factors in addition to highway improvements. For example, the comparatively high production increases estimated for the province of Esmeraldas and northern part of the Pichincha province would also tend to increase shipments through Esmeraldas.

Improvements in the port and in the road connecting Quevedo City to Manta are the determinants of the expected 9% increase in the activities of that port. The role of Quevedo City as an intermediate distribution center could be significant in the evolution of the regional system of urban centers. With an expected population of sixty thousand inhabitants for the year 1973 and locational advantages for wholesale goods consolidation and for local trade, Quevedo might play a very important role in determining the ports through which exports and imports flow.

The introduction of the coastal system has been proved to be advantageous from several different points of view:

1. In terms of transport costs, the system could offer a reduction of approximately 8% over the median unit cost calculated for the whole country,* and in comparison with estimated cost for 1973 without coastal system (Section 4.2.2).

2. A more balanced distribution of inland flows toward ports would reduce the length of backhaul trips. At the same time, marine operations might benefit by being concentrated in Guayaquil and Manta.

3. From a spatial point of view, Santo Domingo, in the north, would play a similar role to that played in Quevedo City in funneling flows to Manta or Guayaquil. In terms of a hierarchical organization of the space, each might play the role of an intermediate urban center between the main coastal and sierra centers of Esmeraldas and Quito on the one hand, and Manta, or Guayaquil and Latacunga on the other.

Inland ports like Daule and Babahoyo might help to reduce overflows on the main land side accesses to Guayaquil. At the same time, both centers might continue to handle commodities directed to Guayaquil, and also internal traffic with other local ports in the Guayaquil Bay. For example, shipment of cargo from Latacunga in the Sierra and Bolivar in the south, by a combined truck inland waterway system may prove 10% less expensive than direct shipping by truck.

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* Table 22 - Environmental Conditions 2 and 3.

4. The cargo carrying capacity of the Coastal system might significantly reduce the demand for trucks. Savings in foreign exchange, as well as in maintenance of roads, might introduce important marginal effects for the economy.

In Sections 4.2.4 and 4.2.5, the alternative of an homogeneous port configuration in Guayaquil, Manta and Bolivar was assumed. If the outcomes of those two sections are compared with the results in Section 4.2.2, it can be seen that the proposed port configuration would lower the median unit transport cost by 7% for the whole country. Comparative technological advantages in port facilities would increase the Guayaquil throughput by 6%, thus raising its participation in total exporting flows of the country to approximately 72%. (See Table 22).

The introduction of the coastal system does not seem to be compatible with the proposed technological improvements in ports. The new system appears in a competitive position with respect to other handling and transport techniques in the Esmeraldas and Babahoyo hinterlands only. With participation of a scarce 15% in the total exporting demand, and less than 1% reduction in the median unit transport costs for the whole country, the coastal system would not be economically justified.

A broad view of the economic pros and cons of the proposed alternatives for the year 1973 is outlined in the following table:

	4.2.2	4.2.3	4.2.4	4.2.5
Estimated cost of transport for the whole country	38.3	35.4	35.7	35.4
Estimated savings with respect to 4.2.2		2.9	2.6	2.9
Estimated costs per year		2.4	3.5	5.9
Estimated benefit for the economy		.5	-.9	-3.0

This preliminary comparison of alternatives indicates an economic advantage for the coastal system. However, and in connection with the coastal system, a final consideration has to be deferred to the role that foreign exchange requirements may play in the choice of alternative policies. In Ecuador, as in any other developing country, a very great importance is attached to the requirements for scarce foreign exchange.

The introduction of a new mode of transportation like the coastal system would certainly have an impact on other modes already in use. In the present case, the effects on highway vehicle requirements for which the larger part of the investment depends on foreign exchange, merits a specific consideration.

In Section 2.2.7.2* a preliminaty estimate of the cargo carrying capacity of the coastal system was calculated in 320 million long ton-nautical miles. On the other hand, the cargo carrying capacity of an average truck in Ecuador was estimated

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* In Chapter 2.

in 162 thousand shor tons-km (Section 2.2.3.6). Therefore the introduction of the coastal system might replace around 3550 trucks, which in foreign exchange might represent a savings of 35.5 million dollars.*

Assuming for the period 1973-1983 the same requirements for truck purchases calculated for the 1963-1973 period, the country would need to import an average of 658 trucks per year. The introduction of the coastal system, then, would stop the imports of trucks during the five years following its implementation. An evaluation of the Coastal alternative in terms of present value follows: **

a. Estimated cost of implementing the system:	11.40 million dollars
b. Estimated present value of benefits at 2.9 million per year during 20 years, assuming 5.5% interest:	12.5 million dollars
c. Estimated present value of savings in foreign exchange during 5 year period at 8% interest over $6.6 million (658 trucks per year):	16.6 million dollars
d. Estimated gross benefit for the economy:	17.7 million dollars

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* At 1963 prices, the cost per truck including spare parts and tires was estimated at $10,030.

** At 1963 prices.

It is evident that the net monetary benefits for the economy would not be the final consideration to be taken into account. The new system would create marginal effects the social cost of which require a careful balance. Among others, the impact on the existing inventory at the moment of the new mode's implementation is certainly important. Also important might be the consideration of present road standards* which would act as a brake on the introduction of bigger trucks capable of lowering operative costs. A highway oriented transport program might demand improvements in facilities and inventory which certainly would require continuation of the present tendencies in the area of social overhead capital investment.

Consequently, it is also clear that the benefits for the society will depend on the relation of the new system to the goals established by this society. The design of transportation policies must supply adequate insights for other areas of national planning policies, as well.

So for the moment, and in terms of the goals of this study, it is concluded that the introduction of an integrated coastal feeder system might favor a more balanced distribution of flows and would make more efficient use of the proposed or existing infrastructure for the period 1973-1983.

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* Roads are not prepared for trucks larger than 11 short-tons

5.2.2.2 For 1983 and Beyond

While no major relative changes are expected to occur in the influence areas of Guayaquil, Bolivar, and Manta, the construction of a new road between Apuela City and Quininde would increase significantly the attraction of Esmeraldas. Assuming for the moment that the rest of the parameters are exactly the same as in Section 4.2.3, it is estimated that the completion of the highway program might save the country around 1.1 million dollars in total transport costs. This figure has only an illustrative value because in actuality total production is expected to be higher in 1983. The expected production increases in the areas affected by the new road programs would certainly augment the benefits. The predicted 56% growth in the exporting throughput of Esmeraldas might create overloads on the actual capacity of the port. However, the activity of minor inland ports, along the Esmeraldas River, like Viche might increase their activity as trans-shipment points between trucks and lighters. Small improvements in those inland feeding ports would help to relieve overconcentration of flows in Esmeraldas as well as promote local activities in small centers. This policy must be well-coordinated with bridge construction policies over the Esmeraldas River. It is likely that the major problems in the port of Esmeraldas might occur on the inland side rather than on the water side.

The projected production increase during the ten year period (1973-1983) is perhaps a parameter whose verification would represent an urgent need for the country's future planning. The results shown in the previous chapter have proven the importance and need of accurate forecasts in the location and amount of agricultural production. In this respect, it is important to indicate that according to this estimate the country would experience an increase of 28 per cent in their exports of bananas, cocoa and coffee.

Flows into the geographically stable Bolivar hinterland might increase by 31% and in Esmeraldas by 56%.* The reason for this is a sort of cause and effect between highway improvements and higher rates of production in the new lands, though other factors like the availability of minimal social infrastructures might be considered before accepting this forecast as definite. The problem between Guayaquil and Manta is mainly a question of competition between ports. The gains of 58% with respect to the expected flows toward Manta might be the consequence of infrastructural improvements on the port installation and highway improvements in the Quevedo-Manta road. Another factor that would change the entire distribution of flows arriving in Quevedo might be the tolls on the Guayaquil-Duran bridge. It is in this region that the role played by political policies** by means of pricing policies, location of specialized facilities, custom

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* It is recommended to see Chapter I, Tables 6, 7, and 8 in order to know under what bases those estimates were made.

** Analyzed in Chapter I.

policies and taxation would have the more visible effects. While important for the whole country the decision to promote the regional development in this area would depend upon the capacity to control local and general policy effects. The combination of the proposed highway system for 1983 and the integrated coastal feeder system maintains the same advantages as with respect to the 1973 highway system. Still a four and a half per cent reduction in the median unit transport cost with respect to Condition 6* for the country as a whole might be obtained. Yet it is estimated that an accurate evaluation of the integrated operation between the coastal system and the proposed marine transportation scheme might prove this combination to be still more advantageous. This argument is supported by the following reasons:

- Only a limited number of minor coastal ports has been analyzed.**
- Operating costs were calculated on the basis of 1968 exports which would be too conservative when compared with the estimated exports for 1973 and 1983.
- The marine side of the integrated operation has been evaluated on the basis of an average type of ship. No consideration has been devoted to the vessel's requirement of specific trade routes.
- The system was calculated as operating exclusively for the traffic of exporting commodities. Occasional runs through

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* Section 4.2.6

** The port of Duran for example would offer an important connection with the railroad system as well as with highways on the east side of the Guayas River saving the cost of bridge tolls. The same argument would be valid for the railroad connection in S. Lorenzo.

the computer have shown that the coastal system would be be advantageously competitive in routes connecting coastal ports in the Guayaquil Gulf with Manta or even with Esmeraldas.*

- The system was assumed to be implemented during the period starting in 1983. No consideration was devoted to the fact that in the previous period the system was already an advantageous alternative.

Under the assumption of more investments being made in the ports of Guayaquil, Manta and Bolivar, so that they might be able to operate more efficiently technologically, the main conclusions are:

1. A geographic "contraction" of the Guayaquil hinterland, due to the proposed highway improvements into the northern part of the country.
2. The relative participation of each port in exporting flows would maintain practically the same percentages as in 1973, under similar environmental conditions (assuming the production projected for 1983).
3. Overflows into certain sections of Santo Domingo - Quevedo - Nobol Guayaquil Corridor would likely create bottlenecks on the roads and accesses to Guayaquil. Port improvements might be dependent upon additional investments in roads and

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* i.e., shipping of flour from Duran, fresh fish from the Esmeraldas and Manta areas, etc.

city accesses.

4. The introduction of the coastal feeder system, while reducing the median unit transport costs estimated for the whole country by six per cent, cannot be considered an advantageous alternative. Repeating the same patterns as in 1973 (Section 4.2.5), the coastal system might prove to be effective inside the Esmeraldas area of influence and for the northern part of the Pichincha province. In the rest of the country the system would hardly be competitive with the proposed port configuration.

A possible alternative, not tested in this study, in place of the coastal system and assuming that production and its locational forecast are accurate, might be the upgrading of Esmeraldas port installations.

The required investment for the coastal system was estimated to be 11.4 million dollars which certainly would cover the cost of building a new port with all the necessary facilities for handling diverse overseas shipments. This new alternative, however, would not eliminate the need for investment in the upgrading of infrastructures and facilities other than in the Esmeraldas port area*

Coming back to the alternatives considered for 1983, it is worthwhile to make a similar cost-benefit consideration to the one already done for the period starting in 1973.

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*The coastal system apart from their carrying capacity would supply a significant amount of warehousing space;such warehousing space may be displaced in response to seasonal and yearly peak demands.

	Alternatives			
	4.2.6	4.2.7	4.2.8	4.2.9
Estimated cost of transport per year - whole country -	50.4	48.2	43.6	40.7
Estimated saving with respect to 4.2.6		2.2	6.8	9.7
Estimated cost per year		2.4	3.9	6.3
Estimated benefit for the economy, per year		-.2	2.9	3.4

An evaluation of alternatives 4.2.7, 4.2.8, and 4.2.9 in terms of their present value and of their net benefits for the economy as a whole follows:

If the estimates are assumed to be the same as for the 1973-1983 period, with the exception of the assumed yearly cargo carrying capacity of an average truck*, then:

Alternative 4.2.7

a. Estimated cost of implementing the coastal system: 11.4 million dollars

b. Estimated present value of losses at 200 thousand dollars per year during 20 years at 5.5% interest: .863 million dollars

c. Estimated present value of savings in foreign exchange during 5 years, at 8% interest over 6.4 million dollars (638 trucks per year): 16.2 million dollars

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* Assumed to be 180,000 ton-km for the period 1983 and beyond, due to better operation conditions.

d. Gross estimated benefit for the economy
at 1963 prices: 3.90 million dollars

Alternative 4.2.8

a. Estimated cost of implementing the new improvements in ports - alongside berths and warehousing:* 6.3 million dollars

b. Estimated present value of benefits at 2.9 million dollars per year during 30 years assuming 2% interest rate:** 12.7 million dollars

c. Estimated gross benefit for the economy at 1963 prices: 6.4 million dollars

Alternative 4.2.9

The coastal system is expected to carry some 348 thousand short-tons between Esmeraldas and Manta assumed to be the main terminal. Assuming that the system will transport some 121 million tons-km per year, then the number of trucks that the system would replace is estimated to be approximately 670.***

a. Estimated cost of implementing the new improvements in ports: 6.3 million dollars

b. Estimated present value of benefits at 2.9

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* Estimating 1.05 million dollars per dock - Ref. 36, p. 107.

** It is a very low interest, however it was taken in order to keep the coherence with the loan interest charged, in this study, to port authorities.

*** The cargo carrying capacity of an average truck in this period was assumed to be 180 thousand tons-km.

million dollars per year during 30 years at 2% interest rate: 12.7 million dollars

c. Estimated cost of implementing the coastal system: 11.4 million dollars

d. Estimated present value of benefits, due to the addition of the coastal system, at 500 thousand dollars per year during 20 years at 5.5 per cent interest rate: 2.2 million dollars

e. Estimated present value of savings during 5 years period, at 8% interest rate over 1.34 million dollars (134 trucks per year): 3.46 million dollars

f. Estimated gross benefit for the economy at 1963 prices: .7 million dollars

Economically, alternative 4.2.8 is the best, with an estimated gross benefit of approximately 6.4 million dollars, followed by the coastal alternative. Again, the problem of selecting among alternatives is a question which cannot be answered by the bounded area of transportation planning alone.

Final decisions might depend on the developmental goals proposed by the government.

In spite of this, it is worthwhile to indicate that this study does not exhaust the problem. The simple indication of what is the most advantageous alternative for the period under analysis is not a final answer. As it was pointed out previously, the port development policy recommended in Section 4.2.8 is basically connected with highway oriented developmental policies. As such, investments for maintenance and upgrading of certain sections of the highway system would be required. The amount of this investment should have to be added to the costs of port improvements. This evaluation has not been considered in this study and must be credited as one of its important shortcomings.

Chapter VI

6.1 Tentative Overview and Recommendations

Three regional cases may be considered in Ecuador - (1) the core regions around Guayaquil and Quito, (2) the resource frontier areas in the Costa and Oriente Regions and, (3) the backward regions in the Sierra. These are, within the perspective of the balanced regional development, the cases where the conflict between welfare and efficiency seems more relevant.

6.1.1 The Guayaquil and Quito Core Regions

The relatively high concentration of population, economic activities and investment in those regions indicate that its growth is closely tied up to national economy and that it performs a critical role in the process of industrialization. At the same time, backward regions have been generating major migratory flows toward the core areas. Capital overhead demand, under such an incremental phenomenon has been motivating an unbalanced distribution of resources.

6.1.2 The Resource Frontier Regions in the Costa and Oriente

The situation here is different, in these regions natural resource endowment (agriculture and mining) may play a significant role if the national strategy of economic development is oriented toward diversification of economic activities. The relative isolation from existing centers of population, as well as its present lack of servicing activities on the existing local centers, are the basic planning problems. The apparent dilemma is whether, from the national efficiency point of view, it is socially justified to promote the development of the resource frontier regions, or to continue the concentration process in the core regions. In spite of the fact that no empirical evidence may support the hypothesis of diminishing net returns of scale in core regions, it is believed that the present troubles in major metropolitan areas of developing and developed countries are an experience which deserves consideration. Long range development policies cannot ignore the current experience in those areas. The social and economic cost inducted by spatially unbalanced growth and its incremental effects over population distribution, are serious topics of concern for designing any developmental policies. On the other hand, even if the core regions have increasing returns the development of the coastal and oriente frontier regions may be justified from the national efficiency point of view. Whether those frontier regions will have higher net returns than the core regions will depend upon the probability attached to the effect that the creation of social infrastructure and inflow of population into these areas. It is likely that with abundant natural resources the improvement of the transport system could significantly affect the relative advantages of the given regions for industrial and agricultural location. When an investment effort is carried out in one region, it will influence the structure of demand, prices, and costs of each region faced to the others because of the external economies provided by this investment effort. Then, it is believed that the building-up of a social infrastructure in the coastal and Oriente regions may be justified. It is the author's belief that it is possible to expect from the investment effort, higher increasing returns in the Coastal and Oriente regions than in the core areas. A final consideration may be dedicated to the national integration criterion, where the locational decisions are evaluated on the basis of the effect that they may have in closing and integrating these isolated areas to the existing spatial structure of the country.

Considering the findings of this study and under the assumption of a national development strategy where the priority for development of richly endowed frontier regions exist, the following recommendations are suggested:

6.2 The Integrated Coastal Feeder System

The implementation of a coastal feeder system operating under an integrated scheme with the marine transportation system is recommended.

Major Advantages:

6.2.1 No major investments in present port installations, with the exception of shallow docks for barges, would be needed.

6.2.2 The construction of interface facilities between the railroad and the coastal systems in San Lorenzo and Duran ports might return to the railroad thin competitive position with respect to the highway system.

6.2.3 The railroad system might be incorporated into the integrated transport operation scheme.

6.2.4 A more balanced distribution of inland transport flows toward and from port cities, as well as a more equitable use of the truck inventory.

6.2.5 As a consequency of 6.2.4, reduction of road congestion in the Guayaquil feeder roads.

6.2.6 Net savings in foreign exchange: the country would reduce its need for importing trucks.

6.2.7 Would facilitate intertrade with neighboring countries for two reasons:

a) Ecuador might order the construction of barges to Chile or Peru which have facilities for their construction.

b) It would facilitate the traffic of small tonnages for local intertrade with Colombia and Peru. The coastal traffic might be extended toward Colombia and Peru using Esmeraldas and Guayaquil as main terminals.

6.3 Ocean and Inland Ports

The creation of a collegiate authority to deal with the coordination and planning of policy investments in ports and their interrelated transportation modes is recommended. The factor of redundancy and overlapping of decisions must be their main concern.

6.3.1 No major investments are recommended in ocean ports infrastructure for the decade 1973-1983.

6.3.2 The upgrading and construction of feeder and local roads around Esmeraldas, Bolivar and to a certain extent San Lorenzo.

6.3.3 The construction of dock facilities for the Integrated Coastal Feeder System in:

6.3.3.1 Esmeraldas: starting with one dock and completing its second dock by the end of the 1973-1983 decade.

6.3.3.2 San Lorenzo: the construction of dock facilities for interface operations with the railroad and the highway systems.

6.3.3.3 Duran: the construction of dock facilities serving the railroad and highway traffic from the east.

6.3.3.4 Construction of dock facilities in Bolivar, Manta, Guayaquil Daule and Babahoyo.

6.3.4 The design of integrated decisions in the area of port pricing, port and general facility construction in Manta and Guayaquil.

Manta and Guayaquil must be considered as an independent subsystem sharing the same hinterland. It is in this area where the risk of duplication might create negative economic effects for the country. A coordinate distribution of activities seems to be a recommendable way for using resources and existing technical endowments.

6.3.5 The design of long-range port policies must be started. Among them it is recommended the upgrading of the Port of Esmeraldas in order to serve in the future as:

6.2.5.1 One of three main ocean terminals for the country.

6.2.5.2 One of the two main terminals for the Integrated Coastal Feeder System. This port might control local coastal operations and international coastal traffic with the Pacific ports of Colombia.

6.4 The Sea Transportation Scheme

The study and reevaluation of present managerial patterns dealing with the National Banana Fleet and the Gran Colombian Fleet is recommended in order to:

6.4.1 Move from the present status toward a gradual adoption of the Collective Bilateral Cargo Reserve with member countries of the Andean Group. This group composed of Bolivia, Colombia, Chile, Ecuador and Peru might be able to reserve 30 per cent of their cargo for the signatories' shipping lines.

6.4.2 Organize on an schedulled basis the integration of operations between the proposed coastal feeder system and the ocean going fleet. This fleet being composed of vessels nationally owned or chartered on the open market, according to route and seasonal needs.

With respect to chartering, the operation of the service with time chartered shipping based on the open market is recommended.

These time chartered vessels, as verified by V. Livanos (Ref. 13 pp. 67 to 103), are notoriously less expensive to operate than similar liner ships.

6.5 The Highway System

The country has been, during the last two decades, in an intensive program of highway construction. It is recommended that future policies in this area might put emphasis on:

6.5.1 Completion of the major highway projects proposed by 1973 and design of a special maintenance program. This program contemplates labor training at the regional level as well as public loans and grants for local enterprises. The main goal of these promotional programs must be directed toward the use of innovative techniques for reducing the need for foreign exchange resources and make more intensive use of labor, certainly a very elastic resource in the country.

6.5.2 An intensive investment program favoring the upgrading of local and penetration roads in the richly endowed Costa and Oriente regions.

6.5.3 A complementary measure for reducing road deterioration might be the avoidance of truck sizes over 10 to 12 short tons.

6.6 Intermediate Urban Centers

The development of market and input-output regional analysis in order to define, more acurately, the locational advantages of centers like Quininde, Santo Domingo, Quevedo, Cuenca and Baeza is recommended. They might play a powerful role in a polarized regional growth. Each of these cities seems to be located in a strategic position among port cities and the leading growth poles in the Costa and Sierra regions. The rapid growth of Guayaquil and the Quito area make it imperative to promote action in favor of intermediate regional centers. These kinds of poles of regional equilibrium must be favored and state intervention might be the determining factor.

In the hands of the central government lies the power for the location of administrative, health and educational services. The allocation of funds, through the operation of grants and special loans in rural developmental programs, factory building, transport and warehousing facilities construction are also powerful public instruments.

Appendix I

A definition of terms and concepts is required as a basis for further development of this study, so that concepts such as economic space, polarization, regional and programming space will keep a uniform connotation throughout our work.

When dealing with the concept of space, we are referring to economic space, --- "an application of economic variables on or in a geographical space, through a mathematical transformation which describes an economic process." (Ref. 61) It is a more operational notion where capital investment, transportation networks and land uses take a particular connotation. Industrial location, facility location, and investment in infrastructure are transformations of the space which might be viewed in different ways. Space can be defined in physical terms, by formal relations and in terms of final objective. These three possibilities lead us to the concepts of Homogeneous,Polarized and Programming Space. Polarization is associated with a relationship generated by flows of interaction due to socio-economic activities, and is more abstract and elusive than the intuitive perception of homogeneity.

Region and Space: an Economic Region: is a homogeneous economic space, and refers to a localized area, while an Economic Space is not. The class of Ecuadorian Provinces with high incomes per capita forms a space; the Provinces are not grouped into one contiguous region. So the Guayas and Pichincha Provinces, while in the same Economic Space, belong to different economic regions. (Ref.61, page 8). The polarized region or space provides dynamic descriptions of the interaction between its internal components, or with another set's elements. The polarization concept embodies the existence of interdependence and hierarchy among elements of a set, as an expression of functional stable relations.

A polarized region has its intuitive expression in the system of communities ranging from metropolis to satellite cities, to small towns and villages which exchange more with this major regional city than with other communities of the same order in the nation.

Regional Growth-Pole: Among the economic and physical indicators of growing flows of interaction, the index of absolute increment of traffic provides the best connection between the concept of the polarized region and the notion of a growth-pole. A regional growth-pole represents a concentration of expanding economic activities, settled in a specific urban area, and inducing further growth of existing or of new activities in its area of influence. The size and boundaries of such areas of influence fluctuate through time, following the evolution of cities. The impact of the new roads, the influence of demographic growth within different towns, and the effect of structural development and differentiation of towns seem to be the main generating factors of change. (Ref.61 , page 11.) The rivalry between the Sierra cities and Guayaquil in the Costa seems to be the political background of the sometimes erratic and uneconomic allocation of funds in the Ecuadorian road programs.

Appendix No. 2

Road Standards and Model's Definition of Terms

Types and thicknesses of pavement for corresponding volumes of traffic in Ecuador, according to the recommendations of the Ministry of Public Works. (Ref. 4, p. VI-8)

Less than 200 ADT (*)------------------no pavement

Between 200 and 500 ADT----------------double surface treatment

Between 500 and 1,200 ADT--------------2-inch asphaltic concrete

Over 1,200 ADT-------------------------3-inch asphaltic concrete

Roadway maintenance and operating cost estimates as used in this study were based on the above criteria.

Pavement and Shoulder Surface Standards

	Model's Road Types							
	1 & 5	9	2 & 6	10	3 & 7	11	4 & 8	12
Pavement Type	3	3	2	2	1	1	1	--
No. of layers	3	3	2	2	2	2	1	--
Thickness (CMS)	12	12	7	7	4	4	2	--
Shoulder Type	6	6	5	5	6	6	6	--
No. of Layers	2	2	1	1	1	1	1	--

Material's Code
1 = Earth
2 = Gravel
3 = Asphalt
5 = Sandy Gravel
6 = Sand or Sand Clay

(*) ADT = Average Daily Traffic

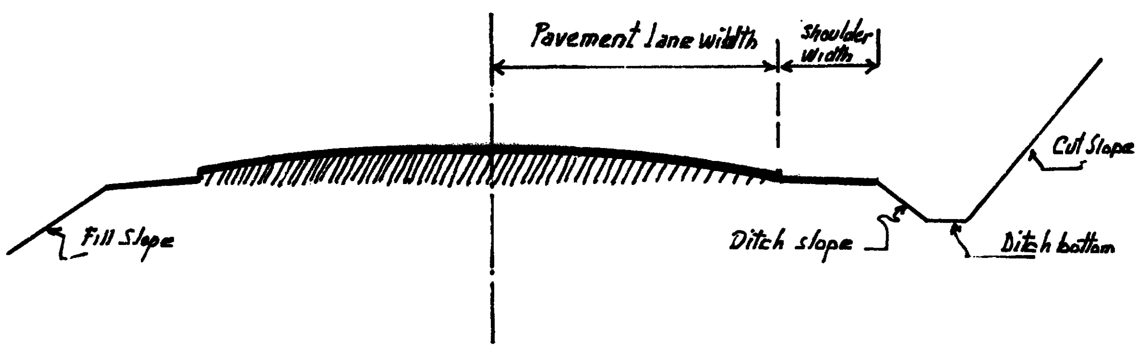
TEMPLATE (Quotations from Ref. 21 - User's Manual)

"1. All template slopes are assumed positive for their normal direction, i.e. Downward sloping fill slopes and upward sloping cut slopes are both input as positive values.

2. Pavement, shoulder, and ditch bottom slopes are defined as rise/run.

3. Ditch side, cut, and fill slopes are defined as run/rise."

4. Definition of terms:



Model's Design and Dimension Standards - for Ecuador -

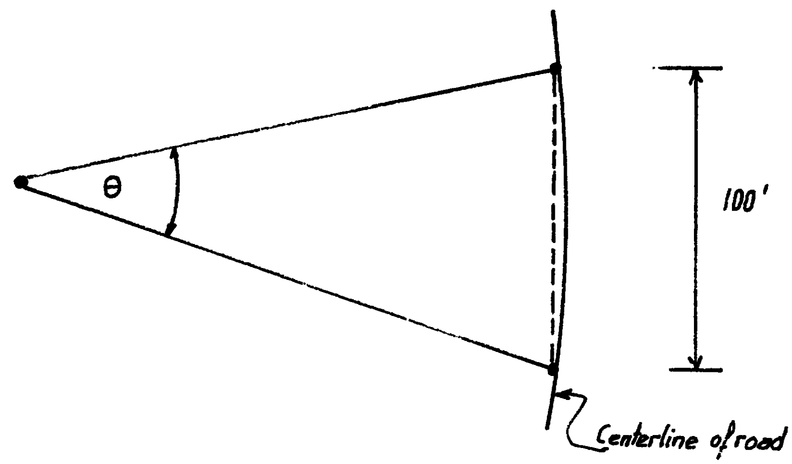
- in metric scale -

	Model's Road Type							
	1&5	9	2&6	10	3&7	11	4&8	12
Width (m)	3.25	3.25	3.25	3.25	1.75	1.75	1.75	1.75
Slope (m/m)	.04	.04	.04	.04	.06	.06	0.6	.06
Shoulder Width (m)	.75	.90	.75	.90	.50	.75	.50	.75
Shoulder Slope (m/m)	.07	.07	.06	.06	.05	.05	.05	.05
Ditch Side (m/m)	.50	.70	.40	.70	.10	.50	.10	.40
Ditch Slope (m/m)	.10	.12	.08	.10	.08	.06	.06	.06
Ditch Bottom W. (m)	.40	.40	.20	.20	.20	.20	.00	.00
Ditch Bottom Slope (m/m)	.02	.02	.02	.02	.00	.00	.00	.00
Cut Slope (m/m)	.75	.75	.75	.50	.50	.00	.30	.00
Fill Slope (m/m)	1.00	1.00	1.00	.60	.75	.00	.50	.00
Side Clear (m)	.60	.45	.45	.30	.30	.00	.00	.00

ALIGNMENT (Quoted from Ref. 21, p. 18-19)

"1. Definition of Average Degree of Curvature

The degree of curvature of a curve is defined as degrees of central angle subtended by a 100 ft. chord. For example:



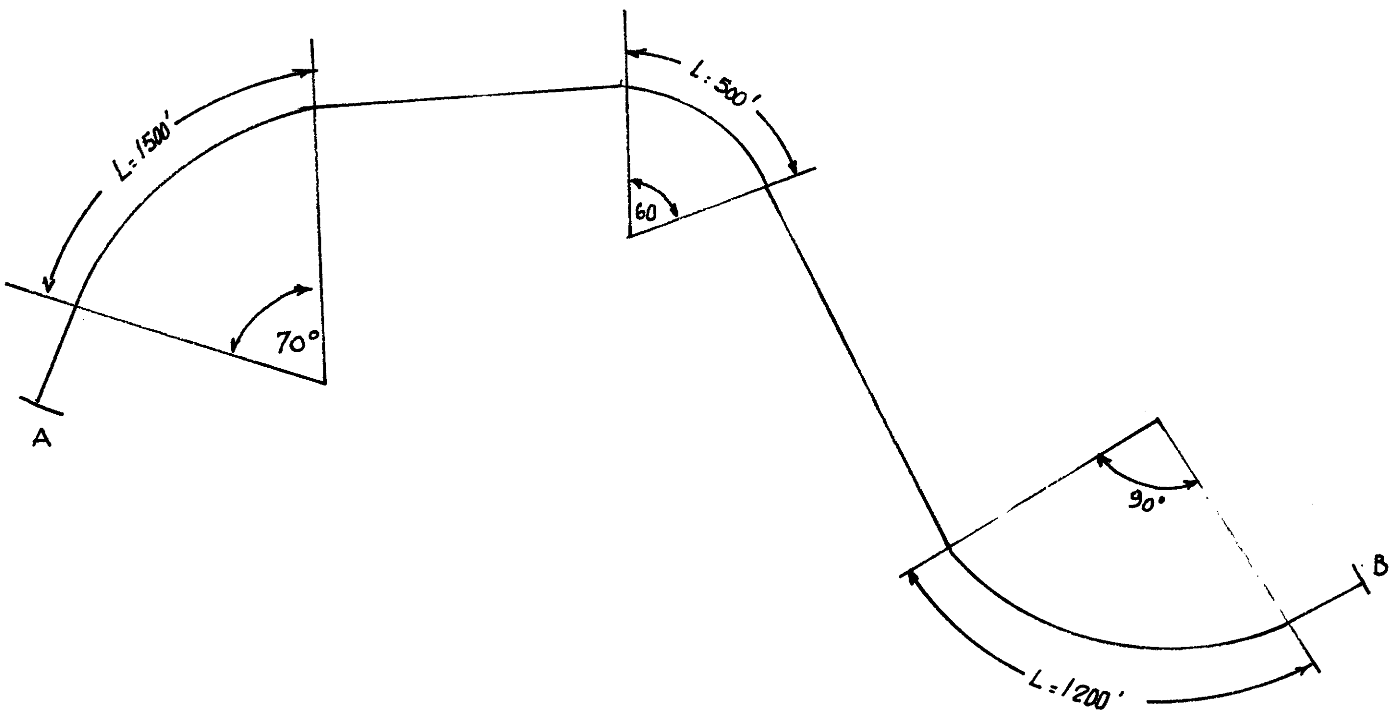
θ is the central angle of this 100' section.

θ is also the degree of curvature of the illustrated curve.

To find the average degree of curvature of an N mile long segment of road, sum the absolute values of the central angles of all horizontal curves (on the segment) and divide by N x 52.8.

(52.8 = number of 100 ft. chords in one mile.)

For example, for the 1.2 mile segment AB, as follows:



$$\text{Average Degree of Curvature} = \frac{70^\circ + 60^\circ + 90^\circ}{1.2 \times 52.8}$$

$$= \frac{220}{63.3} = 3.5$$

As with other averaging processes, one should group segments with similar curves. When the degree of curvature changes abruptly, a new segment should be started."

The average degree of curvature for each road type, was determined from direct measurement of selected roads from Ecuadorian maps. (*)

VEHICLE SIZE AND WEIGHT LIMITATIONS

The following maximum vehicle dimensions, which conform with the Convention on Road Traffic of The Geneva conference of 1949, have been used as a basis in this study. (Ref. 4, p. VI-9)

Vehicle Width. . . . . 2.50 meters

Vehicle Height . . . . 3.80 meters

Vehicle Length:

a. 2-Axle trucks. . . . . .10.0 meters

b. 2-Axle buses . . . . .11.0 meters

c. Vehicles with 3 or more Axles.11.0 meters

d. Semi-Trailers. . . . . .14.0 meters

(*) These were down to a scale of 1:25,000 and 1:50,000.

GENERAL MODEL ASSUMPTIONS (Quoted from Ref. 21, Appendix pages 4-12)

"I. General

1. The deterioration in a paved surface during any year of the analysis period can be preducted as a function of:

a. condition of surface at start of year

b. initial quality of the pavement design (as measured by a structural number)

c. quality of subgrade soil (as measured by CBR)

d. age of surface (since construction or last resurfacing)

e. volume and weight of traffic using surface for a year

f. maintenance performed during year.

2. Deterioration is defined for this study by changes in the parameters of PSI and coefficient of traction.

3. Most important aspects of deterioration are incorporated in the concept of the AASHO(*) present serviceability index (PSI) found by:

$$PSI = 5.03 - 1.91 \log (1 + \overline{SV}) - 0.01 \sqrt{C + P} - 1.38 \overline{RD}^2$$

where:

$\overline{SV}$ = the mean slope variance in wheel paths

$(C + P)$ = the area of surface that is either cracked or patched (expressed in $m^2/1000m^2$)

$\overline{RD}$ = the mean rut depth in the wheel paths."

(*) AASHO: American Association of State Highway Officials

"4. The coefficient of traction for wet pavement is initially 0.6 (IFRCW = 0.6). This decreases due to bleeding and aggregate polishing to a minimum of 0.3 (FFRCW = 0.3) in about ten years after construction or resurfacing (DFRC = 0.03)."

"5. A wet surface is assumed for that fraction of the year input as IMPS.

6. The coefficient of traction for dry pavement surface is constant and equal to 0.7 for the life of the surface.

7. Rolling resistance on paved surfaces is constant at 0.01 for all conditions and ages of interest.

8. Once PSI has been computed, mean slope variance ($\overline{SV}$) can be estimated from the relationship:

$$\overline{SV} = [10^{0.031PSI^2} - 0.54PSI + 2.3] - 1.0 \qquad R^2 = 9.1$$

This equation is based on correlation studies made during the AASHO Road Test. (2)

9. Roughness (RUF) is well correlated with AASHO serviceability (PSI), and the relationship can be expressed as:

$$\text{Roughness} = (5.0 - PSI)/.015 \qquad R^2 = .89$$

10. The area of cracking and patching (C&P) can be estimated by the relationship:

$$(C + P) = \begin{cases} 0 & \text{if } PSI > 4.3 \\ (0.3PSI^3 - 1.3PSI^2 - 6.2PSI + 29)^2 & \text{if } PSI < 4.3 \end{cases} \qquad R^2 = .68$$

This equation is based on correlation studies made during the AASHO Road Test.

11. The mean rut depth ($\overline{RD}$) can be estimated for any level of serviceability by the relationship:

$$\overline{RD} = - 0.03PSI^2 = 0.091PSI = 0.32 \qquad R^2 = .61$$

From AASHO Road Test.

12. If resurfacing is called for, it is handled as a reconstruction operation; therefore, the maintenance model doesn't predict cost of resurfacing.

13. For equations 8, 10, and 11, the regression equations were found using data from the AASHO road Test utilizing the IBM Scientific Subroutine Package routine POLRG. For equation 9, the regression coefficients were found by Yoder and Milhous and reported in N.C.H.R.P. Report #7, Highway Research Board, 1964.

II. Assumptions Concerning Patching

1. All patching is done with bituminous cold mix that is obtained by the local maintenance crews from a central location.

2. All costs for preparing and storing the premixed patching material are included in a "price" for the material at the central location. The cost of obtaining the material on the road section of interest is thus dependent only on this source "price" and the cost of transportation.

3. The trucks used to haul the material to the actual patching site are also used to roll the completed patching. As a result, trucks are the only type of equipment used in addition to hand tools.

4. Average thickness of all patches placed (both skin patches and deep patches) is 5cm (DOP = 5).

5. Placing and rolling cold mix for deep patches or skin patches requires the following expenditure of labor and equipment per cubic meter: (7,8,9)

a. 7.0 hours of common labor (CCM1 = 7.0)

b. 3.0 hours of dump truck and driver (CCM2 = 3.0)

6. The cost of transporting cold mix from a source to the road section can be found using the same estimates of productivity and consumption used for transporting gravel.

7. The percent of liquid asphalt used in the cold mix is 6% of the aggregate weight (AC = 0.06).

8. The mean slope variance (SV) is partially made up of depressions and potholes which are likely to be repaired by patching. Therefore, patching reduces the mean slope variance and this reduction (FIXSV) is a function of the fraction to be patched and the slope variance. The reduction for each year is estimated to be:

FIXSV = 0.3 (FTP)(SV)(KK)

(FIXSV varies between 0 and 1.0)

where KK is an adjustment factor that varies with the amount of cracking that appears each year. That is, the more patching that is done, the more SV will be affected.

III. Assumptions Concerning Sealing

1. Assume that the source of aggregate for sealing is the same as the source of bituminous cold mix.

2. The cost of transporting the aggregate from the source to the road section can be found using the same estimates for productivity and consumption used for transporting gravel.

3. The costs of transporting the liquid asphalt are absorbed in the costs of the distributor and are not explicitly calculated.

4. Aggregate is applied at a rate of 14 kilo/m^2. (SA = 14)

5. Bitumen is applied at a rate of 1.2 liters/m^2. (SB = 1.2)

6. Sealing 100 square meters required the following expenditure of labor and equipment: (7,8,9)

   a. 1.4 hours of common labor (CS1 = 1.4)

   b. 1.4 hours of truck and driver (CS2 = 1.4)

   c. 0.4 hours of distributor and operator (CS3 = 0.4)

   d. 0.3 hours of roller and operator (CS4 = 0.3)

7. Costs for small items such as spreader attachments for trucks, brooms, rakes, etc., are not explicitly calculated but are considered as part of the cost of related equipment.

8. Sealing the surface reduces the amount of cracking and patching noticeable on the road surface. This reduction (FIXCP) is a function of area sealed each year [(FTS x Δ(C + P)]. The amount of reduction for each year (in square meters) is estimated to be:

$$\text{FIXCP} = (0.5)(\text{FTS})\Delta(C + P).$$

IV. Assumptions Concerning Rut Repair

1. All patching is done with bituminous cold mix that is obtained by the local maintenance crews from a central location.

2. All costs for preparing and storing the premixed patching material are included in a "price for the material at the central location." The cost of obtaining the material on the road of interest is thus dependent only on this source "price" and the cost of transportation.

3. The cost of transporting cold mix from a source to the road section can be found using the same estimates of productivity and consumption used for transporting gravel.

4. The percent of liquid asphalt used in the cold mix is 6% of the aggregate weight. (AC = 0.06).

5. This operation is assumed to be mechanized with a motor grader spreading the material. Placing and compating patching material for rut repair requires the following expenditures of labor and equipment per cubic meter:

   a. 1.0 hours of common labor (CRF1 = 1.0)

   b. 0.7 hours of dump truck and driver (CRF2 = 0.7)

   c. 0.25 hours of motorgrader and operator (CRF3 = 0.25)

   d. 0.2 hours of roller and operator (CRF4 = 0.2)

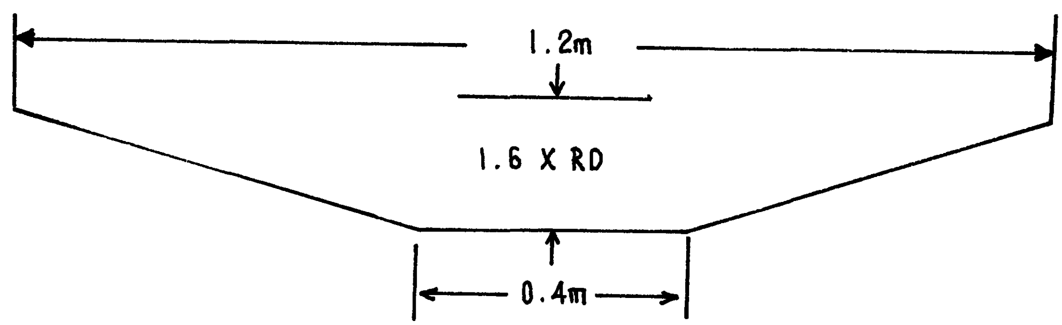
   e. 0.2 hours of distributor and operator (CRF5 = 0.2)

6. Since only the deeper ruts will be filled, the average rut depth will be reduced each time ruts are repaired.

7. Assume that the depth of ruts are normally distributed. For this distribution the reduction in mean rut depth (FIXRD) will be approximately one-half of fraction of ruts filled (FRF).

FIXRD = 0.5 (FRF)(RD).

8. Assume that the shape and size of the average rut filled will be as follows:



Note: This assumption should be valid for values of FRF between 10 and 30 percent.

Volume of patching material required for one kilometer of roadway

$$(CMPR) = \frac{4 \times FRF \times 1.6 \times RD \times 0.8m\ 1000_{m}}{100\ cm/m}$$

$$= 50 \times FRF \times RD$$

ASSUMPTIONS FOR GRAVEL ROAD MAINTENANCE

I. General

1. Average roughness (within attainable range of gravel road) is dependent only on maintenance policy and traffic load.

2. Rolling resistance and coefficient of traction is dependent only on maintenance policy and traffic load except during periods of prolonged heavy rainfall when road becomes spongy and somewhat slicker.

3. As a result of the first two assumptions, output to user cost model will be in the form of one roughness value for each year if blading frequency is the same for wet and dry seasons. Two roughness values will be computed if the blading frequency is different for wet and dry seasons. Three levels of rolling resistance and coefficient of traction will be output each year; one for dry season, one for wet season and one for in-between.

5. All maintenance operations can be done without significantly interfering with traffic.

6. One cubic meter of compacted gravel weighs 2240 kilograms (DCG = 2.24).

7. One cubic meter of loose gravel weighs 1800 kilograms (DLG = 1.8).

II. Assumptions Concerning Blading

1. The surface can be bladed with two passes/area of the grader over the area to be bladed (Pass 1 = 2).

2. The surface is bladed on a selected schedule year-round by adding water during the dry season.

3. Except during dry season, traffic compacts the surface satisfactorily after blading and no additional compaction need be provided.

4. During the dry season, the top 5 cm (AG1 = 5) of gravel must have its moisture raised 4% (WA1 = .04) to allow effective compaction.

5. When water must be added it is assumed that a roller is needed to compact the bladed and watered material since it is likely to dry before it can be compacted by traffic.

III. Assumptions Concerning Regravelling

1. Regravelling is done when gravel thickness is reduced to 10 centimeters (TCRC = 10).

2. Existing surface is bladed to a depth of 3 cm (BD = 3) to remove corrugations.

3. A quantity of gravel, equivalent to 5cm of compacted depth, is added (AG2 = 5).

4. Loose gravel - both original and new - must have moisture raised 4% (WA2 = .04).

5. All required water can be applied in two passes.

6. Four grader passes per area are necessary for regravelling.

7. Assume that the gravel replacement operation will be organized (truck to loader ratio, etc.) so that each truck round trip requires 6 min. of loader time (5 min. to actually load and

1 min. of delay.) Thus the loader can load 10 trucks each hour of net working time.

8. Assume that amount of gravel lost from surface is directly proportional to the total weight of vehicles using raod. The number of each type of vehicle will be converted to an equivalent number of 1600 kilogram vehicles. The total number of equivalent vehicles will be used to estimate gravel loss. This assumption appears to explain the difference in gravel loss rate between the two most complete reports concerning gravel loss.

9. Assume that 0.9 metric tons of gravel is lost per year per kilometer for each 365 equivalent vehicles (one per day) that uses the road. (GL = .9)

ASSUMPTIONS FOR EARTH ROAD MAINTENANCE

I. General Assumptions

1. Average roughness (within range attainable on earth surface is dependent only on maintenance policy and traffic load.

2. Rolling resistance (RR) and coefficient of traction (CT) is also dependent on maintenance policy and traffic load, but rainfall and soil type have an additional effect.

3. RR and CT vary over a wide range during the year but it is assumed that this variation can be adequately represented by considering three distince levels: dry surface, wet surface and softened surface.

4. Water must be added for effective blading during the fraction of the year input as "DRY".

5. An impassable surface is assumed for that fraction of the year input as "IMPS".

6. A slightly softened surface is assumed for that fraction of the year not included in either DRY or IMPS (rolling resistance is somewhat higher.)

II. <u>Assumptions Concerning Blading</u>

1. The surface is bladed on a selected schedule year-round by adding water during the dry season.

2. Except during the dry season (DRY) traffic compacts the surface satisfactorily after blading and no additional compaction is provided.

3. During the dry season (DRY) the top 5cm (AE = 5) of soil must have its moisture raised 2% (WA3 = .02) to allow effective compaction.

4. When water must be added, it is assumed that the material must be rolled to prevent drying out before compaction.

<u>ASSUMPTIONS FOR DRAINAGE MAINTENANCE</u>

1. Basic measure of work is cubic meters of soil that is removed from ditches and drainage structures.

2. All work is done with a standard crew of 25 laborers, 4 trucks and one motorgrader. The assumed operation uses the motorgrader to grade the ditches to their original depth. The laborers load the soil into trucks for removal and do whatever hand work is necessary to clean out and repair the drainage structures within the work area.

3. This crew is capable of removing 100 cubic meters of sediment from the drainage ditches in one day (6 hours working time and a ratio of working time to total time of 3:4 (PCL = .75). (7,8,9,14)

4. The relative amounts of sediment deposited in the drainage system can be estimated by the following relationship:

sediment (in cubic meters) = 6 + 3[(1 + RF/100)(TF)(SSF)]

where:

RF = annual rainfall in centimeters

TF = adjustment factor for terrain

a. mountainous = 1.0

b. rolling = 2.0

c. flat = 3.0

SSF = adjustment factor for side slopes =

(1/cut slope) + (1/fill slope) + (0.5)

ASSUMPTIONS FOR MAINTENANCE OF BITUMINOUS SHOULDERS

1. Shoulder maintenance is a minor fraction of the total maintenance cost. Therefore a typical maintenance policy will be assumed instead of asking the model user to specify a policy.

2. The shoulders are sealed a minimum of once every ten years (0.1 of shoulder area is sealed each year.).

3. The most common repair needed will probably be filling the depressions that form the edge of the travelled surface. The repair needed for this deterioration is considered to be proportional to the patching and rut filling needed for the travelled surface since they are both affected by the traffic volume, subsoil quality, and climate.

4. The patching and rut filling needed for bituminous shoulders increases by 50% (SBI = .5) for each meter that the roadway surface is less than 7 meters. (i.e., a 6 meter wide road will require 50% more shoulder maintenance than one 7 meters and a 5 meter road will require 50% more than a 6 meter road.)

5. Bituminous shoulders for a 7 meter wide travelled surface require 10% as much patching and rut filling per area as the travelled surface.

ASSUMPTIONS FOR GRAVEL SHOULDER MAINTENANCE

1. Shoulder maintenance is a minor fraction of the total maintenance cost. (8,18) Therefore, typical maintenance policy will be assumed instead of complicating the model by asking the model user to specify policy.

2. The shoulders are bladed at least once per year.

3. The shoulders are bladed an additional time for each 500 vechiles per day (ADT) above 500 ADT. (FREQF = 500).

4. The number of needed shoulder bladings is greater for narrow roadways. It is assumed that the need for bladings increases 50% (SGI = .5) for each meter that the roadway surface is less than 7 meters.

5. One shoulder blading requires 2 passes of the motorgrader. (4 passes for both shoulders)

6. Shoulder blading can be scheduled to be done when surface is damp and therefore no water need be added. That is, the model assumes surface is damp and therefore no water need be added.

7. Bladed shoulder material must be rolled since it is not likely to be compacted by traffic.

8. Shoulder can be satisfactorily compacted with same number of passes as for compacting bladed gravel road (RP4) and the width which needs to be rolled is not wider than roller. Therefore, passes needed to roll one section of road (both shoulders) = 2 x PR4."

Appendix No. 3

Outputs from Highway and User Cost Program

THE ANALYST SPECIFIED PROBABILITY ASSOCIATED WITH THE INITIAL TRAFFIC CONDITIONS IS 0.3330

YEAR 1 DISCOUNT FACTOR 0.922 STRATEGY 1

CONSTRUCTION #	YEAR	TYPE	MAINTPOL	STRATEGY
1	1.	2.	0.	1.

THE PAVEMENT DESIGN FOR THIS CONSTRUCTION IS

WIDTH	SLOPE	SHLD-WD	SHLD-SL	DTH-WD	DTH-SL	DTH-WD	DTH-SL	CUT-SL	FILL-SL	PAVE-WD	SIDE-CL
1.70	0.02	1.00	0.05	2.00	4.00	1.00	0.03	2.00	4.00	3.40	10.00
PAVE-CC	LAYERS	MAT-TPE	THICKNESS	MAT-TPE	THICK	MAT-TPE	THICK	SHLD-TPE	THICK1	THICK2	THICK3
1.00	3.00	6.00	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PAVEMENT UNIT COSTS AND PRODUCTIVITIES

PROD	SOURCE	TRANSPORT	LCOST	EQCOST
348.00	0.0	0.0	495.70	3446.40
348.00	0.0	0.0	495.70	3446.40
200.00	300.00	0.0	495.70	3446.40
348.00	0.0	0.0	495.70	3446.40

CONSTRUCTION COSTS (PER KILOMETER)

	THIS PERIOD ACTUAL	THIS PERIOD DISCOUNTED	SUM TO DATE ACTUAL	SUM TO DATE DISCOUNTED
LABOR	32857.	30283.	32857.	30283.
EQUIPMENT	231491.	213356.	231491.	213356.
MATERIAL	6885.	6346.	6885.	6346.
TRANSPORTATION	62.	57.	62.	57.
TOTAL	271295.	250042.	271295.	250042.

OFFSHORE COSTS FOR CONSTRUCTION

	IN SUCRE THIS PERIOD ACTUAL	DISCOUNTED	SUM TO DATE ACTUAL	DISCOUNTED	IN DOLLARS THIS PERIOD ACTUAL	DISCOUNTED	SUM TO DATE ACTUAL	DISCOUNTED
LABOR	14129.	13022.	14129.	13022.	14129.	13022.	14128.	13022.
EQUIPMENT	231491.	213356.	231491.	213356.	231491.	213356.	231491.	213356.
MATERIAL	0.	0.	0.	0.	0.	0.	0.	0.
OTAL	245620.	226378.	245620.	226378.	245620.	226378.	245620.	226378.

ROUGHNESS INCHES/MILE 250.0 250.0 700.0

VEHICLE 1 TYPE 1. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY
MARKET,ECONOMIC COSTS 25.000 0.560 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.107	0.016	0.004	0.001	0.123	0.167	0.036	0.104	0.560
0.053	0.011	0.003	0.001	0.092	0.113	0.034	0.066	0.373

VEHICLE 2 TYPE 2. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY
MARKET,ECONOMIC COSTS 13.600 2.024 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.222	0.021	0.005	0.001	0.437	0.860	0.032	0.445	2.024
0.109	0.015	0.004	0.001	0.478	0.773	0.029	0.156	1.564

VEHICLE 3 TYPE 3. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY
MARKET,ECONOMIC COSTS 1.500 1.877 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.636	0.027	0.020	0.005	0.404	0.0	0.282	0.502	1.877
0.318	0.020	0.014	0.004	0.303	0.0	0.216	0.320	1.194

VEHICLE 4 TYPE 3. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY
MARKET,ECONOMIC COSTS 13.400 1.664 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.346	0.112	0.083	0.005	0.317	0.0	0.362	0.439	1.664
0.174	0.081	0.060	0.004	0.238	0.0	0.286	0.302	1.144

VEHICLE 5 TYPE 3. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY
MARKET,ECONOMIC COSTS 13.200 1.874 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.434	0.145	0.107	0.005	0.317	0.0	0.409	0.456	1.874
0.214	0.115	0.086	0.004	0.238	0.0	0.372	0.313	1.343

VEHICLE 6 TYPE 5. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY
MARKET,ECONOMIC COSTS 0.300 4.845 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
1.308	0.096	0.060	0.007	0.556	0.0	2.254	0.563	4.845
0.654	0.070	0.044	0.005	0.417	0.0	1.966	0.387	3.544

TRAFFIC IN YEAR 1 HAS THE FOLLOWING PROPERTIES

VEHICLES /DAY	BASE COSTS/KM	ELASTICITY	GROWTH RATE
25.	0.560	0.0	0.066
14.	2.024	0.0	0.042
2.	1.877	0.0	0.042
13.	1.664	0.0	0.042
18.	1.874	0.0	0.042
0.	4.845	0.0	0.020

DETAILED OUTPUT FOR USER COST MODEL BROKEN DOWN BY VEHICLE TYPE PER VEHICLE KILOMETER

LABOR HOURS	0.044	0.191	0.177	0.140	0.140	0.364	0.0
VELOCITY, KPH	33.500	18.250	11.583	11.583	11.583	7.417	0.0
FUEL CONSUMPTION, LITERS	0.472	1.112	2.284	2.744	2.848	3.521	0.0
MARKET COST, DOLLARS	0.560	2.024	1.877	1.664	1.874	4.845	0.0
PARTS COST FACTOR PER 1000 KM	0.182	0.261	0.714	0.714	0.714	0.181	0.0
INC.WILL. TO PAY	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NUMBER OF VEHICLES	25.0	13.6	1.5	13.4	18.2	0.3	0.0

	MAINTENANCE COSTS ($/KM) THIS PERIOD ACTUAL	DISCOUNTED	SUM TO DATE ACTUAL	DISCOUNTED	OPERATING COSTS ($/KM) THIS PERIOD ACTUAL	DISCOUNTED	SUM TO DATE ACTUAL	DISCOUNTED
LABOR	0.	0.	0.	0.	11095.	10225.	11095.	10225.
EQUIPMENT	0.	0.	0.	0.	5827.	5370.	5827.	5370.
MATERIAL	0.	0.	0.	0.	9800.	9032.	9800.	9032.
INCREMENTAL WILLINGNESS TO PAY					0.	0.	0.	0.
TOTAL	0.	0.	0.	0.	26722.	24628.	26722.	24628.

FOREIGN EXCHANGE COSTS FOR YEAR 1 IN SUCRE ARE

	THIS PERIOD ACTUAL	DISC	SUM TO DATE ACTUAL	DISC
MAINTENANCE TOTAL	0.0	0.0	0.0	0.0
USER TOTAL	9155.7	8438.4	9155.7	8438.4
GRAND TOTAL	9155.7	8438.4	254775.2	234815.9

	ACTUAL	DISCOUNTED
SUM OF ALL COSTS TO DATE($/KM)	298017.	274670.

```
     VEHICLE PERFORMANCE UNDER THREE FLAT ROADS TYPES(CDE)WIDE CLASS
 ALIGNMENT DATA-ALIGN
  LENGTH    DEG-CURVE
    73.42      0.10
PROFILE DATA- PROF
TYPE-SWITCH AVE-GRADE MAX-GRADE NO-VPIS
     3.00      0.00      3.13     49.00
VPI STA   VPI ELEV  VPI STA   VPI ELEV  VPI STA   VPI ELEV  VPI STA   VPI ELEV  VPI STA   VPI ELEV
     0.0      4.90   1300.00      6.95  12500.00      7.10  14650.00      9.10  15500.00      9.10
16650.00      7.55  20900.00     11.90  23600.00     17.00  25300.00     30.66  27900.00     32.22
28650.00     42.55  28850.00     43.85  29750.00     41.33  31050.00     46.53  31250.00     46.03
32000.00     37.20  33750.00     40.70  35300.00     52.37  37200.00     41.10  37900.00     41.94
38100.00     41.40  39200.00     34.62  40200.00     34.90  41950.00     26.63  43000.00     24.00
43850.00     23.00  45000.00     25.20  45750.00     31.00  46600.00     37.00  48050.00     43.50
48750.00     41.17  49700.00     45.45  51200.00     35.75  52750.00     39.30  53800.00     32.30
55650.00     33.60  57250.00     24.00  58200.00     29.68  59700.00     19.70  61000.00     21.40
62780.00     15.06  64300.00     21.40  64700.00      3.56  65900.00     10.07  68450.00     19.84
70900.00     30.20  71450.00     24.98  72800.00     25.90  73420.00     20.30
ROADWAY CROSS SECTION(HORIZONTAL)-TEMPL
   WIDTH     SLOPE    SHLD-WD   SHLD-SL    DTH-WD    DTH-SL    DTH-WD    DTH-SL    CUT-SL   FILL-SL   PAVE-WD   SIDE-CL
    1.75      0.06      0.50      0.05      0.10      0.08      0.20      0.0       0.50      0.75      3.50      0.30
ROADWAY DESIGN DATA(VERTICAL)-PAVE
  PAVE-CD    LAYERS   MAT-TPE THICKNESS   MAT-TPE     THICK   MAT-TPE     THICK  SHLD-TPE    THICK1    THICK2    THICK3
    1.00      2.00      6.00      0.00      5.00      0.00      0.0       0.0       3.00      0.00      0.0       0.0
ECONOMIC DATA
NO OF PERIODS,DISC. RATE, NO OF VEHICLE TYPES
      4      8.50        6
   FOREIGN RATE OF EXCHANGE
      1      SUCRE  =    1.00000 DOLLARS
   PERCENTAGE OF COSTS THAT ORIGINATE FROM FOREIGN SOURCES
        PER CENT OF VEHICLE COST =  80.00         PER CENT OF FUEL COST =  70.00PER CENT OF TIRE COST =  80.00
        PER CENT OF  LABOR COST =  43.00          PER CENT OF CONSTRUCTION EQUIPMENT COST = 100.00
        PER CENT OF SOURCE COST =   0.0           PER CENT OF MAINTENANCE  EQUIPMENT COST = 100.00
MAINTENANCE POLICY-MAPOL
  DRAIN-SW  RGRVLSW   SHLD-SW    MOW-SW    BLAD-SW   BLAD-DRY  BLAD-WET   MOW-FRQ   RLTFPL    CRKDTH   CRKFSLC   RUT-DTH   SUR PNT
    1.00      4.00      1.00      1.00     -1.00   5000.00   5000.00      3.00      0.80      0.50      0.50      1.50      0.0
RECONSTRUCTION SCHEDULE- RBLC
  NO-UPGRAD
     0
TOPOGRAPHY- TOPOG
NO. OF STATIONS          90
TYPECODE  FLAT      ROLLING   MOUNT     HILLS
   -1.00    100.00      0.0       0.0       0.0
STATION   ELEV.     STATION   ELEV.     STATION   ELEV.     STATION   ELEV.     STATION   ELEV.
     0.0      4.00   1300.00      4.50   3000.00      5.30   5000.00      5.50   8000.00      6.00
10000.00      5.50  11000.00      5.40  14500.00      4.40  13500.00      4.00  14650.00      5.00
15500.00      6.10  16650.00      7.40  20900.00     10.20  23600.00     17.60  25300.00     29.30
25750.00     30.00  26400.00     27.30  27050.00     34.00  27900.00     29.00  28650.00     45.50
29750.00     40.00  30250.00     40.30  31050.00     43.30  32000.00     35.40  32500.00     41.00
33200.00     38.00  34900.00     53.40  35300.00     48.50  35700.00     52.50  36300.00     44.50
36650.00     44.00  37200.00     40.00  38100.00     41.40  38750.00     35.20  39400.00     34.40
39550.00     31.20  40200.00     37.70  41150.00     27.40  41500.00     28.00  41850.00     26.70
42000.00     26.00  42500.00     24.00  43000.00     24.00  43500.00     23.70  43650.00     22.80
43850.00     23.00  44370.00     26.00  45500.00     25.40  45750.00     34.00  46600.00     37.00
47100.00     37.00  47700.00     45.00  48050.00     44.20  46750.00     41.17  46850.00     40.00
49300.00     41.00  49700.00     48.00  50000.00     43.50  50750.00     41.50  51000.00     37.00
51200.00     37.50  51450.00     34.50  52350.00     40.70  52750.00     39.30  53800.00     30.80
55000.00     29.50  55650.00     36.00  57250.00     22.00  57800.00     29.90  58200.00     29.68
58600.00     29.50  58900.00     24.70  59700.00     16.70  60500.00     19.00  61000.00     22.60
61675.00     15.50  62100.00     17.00  64780.00     12.00  63600.00     15.60  65100.00      8.00
65500.00      3.00  66450.00     20.40  65075.00     21.60  69500.00     15.90  70000.00     22.00
70400.00     24.50  70900.00     33.50  71600.00     20.30  72800.00     28.60  73420.00     18.10
SOIL + GROUNDCOVER-CBR,GRCCV
    CBR       EASY    NORMAL   DIFFICULT
    6.00     70.00     30.00      0.0
DRAINAGE RELATED DATA-DRAIN
  WATR-BLCE   IMPASS   AVERAIN   MT-RAIN   FLT-MED   FLT-LGT
    1.00      1.00    120.00      0.0       1.00      1.00
HALL DISTANCES,CONSTRUCTION
                                            PAVEMENT                        MAINTENANCE
    %-BOR   HAULDIST    LAYER1    LAYER2    LAYER3   SHOULDER     WATER    GRAVEL     PATCH   CULVERTS
   10.00      36.00    644.00    380.00      0.0     330.00      2.00     15.00     40.00    142.00
CONSTRUCTION PRODUCTIVITIES + COSTS-PROD
SITE PREPARATION
    EASY    NORMAL      HARD     LCOST    EQCOST
     0.0       0.0      0.19    127.20    854.40
EARTHWORK
  BORROW  TRANSPORT     PROD     LCOST    EQCOST
     0.0       0.0    825.00   1057.00   7464.00
PAVEMENT
    PROD    SOURCE  TRANSPORT    LCOST    EQCOST
  348.00       0.0       0.0    495.70   3446.40
  348.00       0.0       0.0    495.70   3446.40
  200.00    300.00       0.0    495.70   3446.40
  348.00       0.0       0.0    495.70   3446.40
DRAINAGE
   NO. OF CULVERTS =        3.00
   SCOST    WEIGHT     TCOST
   67.10     55.00      0.00
  107.41    110.00      0.00
  168.37    160.00      0.00
OTHER COMPONENTS
  %TCOST    %LABOR    %TCOST    %LABOR
     0.0       0.0       0.0       0.0
MAINTENANCE COSTS AND PRODUCTIVITIES-MUC
  BITDIS   DUMPTRK    TRALOR   MOTORGD    ROLLER   TRACTOR    WTRTRK
     0.0       0.0       0.0       0.0       0.0       0.0       0.0
  CLABOR    EQOPER   FOREMAN   TDRIVER   LIQASHP    PATMIX    LCVSEAL
     0.0       0.0       0.0       0.0       0.0       0.0       0.0
 DIESELFUEL GRCOST   GASCOST    WATERC
     0.0       0.0       0.0       0.0
USER COSTS,ECON. AND MARKET- ECONC,MARK
  LABORC    DRIVER   GASCOST    DIESEL
    0.63      0.63      0.14      0.11
    0.84      0.84      0.22      0.16
     INITIAL COST         TIRE COST        VEHICLE COST        CARGO COST
  ECONOM    MARKET    ECONOM    MARKET    ECONOM    MARKET    ECONOM    MARKET
 1610.00   2210.00    144.00    162.00      1.60      3.27      1.00      1.48
 1450.00   2000.00    144.00    162.00      1.55      3.16      2.75      3.06
 2020.00   2780.00    638.00    835.00      2.50      5.20      0.0       0.0
 8400.00  11600.00    345.00   1070.00      1.42      2.93      0.0       0.0
12000.00  15000.00   1100.00   1210.00      1.75      3.55      0.0       0.0
24400.00  33400.00   2800.00   3210.00      2.21      4.42      0.0       0.0
VEHICLE DATA- VEH
 DEWEILLE     VEHWT    WTORWLS   HPSEPWR   DSNSPEED              CHPVEHP   VEHWDTH     VEHHT    AIRCOEFF  FUELTYPE
0.10E 01  0.10E 04  0.40E 03  0.80E 02  0.16E 03              0.13E 01   0.0        0.0      0.17E-02  0.0
0.20E 01  0.27E 04  0.11E 04  0.10E 03  0.15E 03              0.27E 01   0.0        0.0      0.24E-02  0.0
0.30E 01  0.66E 04  0.26E 04  0.14E 03  0.15E 03              0.14E 01   0.0        0.0      0.34E-02  0.0
0.30E 01  0.13E 05  0.54E 04  0.19E 03  0.12E 03              0.11E 01   0.0        0.0      0.34E-02  0.10E 01
0.30E 01  0.14E 05  0.58E 04  0.21E 03  0.12E 03              0.11E 01   0.0        0.0      0.34E-02  0.10E 01
0.50E 01  0.26E 05  0.10E 05  0.24E 03  0.10E 03              0.12E 01   0.0        0.0      0.34E-02  0.10E 01
```

YEAR 4 DISCOUNT FACTOR 0.722 STRATEGY 1

ROUGHNESS INCHES/MILE 400.0 400.0 700.0

VEHICLE 1 TYPE 1. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY

MARKET,ECONOMIC COSTS 30.284 0.560 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.078	0.014	0.004	0.001	0.116	0.158	0.039	0.013	0.424
0.036	0.011	0.003	0.001	0.087	0.107	0.034	0.008	0.289

VEHICLE 2 TYPE 2. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY

MARKET,ECONOMIC COSTS 15.387 2.024 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.129	0.020	0.005	0.001	0.573	0.773	0.033	0.033	1.567
0.069	0.015	0.004	0.001	0.430	0.695	0.029	0.021	1.257

VEHICLE 3 TYPE 3. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY

MARKET,ECONOMIC COSTS 1.697 1.877 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.212	0.026	0.020	0.005	0.297	0.0	0.285	0.077	0.922
0.106	0.019	0.015	0.004	0.223	0.0	0.218	0.049	0.633

VEHICLE 4 TYPE 3. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY

MARKET,ECONOMIC COSTS 15.160 1.664 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.115	0.106	0.054	0.005	0.233	0.0	0.365	0.067	0.978
0.058	0.078	0.061	0.004	0.175	0.0	0.269	0.046	0.710

VEHICLE 5 TYPE 3. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY

MARKET,ECONOMIC COSTS 20.591 1.874 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.145	0.140	[illegible]	0.005	0.233	0.0	0.413	0.069	1.113
0.071	[illegible]	[illegible]	0.004	0.175	0.0	0.376	0.047	0.872

VEHICLE 6 TYPE 5. DEMAND DATA VEHICLES/DAY TARGET COST ELASTICITY

MARKET,ECONOMIC COSTS 0.316 4.845 0.0

VEHICLE	DEPR	PARTS	MAINT	CREW	CARGO	TIRES	FUEL	TOTAL
0.180	0.092	0.086	0.007	0.255	0.0	2.291	0.125	3.011
0.090	0.067	0.044	0.005	0.191	0.0	1.999	0.066	2.482

DETAILED OUTPUT FOR USER COST MODEL BROKEN DOWN BY VEHICLE TYPE PER VEHICLE KILOMETER

LABOR HOURS	0.032	0.112	0.063	0.051	0.051	0.057	0.0
VELOCITY, KPH	47.083	35.250	35.250	35.250	35.250	35.250	0.0
FUEL CONSUMPTION, LITERS	0.060	0.150	0.543	0.420	0.429	0.782	0.0
MARKET COST, DOLLARS	0.424	1.567	0.922	0.978	1.113	3.011	0.0
PARTS COST FACTOR PER 1000 KM	0.189	0.260	0.724	0.724	0.724	0.180	0.0
INC.WILL. TO PAY	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NUMBER OF VEHICLES	30.3	15.4	1.7	15.2	20.6	0.3	0.0

	MAINTENANCE COSTS ($/KM)				OPERATING COSTS ($/KM)			
	THIS PERIOD		SUM TO DATE		THIS PERIOD		SUM TO DATE	
	ACTUAL	DISCOUNTED	ACTUAL	DISCOUNTED	ACTUAL	DISCOUNTED	ACTUAL	DISCOUNTED
LABOR	0.	0.	0.	0.	10968.	7914.	42557.	34851.
EQUIPMENT	0.	0.	0.	0.	4262.	3075.	18069.	14953.
MATERIAL	0.	0.	0.	0.	6191.	4468.	27621.	22983.
INCREMENTAL WILLINGNESS TO PAY					0.	0.	0.	0.
TOTAL	0.	0.	0.	0.	21421.	15457.	88247.	72788.

FOREIGN EXCHANGE COSTS FOR YEAR 4 IN SUCRE ARE

	THIS PERIOD		SUM TO DATE	
	ACTUAL	DISC	ACTUAL	DISC
MAINTENANCE TOTAL	0.0	0.0	0.0	0.0
USER TOTAL	6907.7	4984.4	29036.4	20952.0
GRAND TOTAL	6907.7	4984.4	274655.9	247329.6

SUM OF ALL COSTS TO DATE($/KM) ACTUAL 359541. DISCOUNTED 322329.

TRAFFIC IN YEAR 4 HAS THE FOLLOWING PROPERTIES

VEHICLES /DAY	BASE COSTS/KM	ELASTICITY	GROWTH RATE
30.	0.424	0.0	0.066
15.	1.567	0.0	0.042
2.	0.922	0.0	0.042
15.	0.978	0.0	0.042
21.	1.113	0.0	0.042
0.	3.011	0.0	0.020

Interface Computer Program and Outputs

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FORTRAN IV G LEVEL  20              MAIN              DATE = 71353          17/36/40            PAGE 0001

                C
                C        INTERFACE ROUTINE
                C
0001                   REAL LABFOR,MODE,IDOCKS
0002                   DIMENSION UNLCDR(5,5,7),UPLCDR(5,5,7),HRSNRM(5,5,7),HRSMAX(5,5,7),
                      1LABFOR(5,5,7),CSTPTK(5),NAME(30),CSLSPT(5,2),CSTVLU(5,2),
                      2TURCST(13,3),TINCST(13,3),VESTRU(4),BARVES(4),REFTRU(4),BARREF(4),
                      3MODE14(4),HARATE(5,5,7),FIXDOP(5,5,7),OPCOST(5,5,7),PROBLO(5,5,7),
                      4  MODE(5,5,7),PAYLOD(5,5,7),VOPCST(5,5,7),HRSDAY(5,5,7),
                      5         ADT(5,5,7,2),IDOCKS(5,5,7,2),CSPTWO(13,3),CSPTVC(13,3),
                      6MODE13(4),AVPRMH(5,5,7),WAMUL(5,5,7),STORAG(5,5,7)
0003                   NPORT=4
0004                   IMODE=7
0005                   NCLASS=3
0006                   READ(5,987)(CSTPTK(K),K=1,NCLASS)
0007            987    FORMAT(8F10.2)
0008                   READ(5,550)(NAME(I),I=1,26)
0009            550    FORMAT(20A4)
0010                   READ(5,1)(((UNLCDR(IP,K,M),UPLCDR(IP,K,M),HRSNRM(IP,K,M),
                      1 HRSMAX(IP,K,M),LABFOR(IP,K,M),
                      2               HARATE(IP,K,M),FIXDOP(IP,K,M),OPCOST(IP,K,M),
                      3 WAMUL(IP,K,M),PROBLO(IP,K,M),
                      4               MODE(IP,K,M),PAYLOD(IP,K,M),VOPCST(IP,K,M),
                      5 HRSDAY(IP,K,M),AVPRMH(IP,K,M),
                      6              STORAG(IP,K,M),M=1,IMODE),K=1,NCLASS),IP=1,NPORT)
0011            1      FORMAT(16F5.0)
0012                   WRITE (6,583)(((UNLCDR(IP,K,M),UPLCDR(IP,K,M),HRSNRM(IP,K,M) ,
                      1 HRSMAX(IP,K,M),LABFOR(IP,K,M),
                      2               HARATE(IP,K,M),FIXDOP(IP,K,M),OPCOST(IP,K,M),
                      3 WAMUL(IP,K,M),PROBLO(IP,K,M),
                      4               MODE(IP,K,M),PAYLOD(IP,K,M),VOPCST(IP,K,M),
                      5 HRSDAY(IP,K,M),AVPRMH(IP,K,M),
                      6              STORAG(IP,K,M),M=1,IMODE),K=1,NCLASS),IP=1,NPORT)
0013            583    FORMAT(16F8.2)
0014                   READ(5,2)((((ADT(IP,K,M,L),K=1,NCLASS),L=1,2),M=1,IMODE),
                      1IP=1,NPORT)
0015                    WRITE(6,583)((((ADT(IP,K,M,L),K=1,NCLASS),L=1,2),M=1,IMODE),
                      1IP=1,NPORT)
0016             2     FORMAT(5F8.0)
0017                   READ(5,3)((((IDOCKS(IP,K,M,L),K=1,NCLASS),M=1,IMODE),L=1,2),
                      1 IP=1,NPORT)
0018                    WRITE(6,3)((((IDOCKS(IP,K,M,L),K=1,NCLASS),M=1,IMODE),L=1,2),
                      1IP=1,NPORT)
0019             3     FORMAT(21F3.0)
0020                   DO 1001 IP=1,NPORT
0021                   DO 1002 K=1,NCLASS
0022                   WRITE(6,560)
0023                   DO 1004 L=1,2
0024                   WRITE(6,1332)L
0025            1332   FORMAT(1X,'L=',I5)
0026            560    FORMAT(1H0)
0027                   TONIN=0.
0028                   TONOUT=0.
```

```
FORTRAN IV G LEVEL  20              MAIN              DATE = 71353          17/36/40            PAGE 0002

0029                   DO 1003 M=1,IMODE
0030                   WRITE(6,1331)M
0031            1331   FORMAT(1X,'M=',I5)
0032                   IF(IDOCKS(IP,K,M,L).EQ.0.)GO TO 1000
0033                   IF(ADT(IP,K,M,L).EQ.0.)GO TO 1000
0034                   IF(HRSMAX(IP,K,M).EQ.1.)GO TO 171
0035            171     IF(PROBLO(IP,K,M).EQ.1.)GO TO 1000
0036                   TONIN=ADT(IP,K,M,L)
0037                   VEHOUT=ADT(IP,K,M,L)/PAYLOD(IP,K,M)
0038                   IF(L.EQ.1)BB=UNLCDR(IP,K,M)
0039                   IF(L.EQ.2)BB=UPLCDR(IP,K,M)
0040                   HRSREQ=TONIN/(IDOCKS(IP,K,M,L)*BB)
0041                   IF(HRSREQ.LT.HRSMAX(IP,K,M))GO TO 125
0042                   WRITE(6,1340)HRSREQ
0043            1340   FORMAT(5X,'PRUEBA DE PRUEBA6',8E10.7)
0044                   WRITE(6,650)HRSREQ
0045            650    FORMAT(10X,'HRSREQ GREATER THAN HRSMAX',5X,'HORAS REQUERIDAS=',
                      1F8.2)
0046                   HRSREK=HRSREQ
0047                   HRSREQ=HRSMAX(IP,K,M)
0048                   GO TO 126
0049            125    CONTINUE
0050                   HRSREK=HRSREQ
0051            126    CONTINUE
0052                   ARR=AMAX1(VEHIN,VEHOUT)/HRSDAY(IP,K,M)
0053                   ASR=AMAX1(VEHIN,VEHOUT)/HRSREQ
0054                   IF(ASR.LT.ARR)ASR=1.1*APR
0055                   RO=ARR/(ASP*IDOCKS(IP,K,M,L))
0056                   IF(IDOCKS(IP,K,M,L).GT.1)GO TO 140
0057                   PZERO=1.-RO
0058                   ALENG=RO/(1.-RO)
0059                   DWAIT=ALENG/APP
0060                   GO TO 150
0061            140    CONTINUE
0062                   SUM=0.
0063                   FIDFAC=1.
0064                   ID=IDOCKS(IP,K,M,L)
0065                   DO 162 I=1,ID
0066                   FI=I
0067            162    FIDFAC=FIDFAC*FI
0068                   AB=(APR/ASP)**IDOCKS(IP,K,M,L)/(FIDFAC*(1.-RO))
0069                   AC=0.
0070                   IIIE = IDOCKS(IP,K,M,L)
0071                   DO 160 N = 1, IIIE
0072                   FNFAC=1.
0073                   IF(N.EQ.1)GO TO 800
0074                   IP=N-1
0075                   DO 801 J=1,IP
0076                   FJ=J
0077            801    FNFAC=FNFAC*FJ
0078                   GO TO 803
0079            800    FNFAC=1.
0080            803    CONTINUE
```

FORTRAN IV G LEVEL 20 MAIN DATE = 71353 17/36/40 PAGE 0003

```
 160    AC=(ARP/ASP)**(N-1)/(FNFAC+AC)
        PZERO=1./(AC+AP)
        ALENG=RO*(IDOCKS(IP,K,M,L)*RO)**IDOCKS(IP,K,M,L)/FIDFAC*(1.-RO)**2)PZERO
        DWAIT=ALENG/APP
 150    CONTINUE
C
C       LOADING AND UNLOADING TIME , INTERFACE OPERATION COSTS PR COMMODITY CLASS
C
        HRSOVR=HRSREQ-HRSNRM(IP,K,M)
        HRSNOP=HRSREQ
        IF(HRSOVR.LE.0.)HRSOVR=0.
        IF(HRSOVR.GT.0.)HRSNOP=HRSNRM(IP,K,M)
        CSPRDY=IDOCKS(IP,K,M,L)*(FIXDOP(IP,K,M)+HRSNOP*OPCOST(IP,K,M)+
       1HRSOVR*WAMUL(IP,K,M)*
       1          WARATE(IP,K,M)*LABFCP(IP,K,M)+HRSOVR*OPCOST(IP,K,M))
        COSTPT=CSPRDY/ADT(IP,K,M,L)
C
C       QUEUE TIME WAITING COST PER TON
C
        CSPTWO(M,L)=DWAIT*VOPCST(IP,K,M)/PAYLOD(IP,K,M)
C
C       COST OF LOSSES PER TON
C
        CSLSPT(M,L)=CSTPTK(K)*PROBLO(IP,K,M)*(1-AVPRMH(IP,K,M))*.1
C
C       COST OF VEHICLE TIME WHILE WAITING FOR LOADING AND /OR UNLOADING OPERAT.
C                                        -PER TON -
C
        CSTVLU(M,L)=PAYLOD(IP,K,M)*VOPCST(IP,K,M)/88
        CSPTVO(M,L)=CSTVLU(M,L)/PAYLOD(IP,K,M)
C
C       TURNAROUND VEHICLE COST PER TON   -VEHICLE TIME IN PORT-
C
        TURCST(M,L)=CSPTVO(M,L)+CSPTWO(M,L)
C
C       INTERFACE COST OPERATION PER TON ,AT INBOUND (L=1) OR OUTBOUND (L=2) NODE
C
        TINCST(M,L)=COSTPT+CSLSPT(M,L)+TURCST(M,L)
        IF(STORAG(IP,K,M).EQ.0.)GO TO 30
        TINCST(M,L)=TINCST(M,L)*(1-STORAG(IP,K,M)/50000.0)
 30     CONTINUE
         GO TO 1005
  1000 CONTINUE
        HRSREQ=0.
        CSPTWO(M,L)=0.
        CSPTVO(M,L)=0.
        TURCST(M,L)=0.
        TINCST(M,L)=0.
 1005    CONTINUE
 1003   CONTINUE
 1004   CONTINUE
        DO 500 M=1,IMODE
        CSPTWO(M,3)=CSPTWO(M,1)+CSPTWO(M,2)
```

FORTRAN IV G LEVEL 20 MAIN DATE = 71353 17/36/40 PAGE 0004

```
        CSPTVO(M,3)=CSPTVO(M,1)+CSPTVO(M,2)
         TURCST(M,3)=TURCST(M,1)+TURCST(M,2)
 500     TINCST(M,3)=TINCST(M,1)+TINCST(M,2)
        VESTPU(1)=CSPTWO(2,3)+CSPTWO(3,3)
        VESTPU(2)=CSPTVO(2,3)+CSPTVO(3,3)
        VESTPU(3)=TURCST(2,3)+TURCST(3,3)
        VESTPU(4)=TINCST(2,3)+TINCST(3,3)
        BARVES(1)=CSPTWO(2,3)+CSPTWO(4,3)
        BARVES(2)=CSPTVO(2,3)+CSPTVO(4,3)
        BARVES(3)=TURCST(2,3)+ TURCST(4,3)
          BARVES (4)=TINCST(2,3)+TINCST(4,3)
        REFTPU(1)=CSPTWO(1,3)+CSPTWO(3,3)
        REFTPU(2)=CSPTVO(1,3)+CSPTVO(3,3)
        REFTPU(3)=TURCST(1,3)+TURCST(3,3)
        REFTPU(4)=TINCST(1,3)+TINCST(3,3)
        BARREF (1)=CSPTWO(1,3)+CSPTWO(4,3)
        BARREF(2)=CSPTVO(1,3)+CSPTVO(4,3)
        BARREF(3)=TURCST(1,3)+TURCST(4,3)
        BARREF(4)=TINCST(1,3)+TINCST(4,3)
        MODE13(1)=CSPTWO(5,3)+CSPTWO(7,3)
        MODE13(2)=CSPTVO(5,3)+CSPTVO(7,3)
        MODE13(3)=TURCST(5,3)+ TURCST(7,3)
        MODE13(4)=TINCST(5,3)+TINCST(7,3)
        MODE14(1)=CSPTWO(6,3)+CSPTWO(7,3)
        MODE14(2)=CSPTVO(6,3)+CSPTVO(7,3)
        MODE14(3)= TURCST(6,3) + TURCST(7,3)
        MODE14(4)= TINCST(6,3) + TINCST(7,3)
        GO TO(502,504,506,508),IP
   502 WRITE(6,503)
   503 FORMAT(32X,'GUAYAQUIL PORT',//)
        GO TO 510
   504 WRITE(6,505)
   505 FORMAT(32X,'BOLIVAR PORT',//)
        GO TO 510
   506 WRITE(6,507)
   507 FORMAT(32X,'MANTA PORT',//)
        GO TO 510
   508 WRITE(6,509)
   509 FORMAT(32X,'ESMERALDAS PORT',//)
   510 CONTINUE
        GO TO (511,513,515), K
   511 WRITE(6,512)
   512 FORMAT(32X,'INTERFACE COST OPERATION PER TON-BANANAS-',//)
        GO TO 517
   513 WRITE(6,514)
   514 FORMAT(32X,'INTERFACE COST OPERATION PER TON-COFFE AND COCOA-',
       1//)
        GO TO 517
 515    WRITE(6,516)
 516    FORMAT(32X,'INTERFACE COST OPERATIONPERTON -IMPORTED LIGHT MACHINE
       1RY-',//)
 517     CONTINUE
        WRITE(6,518)
```

```
      518  FORMAT(40X,'CSPTWO',13X,'CSPTVO',13X,'TURCST',13X,'TINCST',/)
           WRITE(6,520)
      520  FORMAT(32X,4(3X,'IN',5X,'OUT',5X,'SUM',3X),/)
           DO 526 M=1,IMODE
           M2=M*2
           M3=M2-1
           WRITE(6,525)NAME(M3),NAME(M2),(CSPTWO(M,L),L=1,3),(CSPTVO(M,L),
          1L=1,3),(TURCST(M,L),
          1           L=1,3),(TINCST(M,L),L=1,3)
      525  FORMAT(18X,2A4,4X,12(F7.2,1X))
      526   CONTINUE
           WRITE(6,527)NAME(15),NAME (16),(VESTPU(I),I=1,4)
      527  FORMAT(18X,2A4,4X,4(16X,F7.2,1X))
           WRITE(6,528)NAME(17),NAME(18),(PARVES(I),I=1,4)
      528  FORMAT(18X,2A4,4X,4(16X,F7.2,1X))
           WRITE(6,529)NAME(19),NAME(20),(REFTRU(I),I=1,4)
      529  FORMAT(18X,2A4,4X,4(16X,F7.2,1X))
           WRITE(6,530)NAME(21),NAME(22),(PARREF(I),I=1,4)
      530  FORMAT(18X,2A4,4X,4(16X,F7.2,1X))
           WRITE(6,531)NAME(23),NAME(24),(MODE13(I),I=1,4)
      531  FORMAT(18X,2A4,4X,4(16X,I7,1X))
           WRITE(6,532)NAME(25),NAME(26),(MODE14(I),I=1,4)
      532  FORMAT(18X,2A4,4X,4(16X,I7,1X))
     1002   CONTINUE
     1001  CONTINUE
           CALL EXIT
           END
```

PRUEBA DE PRUEBA6**********
HRSREQ GREATER THAN HRSMAX HORAS REQUERIDAS= 24.00
M= 2
M= 3
M= 4
M= 5
M= 6
M= 7

BOLIVAR PORT

INTERFACE COST OPERATION PER TON-BANANAS-

	CSPTWO			CSPTVO			TURCST			TINCST		
	IN	OUT	SUM	IN	OUT	SUM	IN	OUT	SUM	IN	OUT	SUM
VES-REF.	0.0	0.00	0.00	0.0	3.33	3.33	0.0	3.34	3.34	0.0	5.93	5.93
VES-LIN.	0.0	0.12	0.12	0.0	3.85	3.85	342.86	3.97	346.82	0.0	6.54	6.54
TRUK-3.3	0.00	0.0	0.00	0.15	0.0	0.15	0.15	0.0	0.15	1.40	0.0	1.40
BARGE150	0.00	0.0	0.00	0.07	0.0	0.07	0.08	0.0	0.08	1.84	0.0	1.84
REEFIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VESSIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BARG-CNT	0.0	0.01	0.01	0.0	0.29	0.29	0.0	0.29	0.29	0.0	1.06	1.06
VESTRUK			0.12			3.99			346.97			7.95
BARG-VES			0.12			3.92			346.90			8.39
REF-TRUK			0.01			3.48			3.49			7.33
BARG-REF			0.01			3.41			3.42			7.77
MODE13			0			0			0			1
MODE14			0			0			0			1

L= 1
M= 1
M= 2
M= 3
PRUEBA DE PRUEBA6**********
HRSREQ GREATER THAN HRSMAX HORAS REQUERIDAS= 24.00
M= 4
PRUEBA DE PRUEBA6**********
HRSREQ GREATER THAN HRSMAX HORAS REQUERIDAS= 24.00
M= 5
M= 6
M= 7
L= 2
M= 1
M= 2
M= 3
M= 4
M= 5
M= 6
M= 7

BOLIVAR PORT

INTERFACE COST OPERATION PER TON-COFFE AND COCCA-

	CSPTWO			CSPTVO			TURCST			TINCST		
	IN	OUT	SUM	IN	OUT	SUM	IN	OUT	SUM	IN	OUT	SUM
VES-REF.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VES-LIN.	0.0	0.12	0.12	0.0	3.85	3.85	342.86	3.97	346.82	0.0	6.65	6.65
TRUK-3.3	0.00	0.0	0.00	0.15	0.0	0.15	0.15	0.0	0.15	1.63	0.0	1.63
BARGE150	0.00	0.0	0.00	0.07	0.0	0.07	0.08	0.0	0.09	2.10	0.0	2.10
REEFIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VESSIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BARG-CNT	0.0	0.01	0.01	0.0	0.29	0.29	0.0	0.29	0.29	0.0	1.12	1.12
VESTRUK			0.12			3.99			346.97			8.28
BARG-VES			0.12			3.92			346.90			8.74
REF-TRUK			0.00			0.15			0.15			1.63
BARG-REF			0.00			0.07			0.08			2.10
MODE13			0			0			0			1
MODE14			0			0			0			1

L= 3
M= 1
M= 2
M= 3
M= 4
M= 5
M= 6
M= 7
L= 4
M= 1
M= 2
M= 3
PRUEBA DE PRUEBA6**********
HRSREQ GREATER THAN HRSMAX HORAS REQUERIDAS= 24.00
M= 4
PRUEBA DE PRUEBA6**********
HRSREQ GREATER THAN HRSMAX HORAS REQUERIDAS= 24.00
M= 5
M= 6
M= 7

BOLIVAR PORT

INTERFACE COST OPERATIONPERTON -IMPORTED LIGHT MACHINERY-

	CSPTWO			CSPTVO			TURCST			TINCST		
	IN	OUT	SUM	IN	OUT	SUM	IN	OUT	SUM	IN	OUT	SUM
VES-REF.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VES-LIN.	0.12	0.0	0.12	3.85	0.0	3.85	3.97	0.0	3.97	8.34	0.0	8.34
TRUK-3.3	0.0	0.00	0.00	0.0	0.15	0.15	0.0	0.15	0.15	0.0	3.05	3.05
BARGE150	0.0	0.00	0.00	0.0	0.07	0.07	0.0	0.08	0.08	0.0	3.80	3.80
REEFIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VESSIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BARG-CNT	0.01	0.0	0.01	0.29	0.0	0.29	0.29	0.0	0.29	1.60	0.0	1.60
VESTRUK			0.12			3.99			4.11			11.30
BARG-VES			0.12			3.92			4.04			12.14
REF-TRUK			0.00			0.15			0.15			3.05
BARG-REF			0.00			0.07			0.09			3.80
MODE13			0			0			0			1
MODE14			0			0			0			1

L= 5
M= 1
M= 2
M= 3
PRUEBA DE PRUEBA6**********
HRSREQ GREATER THAN HRSMAX HORAS REQUERIDAS= 24.00
M= 4
PRUEBA DE PRUEBA6**********
HRSREQ GREATER THAN HRSMAX HORAS REQUERIDAS= 24.00

OUTPUT FROM THE NETWORK PROGRAM

```
C       ORIGEN : SANTO DOMINGO
C          HINTERLAND CONFIGURATION UNDER ENVIRONMENT CONDITION =NUMBER 2
C       HIGHWAY NETWORK FOR THE YEAR 1973
C       COASTAL BARGE SYSTEM
SAVE
        KORBABBABAYO 1       27      720       0      0
        KORBABKORMAN 1       15      720       0      0
        KORBABKORGUA 1        3      720       0      0
        KORBABKORDAU 1        4      720       0      0
        KORBABKORBOL 1        7      720       0      0
        KORBABKORSME 1       31      720       0      0
        KORBOLBOLIVA 1       27     1440       0      0
        KORBOLKORSME 1       26      720       0      0
        KORBOLKORMAN 1       14      720       0      0
        KORBOLKORGUA 1        4      720       0      0
        KORBOLKORDAU 1        5      720       0      0
        KORBOLKORBAB 1        7      720       0      0
        KORDAUDAULE  1       27     1440       0      0
        KORDAUKORSME 1       31      720       0      0
        KORDAUKORMAN 1       19      720       0      0
        KORDAUKORGUA 1        2      720       0      0
        KORDAUKORBAB 1        4      720       0      0
        KORDAUKORBOL 1        5      720       0      0
        KORSMEESMERA 1       27      720       0      0
        KORSMEKORMAN 1       13      720       0      0
        KORSMEKORGUA 1       28      720       0      0
        KORSMEKORBOL 1       26      720       0      0
        KORSMEKORDAU 1       31      720       0      0
        KORSMEKORBAB 1       31      720       0      0
        KORGUAGUAYAQ 1       28     2820       0      0
        KORGUAPORGUA 1       60     2820       0      0
        KORGUAKORSME 1       28      720       0      0
        KORGUAKORMAN 1       17      720       0      0
        KORGUAKORDAU 1        2      720       0      0
        KORGUAKORBAB 1        3      720       0      0
        KORGUAKORBOL 1        4      720       0      0
        KORMANMANTA  1       27     2820       0      0
        KORMANPORMAN 1       53     2820       0      0
        KORMANKORSME 1       13      720       0      0
        KORMANKORGUA 1       17      720       0      0
        KORMANKORDAU 1       19      720       0      0
        KORMANKORBAB 1       15      720       0      0
        KORMANKORBOL 1       14      720       0      0
        PORGUAKORGUA 1       72     2820       0      0
        PORMANKORMAN 1       68     2820       0      0
        BOLIVAKORBOL 1       26     1440       0      0
        BABAYOKORBAB 1       27      720       0      0
        DAULE KORDAU 1       27      720       0      0
        GUAYAQKORGUA 1       28     2820       0      0
        ESMERAKORSME 1       27      720       0      0
        MANTA KORMAN 1       27     2820       0      0
        UKNEURSDOMIN 1        0     1500    1500      0
SOLVE
NO OF ARCS#  341 NO OF NODES#   89
```

C COASTAL BARGE SYSTEM

ARCS		COST	UPPER	LOWER	FLOW	CBAR	
AZOGES	CUENCA	40	205	0	0	27	K
AZOGES	ELGUN	43	1105	0	0	86	K
AZOGES	UKNEUR	1000000000	0	0	0	999999864	K
AMBATO	PUYO	144	960	0	0	0	K
AMBATO	LATACU	16	2670	0	0	32	K
AMBATO	RBAMBA	25	2670	0	0	0	K
AMBATO	GUARAN	104	205	0	0	42	K
APUELA	UTAVAL	30	1210	0	0	40	K
APUELA	MORENO	41	290	0	0	0	K
ARNLLA	PASAJE	52	205	0	0	104	K
ALFAR	PALMAR	21	2222	0	0	42	K
ALFAR	CHONE	22	2220	0	0	0	K
AGUARI	LAGRIO	50	205	0	0	0	K
BABAYO	DURAN	15	5320	0	0	0	K
BABAYO	GUARAN	75	1105	0	0	0	K
BABAYO	CATRA	11	5320	0	0	22	K
BABAYO	KORBAB	27	720	0	720	-1	K
BABAYO	ZAPOTL	22	5320	0	0	44	K
BABAYO	WORBAB	24	960	0	0	0	K
BAEZA	TENA	84	205	0	0	0	K
BAEZA	AGUARI	104	205	0	0	0	K
BAEZA	PAPALL	39	205	0	0	78	K
BALZAR	QUEVED	15	5320	0	0	30	K
BALZAR	PALSTI	14	2220	0	60	0	K
BOLIVA	PINAS	124	205	0	0	0	K
BOLIVA	PASAJE	13	1105	0	0	0	K
BOLIVA	PORBOL	97	2304	0	0	50	K
BOLIVA	WORBOL	35	960	0	0	70	K
BOLIVA	KORBOL	26	1440	0	0	46	K
BAHIAC	CHONE	24	2220	0	0	48	K
CAYAPA	SLOREN	100000000	0	0	0	99999781	K
CAYAPA	QUININ	100000000	0	0	0	100000095	K
CAYAPA	VICHE	57	445	0	0	140	K
CAYAPA	VICHE	83	110	0	0	166	K
CATRA	BABAYO	11	5320	0	0	0	K
CATRA	ZAPOTL	11	5320	0	0	22	K
CATRA	WORCAT	25	960	0	0	0	K
CAYAMB	UKNEUR	1000000000	0	0	0	999999731	K
CAYAMB	OTAVAL	16	1105	0	0	0	K
CAYAMB	QUITO	29	2670	0	0	58	K
CAYAMB	IBARRA	29	2670	0	0	0	K
CHILCA	RBAMBA	102	1105	0	0	93	K
CHILCA	ELGUN	52	1105	0	0	0	K
CHILCA	DURAN	14	5320	0	0	28	K
CHILCA	NARANJ	51	4000	0	0	0	K
CHINCH	PINAS	124	235	0	0	217	K
CHINCH	UKNEUR	1000000000	0	0	0	1000000011	K
CHINCH	MACARA	20	205	0	0	20	K
CHINCH	LOJA	41	1105	0	0	41	K
CHONE	SISIDR	75	110	0	0	0	K

C COASTAL BARGE SYSTEM

ARCS		COST	UPPER	LOWER	FLOW	CBAR	
CHUNE	ALFAR	22	2220	0	0	44	K
CHUNE	BAHIAC	24	2220	0	0	0	K
CHUNE	PTVIEJ	17	5320	0	0	2	K
CUENCA	SISABL	30	1105	0	0	60	K
CUENCA	AZUGES	40	205	0	0	53	K
CUENCA	LOJA	250	300	0	0	116	K
DAULE	NOBOL	3	5320	0	0	0	K
DAULE	PALSTI	7	5320	0	0	14	K
DAULE	KORDAU	27	720	0	60	0	K
DAULE	WORDAU	24	960	0	0	0	K
DURAN	CHILCA	14	5320	0	0	0	K
DURAN	BABAYO	15	5320	0	0	30	K
DURAN	GUAYAQ	3	5320	0	0	2	K
DURAN	MILAGR	11	2500	0	0	0	K
DURAN	WORDUR	23	960	0	0	20	K
ELGUN	CHILCA	52	1105	0	0	104	K
ELGUN	RBAMBA	73	1105	0	0	116	K
ELGUN	AZOGES	43	205	0	0	0	K
ESMERA	QUININ	22	5320	0	0	45	K
ESMERA	VICHE	11	5320	0	0	22	K
ESMERA	LA'Y'	155	110	0	0	103	K
ESMERA	PURSME	134	960	0	0	8	K
ESMERA	WORSME	25	960	0	0	8	K
ESMERA	KORSME	27	720	0	720	-18	K
GUAYAQ	NOBOL	11	5320	0	0	22	K
GUAYAQ	DURAN	3	5320	0	0	4	K
GUAYAQ	PROGRE	16	5320	0	0	0	K
GUAYAQ	PURGUA	86	4032	0	0	11	K
GUAYAQ	WORGUA	37	1920	0	0	36	K
GUAYAQ	KORGUA	28	2820	0	0	13	K
GUARAN	BABAYO	75	1105	0	0	150	K
GUARAN	AMBATO	104	205	0	0	166	K
GUARAN	RBAMBA	67	205	0	0	104	K
IBARRA	OTAVAL	16	1105	0	0	29	K
IBARRA	TULCAN	31	2670	0	0	0	K
IBARRA	CAYAMB	29	2670	0	0	58	K
JIPIPA	NOBOL	32	5320	0	0	53	K
JIPIPA	MANTA	13	5320	0	0	26	K
KORBAB	BABAYO	27	720	0	0	55	K
KORBAB	KORMAN	15	720	0	0	5	K
KORBAB	KORGUA	3	720	0	720	0	K
KORBAB	KORDAU	4	720	0	0	3	K
KORBAB	KORBOL	7	720	0	0	1	K
KORBAB	KORSME	31	720	0	0	34	K
KORBOL	BOLIVA	27	1440	0	0	7	K
KORBOL	KORSME	26	720	0	0	35	K
KORBOL	KORMAN	14	720	0	0	10	K
KORBOL	KORGUA	4	720	0	0	7	K
KORBOL	KORDAU	5	720	0	0	10	K
KORBOL	KORBAB	7	720	0	0	13	K

C COASTAL BARGE SYSTEM

ARCS		COST	UPPER	LOWER	FLOW	CBAR	
KORDAU	DAULE	27	1440	0	0	54	K
KORDAU	KORSME	31	720	0	0	35	K
KORDAU	KORMAN	19	720	0	0	10	K
KORDAU	KORGUA	2	720	0	60	0	K
KORDAU	KORBAB	4	720	0	0	5	K
KORDAU	KORBOL	5	720	0	0	0	K
KORSME	ESMERA	27	720	0	0	72	K
KORSME	KORMAN	13	720	0	720	0	K
KORSME	KORGUA	28	720	0	0	22	K
KORSME	KORBOL	26	720	0	0	17	K
KORSME	KORDAU	31	720	0	0	27	K
KORSME	KORBAB	31	720	0	0	28	K
KORGUA	KORSME	28	720	0	0	34	K
KORGUA	KORMAN	17	720	0	0	10	K
KORGUA	KORDAU	2	720	0	0	4	K
KORGUA	KORBAB	3	720	0	0	6	K
KORGUA	KORBOL	4	720	0	0	1	K
KORGUA	GUAYAQ	28	2820	0	0	43	K
KORGUA	PORGUA	60	2820	0	780	0	K
KORMAN	MANTA	27	2820	0	0	52	K
KORMAN	PORMAN	53	2820	0	720	0	K
KORMAN	KORSME	13	720	0	0	26	K
KORMAN	KORGUA	17	720	0	0	24	K
KORMAN	KORDAU	19	720	0	0	28	K
KORMAN	KORBAB	15	720	0	0	25	K
KORMAN	KORBOL	14	720	0	0	18	K
LATACU	QUEVED	57	4000	0	0	88	K
LATACU	AMBATO	16	2670	0	0	0	K
LATACU	MCHCHI	21	2670	0	0	42	K
LATACU	UKNEUR	1000000000	0	0	0	999999737	K
LA'Y'	ESMERA	155	110	0	0	207	K
LA'Y'	QUININ	75	110	0	0	150	K
LA'Y'	SISIDR	80	110	0	0	49	K
LAGRIO	AGUARI	50	205	0	0	100	K
LOJA	CUENCA	250	300	0	0	384	K
LOJA	CHINCH	41	1105	0	0	41	K
MANTA	JIPIPA	13	5320	0	0	0	K
MANTA	MCRIST	3	5340	0	0	0	K
MANTA	PIVIEJ	10	5320	0	0	20	K
MANTA	PORMAN	89	3456	0	0	11	K
MANTA	KORMAN	27	2820	0	0	2	K
MACARA	CHINCH	20	205	0	0	20	K
MCRIST	MANTA	3	5340	0	0	6	K
MCHCHI	LATACU	21	2670	0	0	0	K
MCHCHI	QUITO	14	2670	0	0	28	K
MCHCHI	SDOMIN	70	1105	0	0	125	K
MILAGR	DURAN	11	2500	0	0	22	K
MORENO	APUELA	41	290	0	0	82	K
MORENO	QUININ	100000000	0	0	0	100000121	K
NARANJ	CHILCA	51	4000	0	0	102	K

C COASTAL BARGE SYSTEM

ARCS		COST	UPPER	LOWER	FLOW	CBAR	
NARANJ	PASAJE	14	5320	0	0	27	K
NOBOL	JIPIPA	32	5320	0	0	11	K
NOBOL	GUAYAQ	11	5320	0	0	0	K
NOBOL	DAULE	3	5320	0	0	6	K
NOBOL	WORNOB	25	960	0	0	4	K
OTAVAL	APUELA	30	1210	0	0	0	K
OTAVAL	IBARRA	16	1105	0	0	3	K
OTAVAL	CAYAMB	16	1105	0	0	32	K
PORSME	ESMERA	190	960	0	0	316	K
PORSME	WORSME	109	960	0	0	218	K
PORSME	ATLUSA	84	1300	0	0	15	K
PORSME	GULFUS	66	1300	0	0	15	K
PORSME	PACUSA	57	1300	0	0	15	K
PORSME	UKNEUR	169	900	0	0	15	K
PORSME	GENOA	176	1100	0	0	15	K
PORSME	FAREST	215	750	0	0	50	K
PORBOL	BOLIVA	113	2304	0	0	160	K
PORBOL	WORBOL	120	960	0	0	202	K
PORBOL	ATLUSA	84	1300	0	0	10	K
PORBOL	GULFUS	66	1300	0	0	10	K
PORBOL	PACUSA	57	1300	0	0	10	K
PORBOL	UKNEUR	169	2800	0	0	10	K
PORBOL	GENOA	176	1100	0	0	10	K
PORBOL	FAREST	215	750	0	0	45	K
PORMAN	MANTA	101	3456	0	0	179	K
PORMAN	KORMAN	68	2820	0	0	121	K
PORMAN	ATLUSA	84	1300	0	0	0	K
PORMAN	GULFUS	66	1300	0	0	0	K
PORMAN	PACUSA	57	1300	0	0	0	K
PORMAN	UKNEUR	169	5200	0	720	0	K
PORMAN	GENOA	176	1100	0	0	0	K
PORMAN	FAREST	215	750	0	0	35	K
PORGUA	GUAYAQ	91	4032	0	0	166	K
PORGUA	WORGUA	99	1920	0	0	173	K
PORGUA	KORGUA	72	2820	0	0	132	K
PORGUA	ATLUSA	84	1300	0	0	0	K
PORGUA	GULFUS	66	1300	0	0	0	K
PORGUA	PACUSA	57	1300	0	0	0	K
PORGUA	UKNEUR	169	7000	0	780	0	K
PORGUA	GENOA	176	1100	0	0	0	K
PORGUA	FAREST	215	750	0	0	35	K
FAREST	PORGUA	215	750	0	0	395	K
FAREST	PORMAN	215	750	0	0	395	K
FAREST	PORBOL	215	750	0	0	385	K
FAREST	PORSME	215	750	0	0	380	K
GENOA	PORGUA	176	1100	0	0	352	K
GENOA	PORMAN	176	1100	0	0	352	K
GENOA	PORBOL	176	1100	0	0	342	K
GENOA	PORSME	176	1100	0	0	337	K
ATLUSA	PORGUA	84	1300	0	0	168	K

C COASTAL BARGE SYSTEM

ARCS		COST	UPPER	LOWER	FLOW	CBAR	
ATLUSA	PORMAN	84	1300	0	0	168	K
ATLUSA	PORBOL	84	1300	0	0	158	K
ATLUSA	PORSME	84	1300	0	0	153	K
UKNEUR	LATACU	1000000000	0	0	0	1000000263	K
UKNEUR	QUEVED	1000000000	0	0	0	1000000294	K
UKNEUR	ZAPOTL	1000000000	0	0	0	1000000282	K
UKNEUR	ELGUN	1000000000	0	0	0	1000000179	K
UKNEUR	RBAMBA	1000000000	0	0	0	1000000222	K
UKNEUR	TULCAN	1000000000	0	0	0	1000000209	K
UKNEUR	APUELA	100000000	0	0	0	100000223	K
UKNEUR	MACARA	1000000000	0	0	0	999999989	K
UKNEUR	PALMAR	100000000	0	0	0	100000315	K
UKNEUR	SDOMIN	0	0	1500	1500	339	N
UKNEUR	SLOREN	1000000000	0	0	0	999999989	K
UKNEUR	LA'Y'	1000000000	0	0	0	1000000228	K
UKNEUR	NARANJ	1000000000	0	0	0	1000000180	K
UKNEUR	TENA	1000000000	0	0	0	1000000110	K
UKNEUR	AZOGES	1000000000	0	0	0	1000000136	K
UKNEUR	ALFAR	1000000000	0	0	0	1000000294	K
UKNEUR	PORGUA	169	1100	0	0	338	K
UKNEUR	PORMAN	169	1100	0	0	338	K
UKNEUR	PORBOL	169	1100	0	0	328	K
UKNEUR	PORSME	169	1100	0	0	323	K
PACUSA	PORGUA	57	1300	0	0	114	K
PACUSA	PORBOL	57	1300	0	0	104	K
PACUSA	PORSME	57	1300	0	0	99	K
PACUSA	PORMAN	57	1300	0	0	114	K
GULFUS	PORGUA	66	1300	0	0	132	K
GULFUS	PORMAN	66	1300	0	0	132	K
GULFUS	PORBOL	66	1300	0	0	122	K
GULFUS	PORSME	66	1300	0	0	117	K
PASAJE	BOLIVA	13	1105	0	0	26	K
PASAJE	SISABL	40	4000	0	0	0	K
PASAJE	NARANJ	14	5320	0	0	1	K
PASAJE	ARNLLA	52	205	0	0	0	K
PALSTI	VINCES	19	1105	0	0	0	K
PALSTI	BALZAR	9	5320	0	0	23	K
PALSTI	DAULE	7	5320	0	60	0	K
PALSTI	WORPAL	25	960	0	0	0	K
PALMAR	SDOMIN	24	2220	0	0	48	K
PALMAR	ALFAR	21	2222	0	0	0	K
PAPALL	QUITO	35	1105	0	0	100	K
PAPALL	BAEZA	39	205	0	0	0	K
PROGRE	SALINA	19	5320	0	0	0	K
PROGRE	GUAYAQ	16	5320	0	0	32	K
PINAS	CHINCH	124	235	0	0	31	K
PINAS	BOLIVA	124	205	0	0	248	K
PTVIEJ	CHONE	17	5320	0	0	32	K
PTVIEJ	QUEVED	37	5320	0	0	74	K
PTVIEJ	MANTA	10	5320	0	0	0	K

C COASTAL BARGE SYSTEM

ARCS		COST	UPPER	LOWER	FLOW	CBAR	
PUYO	AMBATO	144	205	0	0	288	K
PUYO	TENA	65	204	0	0	72	K
PUYO	UKNEUR	1000000000	0	0	0	999999897	K
QUEVED	SDOMIN	45	2220	0	0	90	K
QUEVED	ZAPOTL	12	5320	0	720	0	K
QUEVED	BALZAR	15	5320	0	60	0	K
QUEVED	PTVIEJ	37	5320	0	0	0	K
QUEVED	LATACU	57	4000	0	0	26	K
QUININ	VICHE	12	5320	0	720	0	K
QUININ	LA'Y'	75	110	0	0	0	K
QUININ	CAYAPA	100000000	0	0	0	99999905	K
QUININ	SDOMIN	36	2220	0	0	72	K
QUININ	MORENO	100000000	0	0	0	99999879	K
QUITO	CAYAMB	29	5320	0	0	0	K
QUITO	MCHCHI	14	2670	0	0	0	K
QUITO	SDOMIN	41	4000	0	0	82	K
QUITO	PAPALL	65	204	0	0	0	K
QUITO	UKNEUR	1000000000	0	0	0	999999702	K
RBAMBA	CHILCA	102	1105	0	0	111	K
RBAMBA	AMBATO	25	2670	0	0	50	K
RBAMBA	ELGUN	73	1105	0	0	30	K
RBAMBA	GUARAN	37	2670	0	0	0	K
RBAMBA	UKNEUR	1000000000	0	0	0	999999778	K
SLOREN	CAYAPA	100000000	0	0	0	100000219	K
SDOMIN	PALMAR	24	2220	0	0	0	K
SDOMIN	MCHCHI	70	1105	0	0	15	K
SDOMIN	QUEVED	45	2220	0	780	0	K
SDOMIN	QUITO	41	4000	0	0	0	K
SDOMIN	QUININ	36	2220	0	720	0	K
SDOMIN	UKNEUR	1000000000	0	0	0	999999661	K
SISABL	CUENCA	30	1105	0	0	0	K
SISABL	PASAJE	74	1210	0	0	114	K
SISIDR	CHONE	75	110	0	0	150	K
SISIDR	LA'Y'	80	110	0	0	111	K
SALINA	PROGRE	19	5320	0	0	38	K
TENA	PUYO	65	204	0	0	58	K
TENA	BAEZA	84	205	0	0	168	K
TULCAN	IBARRA	31	2670	0	0	62	K
VICHE	CAYAPA	83	110	0	0	0	K
VICHE	QUININ	12	5320	0	0	24	K
VICHE	ESMERA	11	5320	0	720	0	K
VICHE	WORVIC	25	30	0	0	0	K
VINCES	WORVIN	25	400	0	0	0	K
VINCES	PALSTI	12	2670	0	0	31	K
WORSME	PORSME	109	960	0	0	0	K
WORSME	ESMERA	25	960	0	0	42	K
WORSME	WORVIC	3	480	0	0	6	K
WORNOB	NOBOL	25	960	0	0	46	K
WORNOB	WORGUA	9	120	0	0	18	K
WORNOB	WORBOL	19	120	0	0	26	K

C COASTAL BARGE SYSTEM

ARCS		COST	UPPER	LOWER	FLOW	CBAR	
WORBAB	BABAYO	24	960	0	0	48	K
WORBAB	WORGUA	10	480	0	0	17	K
WORDAU	DAULE	24	960	0	0	48	K
WORDAU	WORGUA	10	480	0	0	19	K
WORDUR	DURAN	23	960	0	0	26	K
WORDUR	WORBOL	1	120	0	0	0	K
WORDUR	WORGUA	1	480	0	0	2	K
WORZAP	ZAPOTL	25	960	0	0	50	K
WORZAP	WORBOL	30	120	0	0	14	K
WORZAP	WORGUA	14	120	0	0	0	K
WORVIC	VICHE	25	30	0	0	50	K
WORVIC	WORSME	3	480	0	0	0	K
WORCAT	WORBOL	25	120	0	0	20	K
WORCAT	CATRA	25	960	0	0	50	K
WORCAT	WORGUA	14	120	0	0	11	K
WORPAL	PALSTI	25	960	0	0	50	K
WORPAL	WORBOL	24	120	0	0	25	K
WORPAL	WORGUA	14	120	0	0	17	K
WORBOL	PORBOL	82	960	0	0	0	K
WORBOL	BOLIVA	35	960	0	0	0	K
WORBOL	WORDUR	1	120	0	0	2	K
WORBOL	WORNOB	19	120	0	0	12	K
WORBOL	WORPAL	24	120	0	0	23	K
WORBOL	WORZAP	30	120	0	0	46	K
WORBOL	WORCAT	25	120	0	0	30	K
WORBOL	WORGUA	14	480	0	0	16	K
WORGUA	PORGUA	78	1920	0	0	4	K
WORGUA	GUAYAQ	37	1920	0	0	38	K
WORGUA	WORBAB	10	480	0	0	3	K
WORGUA	WORDUR	1	480	0	0	0	K
WORGUA	WORBOL	14	480	0	0	12	K
WORGUA	WORNOB	9	120	0	0	0	K
WORGUA	WORDAU	10	480	0	0	1	K
WORGUA	WORPAL	14	120	0	0	11	K
WORGUA	WORZAP	14	120	0	0	28	K
WORGUA	WORCAT	14	120	0	0	17	K
WORVIN	VINCES	25	400	0	0	50	K
ZAPOTL	BABAYO	22	5320	0	720	0	K
ZAPOTL	QUEVED	12	5320	0	0	24	K
ZAPOTL	CATRA	11	5320	0	0	0	K
ZAPOTL	WORZAP	25	960	0	0	0	K

NODE PRICES

AZOGES	203
AMBATO	92
APUELA	116
ARNLLA	198
ALFAR	45
AGUARI	249
BABAYO	79
BAEZA	145
BALZAR	60
BOLIVA	133
BAHIAC	91
CAYAPA	131
CATRA	68
CAYAMB	70
CHILCA	108
CHINCH	350
CHONE	67
CUENCA	216
DAULE	81
DURAN	94
ELGUN	160
ESMERA	59
GUAYAQ	95
GUARAN	154
IBARRA	99
JIPIPA	105
KORBAB	107
KORBOL	113
KORDAU	108
KORSME	104
KORGUA	110
KORMAN	117
LATACU	76
LA'Y'	111
LAGRIO	299
LOJA	350
MANTA	92
MACARA	350
MCRIST	95
MCHCHI	55
MILAGR	105
MORENO	157
NARANJ	159
NOBOL	84
OTAVAL	86
PORSME	185
PORBOL	180
PORMAN	170
PORGUA	170
FAREST	350
GENOA	346
ATLUSA	254
UKNEUR	339
PACUSA	227
GULFUS	236
PASAJE	146
PALSTI	74
PALMAR	24
PAPALL	106

PUYO	236
QUEVED	45
QUININ	36
QUITO	41
RBAMBA	117
SLOREN	350
SDOMIN	0
SISABL	186
SISIDR	142
SALINA	130
TENA	229
TULCAN	130
VICHE	48
VINCES	93
WORSME	76
WORNOB	105
WORBAB	103
WORDAU	105
WORDUR	97
WORZAP	82
WORVIC	73
WORCAT	93
WORPAL	99
WORBOL	98
WORGUA	96
WORVIN	118
ZAPOTL	57

END

NO OF BREAKTHRUS# 5, NO OF NONBREAKTHRUS# 14, NO OF X CHANG
NO OF NODES FROM WHICH LABELING WAS DONE# 306

SUM OF PRODUCTS 4.948200000000D 05

Appendix No. 4

We should like to present a brief definition of some terms and marine nomenclatures used throughout this study. The following quote is from Reference 58:

" Displacement, Light - The weight of the ship excluding cargo, passengers, fuel, water stores, dunnage, and such other items necessary for use on a voyage.

Displacement, Loaded - The weight of the ship including cargo, passengers, fuel, water, stores, dunnage and such other items necessary for use on a voyage, which brings the vessel down to her maximum draft.

Deadweight Tons - The carrying capacity of the ship in long tons of 2,240 pounds. The difference between Light and Loaded displacement.

Cargo Deadweight Tons - The number of tons which remain after deducting fuel, water, stores, dunnage, and such other tons necessary to support a voyage, from the deadweight of the vessel.

Gross Tons - The entire internal cubic capacity of the ship expressed in tons defined as 100 cubic feet to the ton, except certain spaces which are exempt such as: Peak tanks and other tanks for water ballast, Open forecastle bridge and poop, Excess of hatch ways, Certain light and air spaces, Domes and skylights, Condenser, Anchor gear, steering gear, wheel house galley, Cabins for passengers (only where above deck) and other items which can be found in "Measurement of Vessels," U. S. Department of Commerce, Bureau of Navigation.

Net Tons - The tonnage of a ship remaining after certain deductions have been made from the Gross Tonnage expressed in tons of 100 cubic feet to the ton.

Among allowable deductions are: Crew spaces, Masters cabin, Navigation spaces, Donkey engine and boiler, shaft trunks, a certain percentage of propelling machinery spaces (normally max. 13% of Gross tonnage).

Register Tons - This is applicable to both gross or net tonnage but generally used with reference to Net Tonnage.

Power Tons - This is used to classify a ship for the purpose of establishing rates of pay of ship's officers and is calculated by adding Gross Tonnage to the indicated Horse Power of the ship.

Grain Cubic - Maximum space available for cargo measured in cubic feet, the measurement being taken to the inside of the vessel's shell plating and up to the deck plating.

Bale Cubic - The space available for cargo measured in cubic feet to the inside of cargo batterns, on the frames, and to the underside of the beams (for general cargo, bale cubic applies).

Cargo Stowage Factor - The bale cubic divided by the cargo deadweight equals the stowage factor.

Passenger Vessel - Any ship carrying over 12 passengers is lcassified as a passenger vessel, and is required to meet certain safety and construction standards as well as carry specialized medical staff."

Conferences Related with the West Coast of South America

1. <u>The Association of West Coast Steamship Companies</u>

   Northbound: from Ecuador to Colombia and US Atlantic, Pacific and Gulf Ports; From Colombia to US Atlantic, Pacific and Gulf ports.

2. <u>European/South Pacific and Magellan Conference</u>

   Southbound: Continental Europe, United Kingdom and Scandinavia to Colombia, Ecuador, Peru and Chile.

   Northbound: Colombia, Chile, Ecuador, and Peru to Continental Europe, United Kingdom and Scandinavia.

Note: The description of the trade routes for each of the above conferences is not complete. Segments of the overall trade routes were included.

(Source: Ref. 35, pages 49-50).

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