All development and innovation aim to improve productivity and to meet market needs of so-called diversified "values" of various customers. Such innovations used in a more abundant age of resources and mass consumption are now required to narrow their use appropriate to an age required to conserve energy and depletable resources and to eliminate pollution as much as possible.

The glut of information in various fields is vastly increasing but can be rapidly processed by the use of advanced computers. However, human decision making and selection of optimum choices play a more important role in various stages of management and execution. Contradictions should be patiently resolved and discord avoided by participative discussion of related staffs.

8.7.2 Necessity to Have a Pollution Abatement Program in Advance

Throughout human history in the development of human civilization, especially in modern times, treatment of waste, garbage, excreta, agricultural waste etc. have been left to recycle naturally back into nature if possible. But human recognition of the necessity of waste treatment has taken a back seat to modern production and development.

It seems surprising that the human body has a complicated but ingenious, complete, homeostatic and symbiotic system of mastication, digestion, and nutrient conversion and, at the same time, also has a complete system of extracting, collecting and discharging any kinds of waste and harmful materials and elements to keep the body healthy.

It would be ideal to have in the city a completely homeostatic and symbiotic system comparable to the human body, that positive activities (production, automatic supply lines to consumption centers operating like arteries) and negative activities (collection, extraction and disposal of waste materials acting like veins) are effectively and efficiently balanced and recyclic working. Recently, the industry supplying the processing and equipment of wastewater and solid waste treatment is sometimes called "vein industry."

Social planning in almost all countries has aimed to raise living standards and per capita income --GNP-- by first developing and diversifying production, usually focussing on and promoting industrial activities. Of course, social investment in facilities such as sewage and sewage treatment systems, solid waste treatment and disposal, pollution abatement etc. are inevitably becoming necessary to improve the quality of people's lives. The priority of such investment rises to balance with the production level.

Though investment in such social facilities is apt to lag behind that of production, usually because of budget limitations, it should be clearly recognized that the effects of incomplete pollution abatement clearly become more expensive once the harm is done. Sometimes it is even impossible to reverse the ecological damage caused by incomplete countermeasures.

Human society could not survive in the natural environment without a complicated but balanced coexistence of all kinds of plant and animal life in the total ecological system.

The earlier stages of any development plan should include practical appropriate pollution abatement programs, in order not to reduplicate the failures of industrially advanced countries, such as learning from Japanese experiences of environmental disruption.

8.7.3 Establishment of Environmental Pollution Control Standards -- A Short History of Post-War Japan

In order to maintain the natural beauty of the environment and protect it from blemish, contamination and pollution, it is necessary to have certain standards to measure the degree of pollution and disruption of nature caused by various human activity, irrespective of the conscious intention of offenders.

In fact, the standard must be revised in the future, because its numerical value has a certain absolute weight but is used only as a yardstick to devise necessary future measures of pollution control in response to former conditions. However, once a numerical standard has been decided, humans are apt to grant it absolute authority, considering it to be permanently established and unchangeable irrespective of its basic meaning and objectives.

There can be found many examples in Japan and other countries, which adequately demonstrate that it is laborious and time-consuming to determine or attribute the source of contamination to some specific material (the relation of cause and effect) when any new damage or change occurs.

Therefore, as for a material proven to be contaminative or harmful, it is necessary to remove it as completely as possible at its source or location at which it is generated, in order to avoid harmful diffusion. We think it is wise that the United States administration of pollution control has already announced both a policy aimed at obtaining zero discharge within a determined time limit and a policy of adopting the best available processes and equipment for the time being. Particularly in the case of harmful materials, it is necessary to adopt measures to inform all citizens of the existence of these materials and avoid as much as possible their dispersal over wide and unspecified areas. Once harmful materials are scattered, their recovery necessarily requires the waste of much money and time; it is actually impossible to recover all the materials.

Moreover, it is sometimes difficult to judge if a certain material is harmful or contaminative in terms of quality and quantity. Even harmful materials, however, are useful because of their need or medical efficacy. Besides, it is not so easy or simple to determine the harmful limits of these materials because the degree of harmful influence to the human body varies according to body constitution and health.

In establishing standards for limiting contaminative materials and for preventing pollution, many considerations and studies must be taken into account. Many reference data exist both in Japan and Western countries to establish systems and numerical standards (Appendix 2). To introduce reasonable systems of standards suitable to each country, it is also necessary to consider carefully actual and desired conditions in each country from various perspectives. However, Costa Rica should not expect a comprehensive and final system of standards at the present time, but should determine a basic but flexible set of standards and enforce them firmly while the time is ripe, leaving room for future revision. Frankly speaking, in Japan's case, legislation of the Anti-Pollution Standards Act was promoted only after some social problems related to pollution occurred and citizens' and consumers' movements arose.

In Japan, the Water Pollution Prevention Act was promoted for the first time in post-war Japan only in the light of industrial reconstruction. Seven years after its promulgation (1958), damage inflicted on the fishing industry by wastewater discharged without treatment from pulp factories encouraged the Water Quality Protection Act and the Industrial Wastewater Regulation Act to be enforced finally. The regulation of wastewater began the following year. However, at that time the Japanese Government advocated a policy of economic growth which stressed the importance of industrial production, while disregarding anti-pollution policy including the treatment of wastewater. However, because of the gradually spreading water pollution, citizens' movements aimed at eliminating contamination had gradually risen. Twelve years after the legislation of the aforementioned two laws, in December 1970, the famous Diet session on Public Nuisance was held; in the following year the Uniform Standard Law for all of Japan was enforced, encouraging improvement of the quality of polluted water, especially in the case of public water courses. However, the water pollution already had reached a serious level in some areas; it was difficult to expect sufficient improvement of the quality of polluted water by legislating such uniform standards covering all of Japan. Under such circumstances, with the necessary authority relegated to local governments, additional execution of these standards vis-a-vis each locality was realized. However, such strict standards were enforced in local areas in pollution prevention, carrying a penal condition. This condition was hastily approved without sufficient time for its proper introduction. The policy was strong enough to force the industrial sector consequently to make large additional investments in improved facilities, although much investment had already occurred with some conscientiousness on the part of industry.

Establishment of an Environmental Quality Standard

This standard was legislated by the government with the intention of attaining and maintaining anti-pollution standards through the pertinent ministries and agencies to serve local governments, by devoting full powers to respective authorities. Based upon actual tests and research of Japan's fresh and ocean water, the types of each water area are classified (1) according to the respective degree of contamination at that time, (2) considering related regulations and (3) referring to the degree of desired improvement in each area. Three to six grades of water quality have been established. As for the regulating authority of Japan's 82 water districts, the central government has authority over 37 rivers and 10 sea areas while local governments have authority over the rest.

This Environmental Quality Standard is established not as the ideal water quality standard but as feasible standard with an administrative target. It strictly regulates materials harmful to human health, while various authorities moderately regulate only matters concerning national living dependent upon the condition of each water area concerned. The latter case is to be revised gradually and further strengthened by raising the standards once they are reached.

Basic environmental pollution control standards may be divided into two categories, the items directly regarding to human health, items which are related to poisonous or harmful materials such as cyanide (or cyanogen), mercury alkylates, organic phosphorous compounds, total mercury, and poisonous metals such as cadmium, lead, copper, hexavalent chromium and arsenium. (Appendix 4)

There are also those itmes related generally to human life, items which are mainly used in household-used water, such as pH, suspended materials, BOD, COD, DO (dissolved oxygen) and number of coliform bacteria (total and fecal) etc.

Items in the former category (human health) should be controlled strictly disregarding any ratiocination, be it related to economics, local or partial specific conditions etc., because they have the potential to cause a fatal accident if erroneously discharged. However, items in the latter category (human life) have only a small possibility to inflict substantial damage on human health; they can sufficiently be controlled at some safe level by fixing standard levels for their content proportion.

Furthermore, several other items which possibly bear harmful effects on human life directly or indirectly should be considered carefully; they are materials as phenols, ABS, total nitrogen (ammonium-, organic-, nitric and nitrous nitrogens), organic chlorine compounds, oily materials etc.

8.8 Gran Puntarenas -- Present Condition, Comments and Recommendations

8.8.1 Urban Area of Puntarenas Sandbar

Puntarenas, which was founded around the fifteenth century, has continued to develop steadily and is blessed with comparatively mild climate as a port city in the tropical zone.

Puntarenas city has two faces, the one of a tourist city and the other of a fishing city. In either case, more efforts should be made at environmental improvement.

A population of approximately 30,000 persons inhabit the Puntarenas Sandbar (30,000/180 ha = 166/ha). While this density is not really low for such an area, there is little possibility for it to increase if urbanization rises. Although natural vegetation is abundant and the sewage system is already fairly well developed other than its collecting system, the city is situated as low as one meter above sea level, where some houses use septic tanks. Some parts of the city therefore possibly are in danger of being flooded during high tides or heavy downpours, but there are no fatalities. It is, therefore, necessary to undertake a long-term improvement in zoning of urban housing, especially in areas where there are old warehouses and low-grade housing.

The main sewage pipes are laid along the main streets running from east to west while the drainage pipes cross perpendicularly. Sewage water presently drains into El Estero on the north side of the city. Investigation of the quality of sea water on both sides of the Puntarenas Sandbar and the Gulf of Nicoya is now undertaken under the guidance of Peruvian consultant, CEPIS, to regulate pollution caused by untreated sewage water. The results of the investigation (though officially still unpublished) seems to encourage at least primary treatment of sewage water emitted from the city. AyA has likewise concluded similar recommendations judging from the degree of contamination in El Estero caused by sewage drainage.

With respect to tourism and recreation, El Estero seems quite suitable as a sports and recreation area so long as the quality of sea water is acceptable even if cargo and fishing vessels use coastal waters on their way to FERTICA.

Comments and Recommendations

For the beautiful, long and narrow sandbar of Puntarenas, decisions should soon be made on the following points:

(a) The selection of a site and planning for a primary sewage treatment plant including a pumping station for collecting intake and discharging effluent,

(b) a plan for controlling the industrial wastewater of several private companies in the city.

Several factories, particularly those processing marine products on the northern coast or in other areas of the city, do not yet treat their wastewater. In Chapter VI of this study, a land reclamation work is recommended for the northern side of Pueblo Nuevo. This plan should be considered concretely with regard to its merits listed as follows:

(a) The present marine products factories can be moved to the reclaimed land, because they presently lack space for extention or waste treatment.

(b) The city can utilize the reclaimed land in many useful ways - for example, to construct a sewage treatment plant, to establish a residential area for people who have been forced to move out of inferior parts of the city to make way for their reconstruction. It seems profitable for the city to have a public space of considerable size at its disposal.

8.8.2 El Roble and Barranca Area

This area extends from the base of Puntarenas (Chacarita and El Roble) to Barranca, where it meets the Pan American Highway. It is a strip of land, about eight kilometers long running from west to east along a main road and about two kilometers wide.

Going from the Pan American Highway in the east toward Puntarenas, we can see the Rio Barranca riverbed on the left side and a railway bridge of the Pacific Railroad coming from San Jose. Though indeed small, Barranca is a market center of agricultural and livestock products which are transported from the Province of Guanacaste along the Pan American Highway. Along both sides of the main road there is a small industrial zone having a slaughterhouse and warehouses for receiving and processing agricultural products.

Barranca has a slightly high altitude and gently slopes along the main road down toward El Roble, to the west. About three kilometers west of Barranca, we can see a part of a residential area constructed by INVU. This residential area composed of single-storied houses is 98.7 ha. Presently 637 houses have already been built, but plans call for construction of 1,300 houses when the project is completed.

Bordering this area, a sewage treatment plant has been constructed and is in operation. The domestic sewage from INVU housing area and hospital waste drained from the Monseñor Victor Manuel Sanabria Hospital are mixed and treated by a biochemical process, explained in 8.2.2 and Table 8.5.

About one kilometer further west, slightly west of the Barranca-Inter-American Highway interchange, the main road is to intersect the new Costanera Sur Highway, which originates from the Pan American Highway. The Costanera Sur will run to Caldera along the sea shore and will be joined to a new highway connecting Caldera and San Jose.

From the inner-most and east-most part of El Estero, there is a canal of about two kilometers in length, through which FERTICA imports materials such as ammonia, phosphorous ore, potassium salt etc. This plant synthesizes nitric acid by oxidation of ammonia and manufactures ammonium nitrate. Moreover, it produces ammonium sulphate and many mixtures of fertilizer which suitably meet the specifications of soil type and plant characteristics for any field.

The chimney of this factory emits a yellowish brown exhaust - probably containing nitrogen oxide - which odiously hang over neighboring inhabitants. This plant seems to serve as a sample source of air pollution.

Moreover, on the open field just behind the FERTICA plant, Puntarenas garbage is burnt. Generally, urban garbage is incinerated, but in this area land is already alloted for burying and landfill. In the dry season some garbage is incinerated.

As mentioned above, no significant population increase can be foreseen in the urban area of Puntarenas sandbar, other than that caused by natural growth. Our study indicates that the future increased population should be accommodated in the area of El Roble and Barranca.

Many smaller houses of comparatively lower classes are scattered in lowland areas beside the Barranca-El Roble main road, near the Barranca River. These houses supposedly often are suddenly flooded after a down-pour and/or at high tide. At these times, septic tanks in smaller houses may be washed out and wastewater overflows, polluting the area.

The plan of INDECA Report regarding the sewage system which will handle rain water drainage and household sewage systems is most worthy. Its proposed drainage system should be constructed at least in the present residential area as soon as possible.

As to the hygienic safety of the lowland area, it would be most difficult to raise the whole area. Moreover, the plan for an emergency drainage pump system in combination with enclosed protective concrete retaining walls would be too expensive, because the area covered is too extensive.

In Japan too, there are several areas almost at sea level in Metropolitan Tokyo. They are protected by a combination of protective retaining walls and emergency drainage pumping stations of comparatively large capacity.

Recommendations

(a) Drainage Control Ponds

If the plan of INDECA Report is not immediately implemented, after careful investigation of the conditions relating to the lowland areas whose development is being planned in consideration of heavy rainfall and high tides and their relation to residential locations, before completing a sewage system in the area, the construction of single drainage control pond at suitable location or a set of many smaller ponds situated at regular intervals along shallow ditches forming natural flow lines for rain water drainage should be considered.

Of course, the soil taken from these drainage ditches can be used rather conveniently for raising the ground level, especially where needed in constructing new buildings.

(b) Selection of An Area to Be Used for Sewage Treatment Plant and of Type of Final Sewage Treatment Process

As already pointed out in the INDECA Report, it is necessary to construct a final sewage treatment plant and to discharge the treated, hygienically harmless effluent northward toward El Estero through a canal, instead of draining it on the southern seashore, that is, at the mouth of Rio Barranca. This is not only for hygienic reasons because the effluent may contain hospital waste, but also for esthetic or socio-psychological reasons even after treatment.

It seems worthwhile to consider the type of final sewage treatment process to be selected for this area. If it is possible to acquire a larger area for constructing the plant, we recommend a process using a lagoon system which would enable the processing of a larger volume for a longer detention time. This lagoon requires a dug out pond sealed with rubber or plastic sheet instead of a concrete basin.

As to the selection of a plant site, the area should be as wide as possible. If a lagoon system is adopted, natural and tropical solar energy can be fully utilized for a photosynthetic processing by algal biomass or aquatic weeds.

The wide area behind a mangrove grove on the northern side of the Puntarenas Sandbar can be used as a site for a final sewage treatment plant. A decision on this project should not be made from an economic aspect only.

The existing mangrove grove should definitely be preserved. Both the treated effluent and the sludge from the sewage treatment plant can be recovered and used on farmland through irrigation and for soil conditioning.

(c) Air Pollution Abatement of the FERTICA Factory

The brown smoke belched from the FERTICA chimney envelops the whole region. To abate this air pollution the smoke should not only be reduced, but should pass through some kind of gas washing device, gas washing tower or Venturi scrubber etc. Surely more than 80 percent of chemical constituents can be easily removed; some nitrogen oxides can also be eliminated.

In order to design efficient gas washing equipment, a more precise survey is needed, as well as various data on chemical constituents including the composition of nitrogen oxides, total gas volume and temperature, in relation to the conditions of the production process.

If the lime slurry can be effectively used for neutralization in washing, the used slurry can be recovered as by-product.

If effective gas washing equipment be adopted in the factory, it will probably be the first and will therefore set a precedent to pave the way for pollution control equipment to be used in industry. The administration should therefore previously form regulations based on an official assessment of environmental pollution.

(d) Active Conservation of Vegetation in the Area

Material development can only be achieved at some sacrifice to nature. After completing construction for industrial, business, residential or transportation uses, adequate attention should be paid not only to environmental restoration but to its improvement. To mitigate the unpleasant effects of excessive industrialization and urbanization, parks, gardens, avenues etc. should be constructed. Comprehensive and well-informed planning is indispensable for preserving freshness of this site.

Construction results in so-called "concrete made" civilization; vegetation also undergoes considerable change. The vegetation of El Roble and Barranca area seems poorer than that of Puntarenas Sandbar. It may be advisable for the former area to make a long-range plan as to suitable vegetation for this area based on potential vegetation. The plan should include buildings, factories and houses on both sides of highway, in order to encourage plant life (community) as wide as possible.

If vegetation can be sufficiently restored, the area will become comfortable to live in and attractive to visitors.

8.8.3 Water Resources in Gran Puntarenas

According to the INDECA Report, (Chapter 12, "Various Public Facilities: Service Infra-Structure"), the present state of and future possibilities for developing water services are described in detail based on some actual surveys conducted by AyA.

Possibilities are shown as follows:

(a) More ground water may be made available by digging more wells in areas of Socorrito, Chagite, and north of El Roble station.

i) Ground water from deep wells (36 to 46 meter deep) in the El Roble area is expected to be of good quality,

ii) The ground water from shallow wells in the Barranca area is feared to be polluted and to have high salinity.

(b) Development of local public water resources:

i) With the resources of Carrizal, Socorrito and Chagite areas, the resources in La Rioja, Barranca and El Mango areas will sufficiently satisfy future needs of this area -- from Puntarenas to Barranca -- according to SENAS. This report advises that it is necessary to confirm these possibilities by actual surveys.

ii) As a water source, the Alanjuez River may be used, for this report says that the river has a minimum capacity of 1,300 liter/second. However, the water must be treated before being used.

iii) The well water from the area around the Maria Jesus River may be sent to Caldera, Mata de Limon, El Arto de Las Mesas etc.

iv) Well water in the west of Cabezas will be sufficient in volume to supply the areas of Cabezas, Estero de Mero, Barbudal, the hill of Roca de Carballo etc.

v) The water from wells situated on the south side of the Barranca River will be sufficient for supplying the area of Esparza.

Furthermore, it is recommended in the Report that these water distribution systems in the central area of Gran Puntarenas should be so connected with one another that the water can be used in any area in case of an emergency.

AyA will surely have adequate and sufficiently long-range, future planning and scheduling in regard to the development of water resources in the Gran Puntarenas area.

To the above information might be added several considerations in order to assure the development of a good and sufficient water supply to meet future needs.

(a) Water pollution, whether caused by domestic, cattle-related (by manure) or industrial wastes, must be carefully handled in order to preserve hygienic conditions of the surface and ground water to be supplied for public drinking.

The environment of wells to be built in the area should be kept to preserve their cleanliness and hygiene; careful administration of pollution control should be exercized in order to protect the area against various kinds of water pollution, such as pollutants from various kinds of wastes - including harmful materials.

(b) With regard to preservation areas of water resources, for example, the upstream river basin of the Alanjuez River, the area surrounding the reservoir should be cultivated with adequate vegetation, giving careful consideration to good vegetation in reference to the real and potential vegetation maps for the area. For example, the area should be covered with adequate forests in order to maintain underground stability. Instead of surrounding the shore of the reservoir lake with concrete, it should be planted and covered with waterweeds, which are effective for natural purification of water.

8.8.4 Port of Caldera and Surrounding Areas

The reclamation work of the port at Caldera is now being undertaken and is to be completed two year hence. Moreover, the construction of the Costanera Highway to Caldera from El Roble and Barranca has just begun, including the bridge at Mata de Limon. The highway will extend to San Jose and also from Cascajal to the southern coastal region along the Pacific Ocean to Golfito finally.

The marshland Mata de Limon, where mangrove groves grow thick as natural vegetation, has to date been protected as a tourist place or beautiful and calm spot. Population living in the surrounding area is few in number and not dense. However, with the completion of the port of Caldera the area is expected to develop gradually. The port is to become a commercial port.

The present scenery of Mata de Limon conspicuously will change after a big bridge is completed over the inlet. Though areas surrounding Playa Corralillo, Playa Terciopelo, Playa Icaco, Playa Tivives etc. are still somewhat removed for sight-seeing and recreational places at present, they have development potential. Detours around the Punta Corralillo to the southern hinterland of Caldera and transportation along the Caldera Highway can be developed.

Recommendations

1) When the marshland of Mata de Limon is developed, urbanization, local industrialization and commercialization can be expected to some extent. Therefore, in order to prevent a chaotic sprawl or the partial urban deterioration into slums, the construction of new towns or city must be studied, programmed and promoted to parallel completion of the Port of Caldera.

2) At that time, high level sewage system, sewage treatment facility and environmental sanitary facilities related to the port administration will become necessary. The various solid wastes emitted into the port area naturally depends upon the nature of products entering and leaving the port. Therefore, it will be necessary to observe carefully business activities at the port to make best use of facilities and treatment processes.

3) Various health conditions of port-related facilities including a quarantine center, warehouses, business centers etc. should be carefully handled under the control of the Ministerio de Salud. Outside of the harbor area, hotels, restaurants and some factories of the food related industry should be controlled strictly from the standpoint of health and hygienic concerns.

4) Various excavated areas should be better restored by adequate vegetation. All hill embankments, the area surrounding the port, along the highway and newly extended railroad etc. should be

recovered first by using grass with organically fertile soil, then with large plants having substitutional vegetation. The entire revegetation process requires a lengthy time period.

5) Transportation systems should be carefully scheduled especially for the convenient and cheap to use of port workers commuting from locations around Caldera and Puntarenas, in order to eliminate the possibility of slum formation.

8.9 Research and Development

In the last two decades, various pollution problems have appeared increasingly, requiring many kinds of sophisticated treatment processes that use mechanized equipment and advanced technology in order to save space and to increase efficiency. This equipment increases initial costs. However, the chemical processing makes the treatment more efficient but operating costs are more expensive for both air and water treatment. Chemical treatment usually generates considerable amount of sludge which is difficult to dewater and troublesome to handle and to dispose.

Recent tendencies of research and development focus (1) on reducing NOX and very fine dust in the various exhaust gases emitted in combustion processes, (2) on efficient ways of saving energy and resources on the one hand and (3) on processes producing better and safe effluents by tertiary treatment, on the other hand, in the waste treatment.

Another important facet of waste treatment is the removal of heavy metals down even to a trivial limit (ppb order). But such harmful materials should not be disposed anywhere as previously stated.

Various biochemical processes have a lengthy history and have been developed with many modifications. The processes are comparatively economical but because the retention time is lengthy, the size of the treatment basin should be large. It is comparatively difficult to reduce the size of basin. To make the basin more effective, however, many kinds of biochemically contact-type processes have been developed recently, for example, a tower type trickling filter using plastic media, rotating disk contracter, tube type water recirculating contracter etc. The operating costs of these types of equipment are comparatively economical. This equipment is conducive to organic waste treatment in areas of high-priced land.

One of the most interesting and useful processes for the treatment of sewage and organic waste uses only soil. The process is conducive to comparatively small-scale use and capacity, for example, to sewage treatment for rural areas in Costa Rica.

8.10 General Comments and Recommendations

1) As both the AyA and the Ministerio de Salud have already pointed out the shortage of specialists and trained staffs for pollution control, environmental engineers must be sufficiently trained in order to set qualified environmental pollution control standards. To accomplish this, it is necessary to survey and understand in advance the present situation and problems in the fields of air, water and solid waste.

Cultivation of human resources, especially, cultivation of technical specialists, requires extended time and labor, for they must have special skills and abundant practical experience.

To recruit trainees for this work it may be advisable to give them some preferencial treatment, e.g. some special qualification when they have finished their training courses or to allow them to enter more advanced courses for higher staff positions.

Furthermore, it is necessary to have a clearly defined personnel programme, for example, to provide two or three specialists for each provincial capital in three to five years -- a total of 20 persons. The programme is recommended to begin as soon as possible.

2) Recently the area of Guanacaste and Nicoya sandbar are reported to be drying up; trees have been cut almost up to the hilltop. It is necessary to restore suitable and stable vegetation in order to retain subsoil moisture in these areas.

This requires long-range ecological planning, and a survey of real and potential vegetation must be undertaken before designing a new vegetation system. A preliminary survey can probably be completed in about one month by a three to five member group, when they co-operate with Costa Rican experts. As recommended previously, a similar survey for Gran Puntarenas should be undertaken as soon as possible with regard for the surrounding area.

3) The environmental pollution abatement programme should be started first by obtaining a series of data concerning the present state of water pollution and the effects of sewage and industrial waste-water.

(a) As for sewage water, a hydraulic and hydrological survey of several important rivers should accompany a sanitary engineering and ecological survey regarding the pollution and the natural purification of sewage water draining into rivers. Surveys of this kind are needed in regard to the Rio Grande de Tarcoles and the Rio Barranca.

AyA has reportedly recommended continuation of a program to monitor sewage effluents discharged into the Rio Grande de

Tarcoles and its tributaries, in cooperation with the Instituto Costarricense de Electricidad (ICE) which has built four hydroelectric plants on the river. The results will prove to be most interesting and useful from a wider perspective.

(b) As for industrial wastewater, more than 100 factories in the central area are probably discharging their wastewater into rivers without any treatment.
The present state of the wastewater must be surveyed in advance vis-a-vis the respective conditions of each factory, before any wastewater pollution control standard is determined officially. An exemplified list of various survey items is shown in Appendix 7. The data should be obtained by means of direct inspection of and inquiry at the related factories.

4) Sewage Treatment by the Use of Soil

The process of using soil for sewage treatment has been developed successfully in Japan. It seems suitable on a comparatively small scale especially in rural areas having a population of about 2,000 or less. Survey and experimentation are recommended as part of a plan for setting up a pilot plant in some rural areas in Costà Rica for demonstration purposes.

The main characteristic features of this process are briefly explained in Appendix 8. The process is believed to be suitable to use of volcanic soil. The pilot plant will surely contribute to improvements of septic tanks in the country.

5) In establishing an environmental pollution control standard and the control system, it seems most important to decrease initially the discharge of poisonous materials because poisonous materials are clearly related to the safety of human health (Appendix 4 and 5).

TABLE OF APPENDICES

Appendix 1. Table 8.12 Growth of Industrial Production in Pre- and Post-War Japan

	Fishing (th. ton)	Fabrics (million m^2) Cotton	Fabrics (million m^2) Artificial	Steel (th. ton)	Aluminum (th. ton)	Cement (th. ton)	Pulp (th. ton)	Paper (th. ton)	Automobiles (thousand)
1935	3,977	3,438	623	4,704	2.7	5,538	770	1,107	(1938) 24.4
1955	4,907	2,524	1,450	9,408	57.3	10,563	1,908	2,204	(1961) 813.9
'55/'35	1.23	0.73	2.33	2.00	21.2	1.91	2.48	2.00	33.4
1970	9,315	2,616	4,291	93,322	729.7	57,189	8,801	12,973	5,289
'70/'55	1.90	1.04	2.96	9.92	12.7	5.41	4.61	5.89	(70/61) 6.50

Table 8.13 Total World Production, Share (%) of Several Developed Countries (A) and Growth Ratio ('70/'59) (B)

	Fishing (th. ton)	Rayon (th. ton)	Artificial Textiles (th. ton)	Steel (mn. ton)	Aluminium (th. ton)	Cement (mn. ton)	Pulp (th. ton)	Paper Products (th. ton)	Coal (mn. ton)	Oil Consumpt. (mn. kl)	Automobiles (thousand)
Total World Production											
1959	40,200	2,522	575	301.8	3,840	285	49,768	74,355	2,030	1,237	13,436
1970	69,600	3,442	5,895	597.0	10,750	571	108,400	129,298	2,126	2,685	29,403
	1.73	1.35	10.25	1.98	2.80	2.00	2.18	1.74	1.05	2.17	2.19
Share of Several Developed Countries % (A)											
Japan A	13.0	14.5	19.8	15.6	8.3	10.0	8.3	10.0	1.9	8.6	18.0 (A %)
Japan x B	1.50	1.29	14.40	5.62	8.94	3.31	3.81	2.88	0.85	6.54	20.1 (B times)
U.S.A. A	4.0	18.4	33.0	20.0	33.1	11.9	36.6	36.8	25.0	31.0	28.2
U.S.A. x B	0.98	1.19	6.65	1.41	2.01	1.19	2.01	1.53	1.40	1.48	1.23
USSR A	10.4	13.7	3.4	19.4	16.0	16.7	6.5	5.2	20.4	14.0	3.1
USSR x B	2.38	2.87	14.50	1.93	3.45	2.48	2.45	2.08	0.35	-	1.86
W. Germany A	4.3	7.2	10.2	7.5	4.0	3.0	1.6	4.3	5.2	5.8	13.1
W. Germany x B	1.93	1.27	15.50	1.53	2.83	0.75	1.30	1.60	0.88	4.23	2.24
France A	1.1	3.8	3.6	4.0	3.5	5.1	1.7	3.2	1.8	4.1	9.4
France x B	1.04	1.20	6.51	1.57	2.17	2.04	2.05	1.58	0.64	3.48	2.14
Great Britain A	1.6	4.8	6.1	4.7	1.1	6.7	-	3.8	6.8	4.4	7.1
Great Britain x B	1.19	0.69	9.2	1.38	4.76	2.97	-	1.19	0.69	2.18	1.34

Table 8.14 Several Basic Reference Indeces

1) Population and Its Rate of Increase, Area of Each Country

Country	Land Area (th. km^2)	(%)	Population 1971 (thousands)	(%)	Density P/km^2	Rate of Population Increase (%) 1950	1970
World	135,800	100.00	3,635,000	100.00	26		
Japan	372	0.27	104,328	2.87	280	1.72	1.26
U.S.A.	9,363	6.89	204,800	5.63	21	1.39	0.88
W. Germany	248	0.18	59,431	1.63	239	0.60	0.17
England	244	0.18	55,711	1.53	228	0.45	0.45
France	547	0.40	50,777	1.40	92	0.79	0.61
Netherland	41	0.03	13,019	0.36	317	1.52	1.00

2) Japanese Regional Population Density (Showing concentration of central areas.)

	Population Density P/km^2 1968	1971	(increase) (%)
Hokkaido (northern islands, including Sapporo)	67	66	-99
Tohoku (northern Honshu island, including Sendai City)	136	135	-99
Kanto (Central area of Honshu, including Tokyo)	869	936	108
Chubu (" " " , including Nagoya)	266	274	103
Kinki (" " " , including Osaka, Kobe, Kyoto etc.)	551	583	106
Chugoku (western most area of Honshu, including Hiroshima)	219	222	101
Shikoku (small southwestern island)	209	208	-100
Kyushu (southwestern-most island, including Okinawa Islands)	292	287	-98

3) Population Distribution showing Population Concentration into the Tokaido Megalopolice (eastern seaboard from Tokyo to Nagoya and central Kinki area

	1968 Area, km^2	(%)	Population (thousands)	(%)
All of Japan	369.9	100.0	101,408	100.0
(1) Tokyo and vicinity	13.4	3.6	22,743	23.4
(2) Nagoya and vicinity	21.4	5.8	8,379	8.3
(3) Osaka and vicinity	18.5	5.0	14,730	14.5
Tokaido Megalopolice [(1) + (2) + (3)]	69.8	18.9	50,780	50.1

4) Variation (Growth) of Various Indeces

Year	Population (thousands)	Density (P/km^2)	Price index(1934-36=1) (wholesale	consumer)	Price of Rice (yen/10kg)	GNP (net)	Export (million dollars)	Import (million dollars)
1940 (War)	71,933	188	1.6 (1945:3.5)	(1946:50.6)	3.25	-	857	809
1950	83,200	226	246.8	219.9	445.00	(1951) 94,611	820	974
1960	93,419	253	352.1	328.0	870.00	203,483	4,055	4,491
1970	103,720	280	399.9	577.9	1,250.00	574,408	19,318	18,881
(Increase Ratio '70/'60)	1.103	1.109	1.136	1.762	1.437	2.823	4.76	4.20

Appendix 2. Examples of Various Types of Industrial Waste and Their Treatment

In referring to various factories interspersed in the Meseta Central and those in Gran Puntarenas, brief technical explanations of the characteristics of wastewater discharged from these factories in relation to their probable treatment processes and their expected results are inserted hereunder.

Coffee Processing

One of the largest industries in Costa Rican agriculture and chief sources of wealth is coffee grown on plantations at higher altitudes area around the central plateau. The climate at altitudes higher than 1,000 meters is reportedly ideal for growing Arabica type coffee.

During coffee harvest, in September to November, coffee beans are washed and their shells are removed, using about 1 to 1.5 m^3 of water per one sack (60 kg) of coffee beans. The wastewater containing the shells has a high BOD content (3,600 ppm) and is discharged from the local COOP's factory. The washing process improves the quality of the coffee. However, a considerable amount of pollutants are generated. Either an Oxidation pond or a coagulation and sedimentation process using $CaCO_3$ and poly-electrolyte coagulant should be employed or at least tried for better waste treatment. About two thirds of the BOD and 80 percent of suspended solids reportedly can be removed from the waste. The sludge can be recirculated to the farmland for use as fertilizer. Also, it is said that waste in the form of suspended solids from instant coffee production can be recovered as a raw materials for producing activated powdered carbon.

Milk Processing

Cattle breeding is another basic and important agro-industry in the country, because of the production of meat and milk. Land may be fully utilized nearly to the top of volcanic mountains for cattle breeding.

In Japan, there is much land at high altitudes, but it cannot be utilized so efficiently because of the very cold winter season.

As an agro-industry, the processing of fresh milk, butter, cheese and powdered milk (plants are now under construction) needs to use water for washing equipment, utensils and the factory itself. The wastewater contains a moderate level of BOD, produced by oil and protein. An oxidation pond or biological treatment can be applied to the waste.

Slaughterhouse and Meat Processing

Slaughter house is a necessary process of meat production. The production of beef, chilled or frozen, also plans an important role in the country's exports.

The under-mentioned quantity of water is generally used for washing internal organs, skin and blood of hog carcasses but the volume depends largely on the number of hogs processed and the time schedule they fluctuate widely.

80 -- 90 hog/day	1.1 -- 1.8 m^3/hog
200 "	0.8 -- 1.0 "
300 -- 600 "	0.5 "

The BOD in the wastewater greatly depends on the blood content. In a modern process, blood can be separated and recovered efficiently from cattle having an average weight of 375 kg; 15 to 16 liters (about 60 percent) of the total blood volume can be recovered and the remaining 6 to 7 liters are discharged into the waste. In the case of hogs having an average weight of 80 kg, 2.2 to 2.4 liters (about 40 percent) of the total volume (5.6 liters) of blood are wasted. From both the viewpoint of efficient use of resources and that of decreasing the waste load, the recovery of blood is very important. BOD loading data are shown as follows:

Blood Recovery	Waste Volume	BOD Loading
60 -- 70%	0.5 m^3/hog	0.45 kg BOD/hog
40 -- 50	0.94 "	0.78 "
0		0.93 -- 1.25 "

The typical quality of wastewater is shown as follows:

pH	Evap.Res.	Ig.Loss	Ig.Res.	S.S.	COD	BOD	NH_3-N
6.3 -- 7.3	1300	1000	300	500	200	800	37
	(2700)	(2300)	(360)	(2300)	(400)	(1700)	

The complete waste treatment process is composed of:

(a) Screening (removal of hair, pieces of meat, coarser suspended materials etc.);

(b) Waste collecting pond with aeration (partially removal of 50 to 60 percent of SS and 20 to 25 percent of BOD);

(c) High rate trickling filters, two stages, (95 percent removal of SS nad 85 to 95 percent of BOD) or activated sludge process (BOD removal of about 90 to max. 98%).

Of course, an oxidation pond or lagoon can be applicable for this waste treatment. However, sufficient volume and proper and pertinent handling of the sludge (solid) are recommended.

Tannery, Hide Processing

The hide is another important product of the cattle industry. However, the tannery process generates troublesome wastewater and gives off an offensive odor. The wastewater seriously contaminates public water courses if discharged without treatment and is comparatively difficult to treat. Probably factories should be relocated far from the populated areas in order to avoid problems of odor.

Usually tannery waste is alkaline, strongly colored and high insoluble solids and BOD. Examples of the quality of wastewater for total and partial wastes of each process are shown in the table below.

8.15 Total and Partial Waste Processing of Tannery

	Total Waste		Partial Waste of Each Step of Processing		
	Tannin	Chronium	Liming	Wash After Tanning	Tanning by Tannin
(Volume of Waste)			3.0 l/kg	3.0 l/kg	8.5 l/kg
pH	- 13	6 - 9	11 - 13	4 - 5	6.7
Evaporation Residue	1,300-10,000	7,000-10,000	20,000-40,000	3,000-6,000	15,000-20,000
Suspended Solids	360-3,950	1,500-3,000	5,000-8,000	300	2,000-4,000
BOD	100-3,200	- 700	3,000-5,000	30-50	9,000
Total N	30-450	-	1,000-4,000	-	1,300
Cr	-	50-400		30-50	-

By using natural sedimentation, only about 40 percent of BOD and 70 percent of suspended solids can be removed, but the treatment seems to be incomplete. It is better to adopt the combined treatment of chemical coagulation or natural sedimentation and biochemical treatment with pH control.

By chemical coagulation, more than 60 percent of BOD would be reduced; sulphine and chromium, if used in the tanning process can be removed rather easily. By biochemical treatment, more tha 90 percent of BOD can be removed.

The sludge from tannery waste, if it does not contain chromium, can be disposed on farmland.

Fruits and Vegetable Processing

Many kinds of products can be produced from fruits and vegetables - e.g., canned products, sauces, juice etc. Because fruits and vegetables are seasonal products, the production schedule in each factory varies widely depending on the type product and the season of production.

Wastes usually contain carbohydrates with sugar, organic acids, food coloring, suspended pieces of skin, cellular materials, seeds etc. The quality of the waste depends on kinds of raw materials and production processes; the waste becomes easily septic. All wastes, however, are comparatively easy to treat by using biochemical treatment with pH-control.

In the case of tomato juice and ketchup production, the waste contains red coloring. It is best to mix it in a chemical coagulation process in order to reduce the coloring as completely as possible.

Pineapples and bananas are other important agricultural products. Pineapple contains a high percentage of sugar. Canned pineapples are slicings of fresh fruits dipped in syrup. The syrup is extracted by pressing the residual flesh of the fruit, purified by a special ion exchange process, and is in concentrated form. Because the recovered juice contains about 15 to 20 percent sugar, it can be reused, as has been adopted economically in Hawaii. The final residual is composed of the pulp of pressed fruit and can be reused as a component of animal feed and organic fertilizer.

Marine Products, Fish Washing and Processing

Once the fishing boats arrive at their piers, it is necessary first to wash all the fish caught, packed them with ice and transport them to consumer areas as fast as possible. Part of them are refrigerated as frozen fish. In fish canneries, the production processes are composed of defreezing, degutting, cleaning, separating according to size, butchering, packing, sterilizatoin, cooling, etc. Representative data of the quality of wastewater from tuna canning is shown in Table 16.

The water used in washing the fish is sea water. The wastewater containing fish oil and blood to some degree, various fresh fish processing wastes, scrub water and residue from floor-washing, wastewater from refrigeration, etc; this changes greatly in volume and quality, depending on the operation in each factory. Sea water having become wastewater after variously used in fish processing can be treated biochemically if the chlorinity (salt concentration) is constant, but it must be collected and treated separately from fresh wastewater.

Table 8.16 Waste Discharge (Average) from Each Process of Tune Canning
Waste Discharge; Ton/Ton of Raw Material/Day

	Wastewater (ton)	S.S. (kg)	COD (kg)	BOD (kg)	
Defreezing	(5-23) 9.5	0.5	0.9	2.8	
Cutting Head and Tail Fin	2.7	1.04	1.1	2.7	
Boiling	(0.2)	(0.5)	(1.3)	(1.6)	(boiled water)
Butchering	2.3	0.25	0.14	0.3	
Cleaning	2.3	0.04	0.05	0.1	
Meat Packing	2.3	0.05	0.09	0.2	
Floor Washing, etc.	0.7	1.0	0.33	0.7	
Byproducts Process.	5.7	0.4	0.67	1.3	
Total	24.5	3.7	4.6	9.3	
Wastewater Contains:	Higher (ppm)	1,200	2,800	3,800	max.5,400
	Lower (ppm)	200	500	800	max.1,200

Various concentrated wastes from boiling etc. can be recovered by their concentration oil separation by centrifugal processing and clear liquefaction by filtration for use as seasoning elements. These wastes can also be dehydrated into powder.

Concentrates and less from the by-products of non-edible fish can be recovered to use in animal feed. The water in the fish stock is neutralized with the rest of the concentrated being fish soluble and is absorbed by animal feed.

From the waste of fish paste, high quality protein can be recovered by coagulation with polyacrylic amide to use also in animal feed.

Any kind of solid wastes should not be thrown away into the sea.

Metal Plating and Metal Surface Processing

The wastes from metal plating obtained in the plating bath contain heavy metals in high concentration, but the wash itself contains slightly a lower concentration. In this industry, water use is very important. Almost all heavy metal ions in copper, iron, chromium, nickel, cadmium etc. except hexavalent chromium, can be removed by precipitation after neutralization. The poisonous hexavalent chromium deriped from the chromate process can be collected, pH-controlled and reduced by chemicals such as SO_2 gas or a bisulphite solution under the automatic regulation of pH and Redox potential. After reduction of Cr^{+6} to Cr^{+3} (tri-valent), it is easily settleable by neutralization.

Large amount of acid and/or alkaline are used for metal surface processing; the waste must be neutralized, but they often generate large amount of metal hydroxide sludge which is very difficult to dehydrate.

Extremely dangerous cynide is often used in this industry. Wastes containing cyanide certainly must be oxidized for safety. Careful attention should be paid in the process of acidifying the cyanide waste, because of gasilication of cyanogen is very dangerous.

Paper and Paperboard Processing

Paper processing discharges quite much sludge containing both fibers and fillers, which are easily separable by floatation or sedimentation. Some fibrous sludge can be recovered and reused for lower grade paper or as packing in paperboard. If recycled paper is used, deinking waste is generated and must be treated by combining floatation with chemical coagulation.

Earthenware, Chinaware and Porcelain Processing

This waste contains a considerable amount of fine clay or sandy inorganic particles which are comparatively easy to separate. If necessary some coagulant can be applied; the clarified water can be reused if desired in order to save the water.

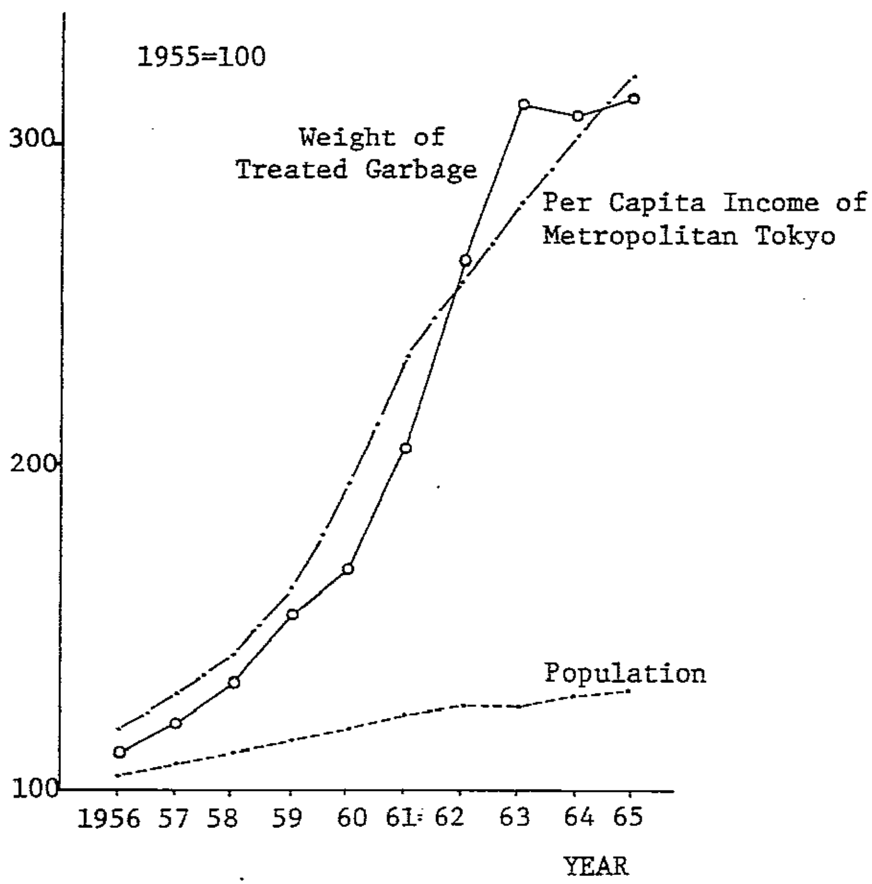
Wooden Laminates (Plywood) Processing

The waste from artificial wood laminates contains an appreciable amount of suspended wooden fibers and colored, soluble wood resins. The colored, soluble resins are slightly difficult to separate and decomposed. Sedimentation combined with chemical coagulation and biochemical processes can be applied as a treatment to some degree, but not completely.

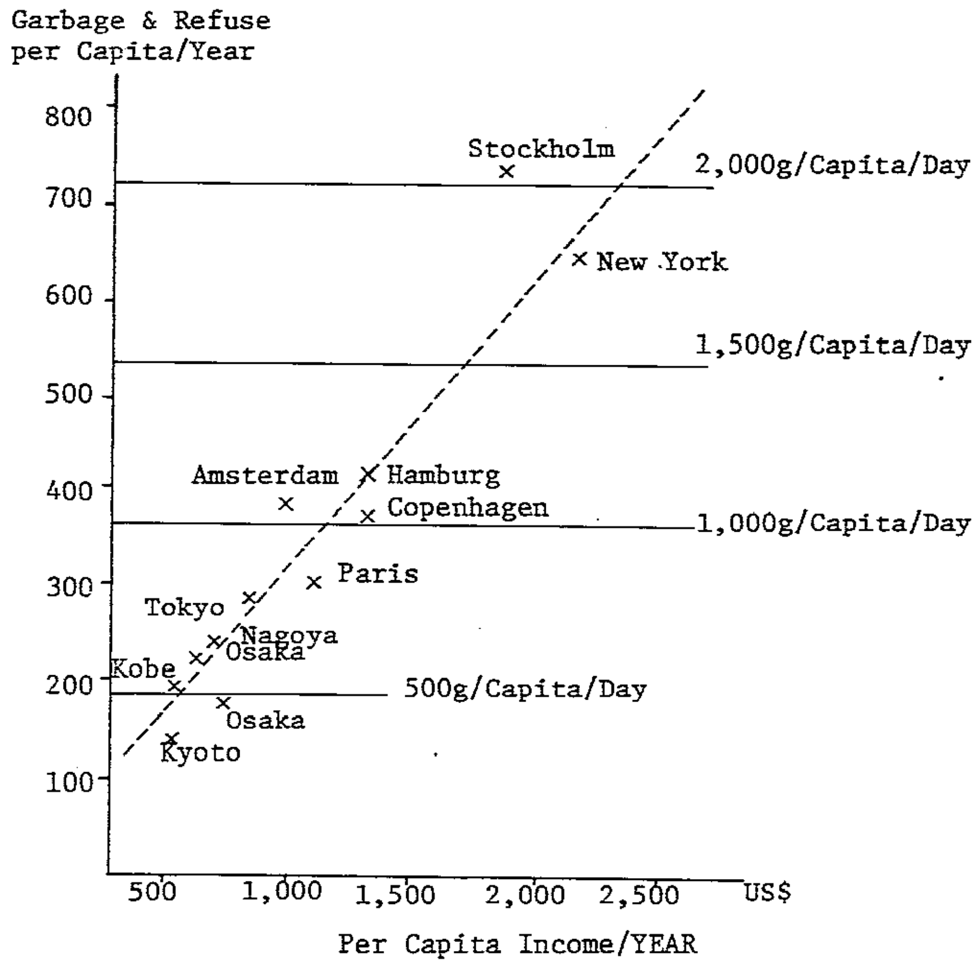
Machinery Processing

Machine shop and mechanized factories discharge an oily waste containing mineral oil and various lubricant oil that is sometimes free or emulsified. Emulsified oil is contained in mineral oil and it requires more time to separate or destroy the emulsion while retaining the natural oil. A coagulant can be applied to flocculate the emulsion, but this is usually an expensive process. The physical separation of emulsified oil can be accomplished by the use of "coalescer" equipment. The equipment is used for the separating emulsified oil in the balast waste of tankers.

APPENDIX 3 Volume of Garbage and Refuse in Some Statistics

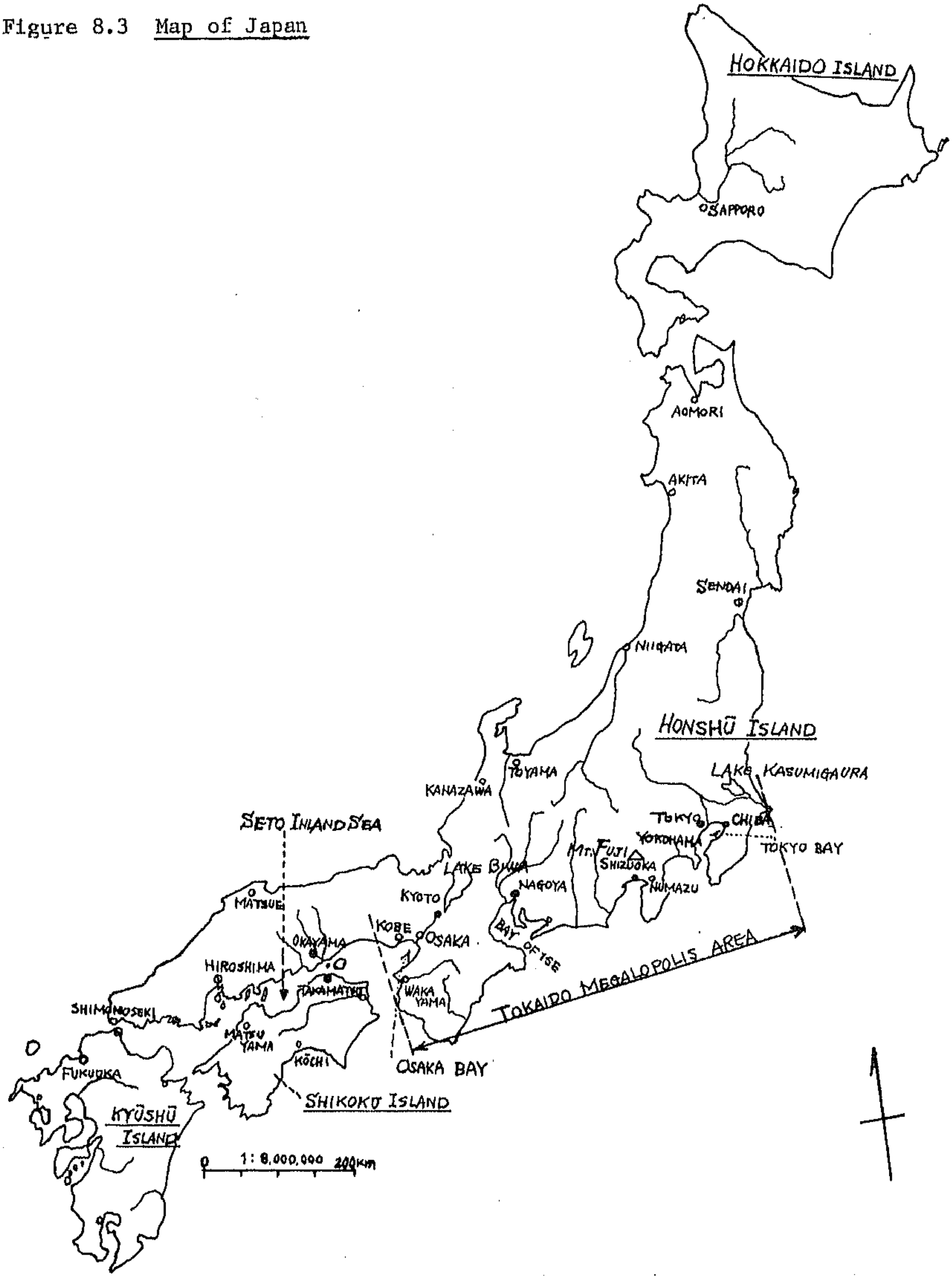


Correlation of Weight of Treated Garbage by Income and Population of Citizens in Tokyo



Correlation of Disposal of Garbage by Income

Figure 8.3 Map of Japan



Appendix 4. Poisonous Materials, Their Industrial Uses and Sources

Cd (Cadmium)

1) Metal mining of zinc, copper etc. and refining process
2) Compounds as CdO $CdSO_4$, Cd-stearate etc.
3) Pigments as DdS-ZnS, CdS-HgS etc. for paints, printing ink, glass, plastics etc.
4) Electric dry cell, Braun tube, electric rectifier etc.
5) Metal plating solutions
6) Components of alloys
7) Catalysts for the production of tele-phthalate
8) Stabilizers of PVC plastic

Pb (Lead)

1) Metal mining of lead, zinc, copper, cadmium etc. and refining process
2) Electric wire and telephone cable, lead pipe, lead plate, lead shot, etc
3) Compounds as litharge (PbO), white lead ($ZPbCO_3$, $Pb(OH)_2$)* read lead (Pb_3O_4)*, sugar of lead (lead acetate), lead stearale, lead chromate*
4) Pigments for paint and printing ink
5) Electric battery
6) Soldor
7) Crystal glass
8) Electroplating
9) Glaze for earthenware
10) Organic lead compounds for pesticide, agricultural chemicals etc.
11) Anti-knocking reagent (4-ethyl lead) (Its use and production are recently prohibited.)

(* pigments)

Cr (Chromium)

1) Chrome ore in mining and refining
2) Chromium compounds, Na-bichromate, Na, K-chromate etc.
3) Pigments, chrome yellow (lead chromate), zinc chromate, chromium oxide
4) Paint and printing ink containing pigment
5) Metal alloys (chrome steel, high tension steel, Ni-Cr-steel etc.)
6) Tanning chemical

7) Metal surface finishing

8) Textile dyeing

9) Boiler cleaning reagent

10) Other various uses (matches, catalysts, antiseptic processing of wood etc.)

Ar (Arsenic)

1) Metal mining such as copper, zinc, lead, cadmium etc. and refining

2) Arsenic compounds (Arsenous and arsenic acid, Na-arsenate etc.)

3) Some chemical fertilizer, impurities of phosphate rock, iron ore etc.)

4) Medicine and agricultural chemicals

5) Glass production process

6) Antiseptic processing of wood, hides, fishing wirenets

7) Dyeing, processing transistors, desulphurizer etc.)

Cu (Copper)

1) Metal mining of copper, lead, zinc etc.) and refining

2) Electric wire, metal plate, cast copper, copper alloys of bronze, brass etc.)

3) Copper compounds (oxide, sulphate, chlorides, carbonate-hydroxide etc.)

4) Metal plating

5) Pigment for ship paint

6) Rectifier and photocell

7) Agricultural chemicals (Bordeaux mixture)

8) Antiseptic process of wood

Hg (Mercury)

1) Mining of mercury compounds (HgS etc.) and refining

2) Electrode of electrolytic cell for chlorine-caustic production

3) Production of mercury compounds (Calomel Hg_2Cl_2, Chloride, HgO)

4) Pigment (Cinnabar, HgS)

5) Metal plating

6) Paints, laquerware, color paints containing Hg-pigment

7) Fluorescent lamp, light mercury, thermometer, pressure gauge, electric switches using liquid mercury or vaporous mercury, mercury cell

8) Medicine and agricultural chemicals*

9) Catalyst for chemical reaction*

10) Amalgamating other metals

(* Its use is prohibited; these products are being changed.)

Zn (Zinc)

1) Metal mining of zinc, copper, lead etc. and refining
2) Zinc plated steel plate (galvanized iron)
3) Zinc metal plate, die-casting
4) Metal alloy of brass, bronze, white gold etc.
5) Zinc compounds (zinc oxide, zinc sulphate, zinc sulphide etc.)
6) Pigment (zinc white ZnO, zinc chromate, etc.) for paint and plastics
7) Metal plating
8) Activation reagent for activated carbon
9) Electric dry cell coagulant for acrylonitrile or uiscose fiber etc.

Mn (Manganese)

1) Metal mining and refining
2) Contained in steel (de-oxygen, de-sulphur)
3) Metal alloys (Cu-Mn, Mn Bronze, Ni-Mn etc.)
4) Manganese compounds ($MnCl_2$, $MnSO_4$ etc.)
5) Electric dry cell
6) Paint and printing ink
7) Glazing for earthenware and porcelain
8) Dyeing, pigment (mangan white), fertilizer for grapes, tobacco etc.

Other Poisonous Materials

CN (Cyanide)

1) Metal plating bath liquid
2) Refining in copper mines, separating gold and silver
3) Synthetic processing of acrylonitrile and waste from the processing
4) Gas liquor from coke oven waste contains and thio-cyanate
5) Many kinds of complex metal compounds of CN

PCB (Polychlorinated biphenyl)

1) Electric transformer oil and electric condenser (for insulation)
2) Used in the heating process as heat conduction media
3) Used in carbonies copy paper
4) In polluted fish as biological concentrate

Industrial Fields Handling and Producing Poisonous Heavy Metals

Industrial Fields	Cd	Pb	Cr	As	Hg	Cu	Zn	Fe	Mn	Existence and Use of Heavy Metals
1. Metal Mining, Coal Washing	0	0	0	0	0	0	0	0	0	Products and impurities in metal ores
2. Textile Dyeing & Processing			0							Use of Na-bichromate for dyeing
3. Artificial Fibers							0			Fiber coagulants for viscose, acrylonitril etc.
4. Chemical Treatment of Wood			X	X		0	0			As antiseptic, anti-insect
5. Pulp & Paper Industry	0	0	0		0	0	0	0	0	Printed ink in recovered paper
6. Chemical Fertilizer	0			X	0					In Phosphate rock or ores
7. Chlorine-Caustic Production by Mercury Cell					X					As anode in the electrolytic cell
8. Inorganic Pigment Production	X	X	X		X		0	0	0	As pigments, heavy metal compounds
9. Inorganic Chemicals Other than Upper Two*	X	X	X	X	X	0	0	0	0	As heavy metal compounds products and their production processes
10. Acetylene Derivatives from Carbide					X					As catalyst
11. Organic Pigment & Artificial Dyestuff			X	0		0				Dyestuff of heavy metal complex compounds and its production process
12. Petrochemical Industry Other Than 11	X		0			0	0			As catalysts in synthesizing processes
13. Fatty Acid Production							0			As catalyst of hydrolysis of oil & fat

(con't)

	Industrial Fields	Cd	Pb	Cr	As	Hg	Cu	Zn	Fe	Mn	Existence and Use of Heavy Metals
14.	Photographic Materials Sensitized Paper etc.	X	0	0					0		In films
15.	Pharmaceutical Industry	Ø	X	X	X	X		0			Medicines containing heavy metals
16.	Agricultural Chemicals Pesticide, Herbicide etc.		0	0	0	0	0	0			In organo-metal compounds products and in their production process
17.	Chemical Reagents Production	X	X	X	X	X	0	0	0	0	Production of heavy metals containing reagents
18.	Tannery of Leather			X							For tanning process
19.	Glass and Products	X	X	0	0			0			For optical, crystal glass, and coloring
20.	Cement Production & Concrete Mixing	0 0	0 0	0 0							Contained in raw materials
21.	Refining of Ceramic Raw Materials	0	0	0				0	0	0	In glaza and pigments
22.	Iron & Steel Industry			0					0	0	As the component of alloys
23.	Non Ferrous Metal Industry	X	X	0	X	X	0	0	0	0	Product metals themselves and impurities
24.	Metal Products and Machine, Instrument etc.	X	X	X		X	0	0	0	0	In raw materials and products
25.	Metal Finishing (Acid & Alkaune)	X	0	X			0	0	0	0	Metals to be processed
26.	Metal Electro Plating	X		X	X		0	0			In plating solutions
27.	Hotel & Lodge Using Spas				X						In spring water as minerals
28.	Developing Photo-Film	X							0		In film processing
29.	Testing Laboratories	X	X	X	X	X	0	0	0	0	In materials to be tested or for experiment
30.	Organic Chemical Production Other Than 10 - 14	0	0	0		0		0	0		Paint, printing ink and other organic compounds

Appendix 5. Emission Control Standards of Poisonous Materials in Japan

Careful consideration has been given to set pollution control standards based on minimum effects on human health.

1. Cyanide: Unuseable if detected. (Limit of detection: 0.1 ppm)

The tolerable limit of cyanide on human life is reportedly 2 ppm, with a safety consideration factor of 100 times. This limit concentration seems to coincide with 48 Hr TLm for fish. The value has been set in consideration of the case in which a cyan-complex could be decomposed to free cyanogen.

2. Mercury Alkylate: Unuseable if detected. (Limit of detection: 0.001 ppm)

If man assimilates the material over a long term, the nervous system is adversely affected. Even eating fish contaminated with mercury alkylate affects the human nervous system.

3. Total Mercury: Unuseable if detected. (Limit of detection: 0.02 ppm)

Inorganic mercury can be changed to harmful organic mercury. The limit of biological thickening (accumulation) for human body, 0.25 - 0.30 mg/day, should be taken into consideration. The possibility of being affected by fish contaminated by total mercury should be considered. There is a safety factor of ten.

4. Organic Phosphorous Compounds: Unuseable if detected. (Limit of detection: 0.1 ppm)

The use of pesticides and agricultural chemicals such as parathion, methyl-parathion, EPN and methyl dimethon are already generally prohibited. Recently extremely poisonous pesticides are being replaced by materials with effective but lower content poison on the market. The limit of their assimilation into the human body is 100 mg; a safety factor of several thousandths and the survival limit for fish (safety factor of 1/10 of 48 Hr TLm) should be considered.

5. Cadmium: Harmless if less than 0.01 ppm, for infrequent contact (Limit of detection: 0.002 ppm)

A safety factor of several thousandths is used in preventing acute poisoning. A safety factor Mu Hilied several ten times should be considered though in light of accumulated assimilation in the human body, (for example, there is the historical case of the painful Itai-itai disease) through potation of water, contaminated at 0.5 ppm.

6. <u>Lead</u>: Harmless if less than 0.1 ppm, for infrequent contact. (Limit of detection; 0.15 ppm)

Oral dosage of 10 g causes death. Symptoms of lead poisoning might appear at 1 ppm. The safety factor is one-tenth.

7. <u>Hexavalent Chromium</u>: Harmless if less than 0.05 ppm, for infrequent contact. (Limit of detection: 0.05 ppm)

The limit for chronic poisoning is 0.1 ppm. It will be necessary to replace the use of either hexavalent or trivalent chromium by using total chromium to avoid pollution. Because trivalent chromium can be oxidized to form hexavalent chromium by residual chlorine in drinking water, care should be taken.

8. <u>Arsenic</u>: Harmless if less than 0.05 ppm, for infrequent contact. (Limit of detection: 0.01 ppm)

Arsenic becomes extremely harmful when combined with acids or metals. In Japan, arsenic contained dry milk in 1955 caused much suffering.

Recently, the accuracy of chemical analyses of the above chemical has been improved as follows:

CN *	0.001 mg	by photometric colorimetry
Organic phosphorous compounds	0.1 ppm	
Arsenic *	0.001 mg	
Hg- alkylate	0.0005 ppm	by atomic absorption photometry
Total Hg	0.0001 ppm	
Cd	0.005 ppm	
Pb	0.05 ppm	
Total Cr	0.1 ppm	
Cr^{+6}	0.1 ppm	

* This depends upon the initial sampling and concentration by evaporation.

Appendix 6. Tentative Projected Data for Water, Sewage and Garbage of Gran Puntarenas in 2000

(per capita/day)

	Population 1973	Population 2000	Water (400 l/capita/day) m^3/d, l/s	Sewage(85%) m^3/d	Garbage (700 g/capita/day)[1] kg/d	Garbage 30% kg/d
Puntarenas (Peninsula)	26,940	30,000	12,000	10,200	21,000	6,300
El Roble Barranca	5,883	70,000	28,000	23,800	49,000	14,700
Caldera	6,686	10,000	4,000+9,320[2]	5,100[3]	7,000[4]	2,100
Esparta		40,000	16,000	12,000[5]	24,000[6]	10,000[7]

1) Roughly 30 percent of the total garbage is organic kitchen garbage which can be used for compost, farmland or landfill.

2) Estimated at the Port of Caldera, for ships, warehouses and sprinkler (by MOPT).

3) Estimated for water at 6,000 m^3/d.

4) This value does not include the port.

5) Estimated for 75 percent of the water.

6) 600 g/capita/day is used.

7) Estimated for roughly 40 percent.

Requirements for Sewage Treatment Plant Site (tentative):

Treatment Capacity	For Oxidation Ditch (about 3-day retention)	Aerated Lagoon or Stabilization Pond (about 10-day retention)
5,000 m^3/d	12,500 m^2	2 - 4 ha
10,000	25,000	4 - 8
25,000	60,000	10 - 20

Requirements for Garbage and Refuse Landfill Site (tentative):

Site	70% of Total Vol.[1] (m^3/day)	Area[2] for One Year (m^2)
Puntarenas	45	15,750
El Roble -- Barranca	104	36,400
Caldera	15	5,250
Esparta	44	15,400

1) Apparent volumetric specific gravity of $3m^3$/1 ton is estimated; usually 2-5 m^3/1 ton are reportedly measured.

2) Approximately 30 cm of garbage and 10 cm soil are accumulated; about 1.3 meter depth per year might be estimated. The site could be utilized for more than 5 years.

A Primary Sewage Treatment for Puntarenas Peninsula can be imagined as follows:

For a population of 30,000, 85 percent of supplied water, (350 l/capita/day x 0.85 = 300 l/capita/day), is 9,000 m^3/d or 375 m^3/hr. Three times that volume can be treated in the rainy season, i.e., 27,000 m^3/d and would settle at a rate of a max. of 50 m^3/m^2/day, that is, surface area of the settling pond should be 540 m^2. Then the tentative dimension of the settling pond would use either one 26.2 mø Circular Clarifier, two 18.5 mø Circular Clarifiers or two 30 m x 9 m rectangular settling basins with screens and pumping systems.

Appendix 7. An Exemplified List for Field Inspection of Industrial Wastewater, Facts and Conditions in Various Factories

1. Name of company and factory Address:

2. Kind of industrial classification

3. Main products, raw materials and byproducts

4. Production capacity (per day, per week, per month or per year)

5. Industrial water: source and quality

   Quantity of water for each use - boiler, cooling, production, washing and cleaning, (m^3/min. m^3/hr etc.)

6. Wastewater to be discharged:

   Quality and quantity

   Maximum, average volume, m^3/hr, m^3/day (hrs per day),
   Quality, analytical data,
   Present treatment and disposal, future facilities and plans
   Location of discharged

7. Solid waste, volume per day, month, etc.

   Main discharge and quality,
   Method of final disposal

8. Company data:

   Amount of capital
   Total sales amount
   Sales income
   Profit and dividend
   Number of employees and workers
   Market price of main product, cost of waste treatment if used etc.

9. Environment of area where treated effluent waste is discharged, at present and in future, other.

10. Previous experience, effects and problems connected with wastewater and solid waste disposal in the surrounding environment including urban zone, factories, farmland, marine areas etc.

11. Operating capacity, competence of staff maintenance of waste treatment process and facility, laboratory and experimental staffs, capability of technical innovation for environmental quality improvement, etc.

Appendix 8. Sewage Treatment by the Use of Soil -- Essential Points

There are several conventional types of organic waste treatment by soil, that is, spraying or broad casting the raw waste or sediment after secondary treatment by sprinkler, gravity penetration (filtratoin) etc. The important points to be considered in waste treatment by soil are:

(a) Problems connected especially with waste sprayed in the air,
(b) Pollution of underground water by impurified wastewater leaked or filtered through soil layers.

The surface layer of soil, about 50 to 100 cm. thick, is usually composed of inorganic minerals combined with biological-organic components, containing various kinds of micro-organisms of plant and animals basically. These indicate the decomposition capacity of various organic materials. This is why the soil can be utilized effectively for treating organic waste.

The hygienic problems of soil treatment mentioned above can be solved by using this new technology. In case wastewater is fed through a vertical-type well, the soil pollution can occur, depending on the depth of the well and the level of underground water.

This type of soil treatment should use a soil-covered underground trench, avoiding direct vertical penetration. The merits of this type of sewage treatment or organic waste are: (1) it naturally avoids clogging by the biological action of decomposing organic sediment in the soil; and (2), depending upon the quality of wastewater, there are several modifications such as an underground trench for sedimentation, recirculation, contact aeration etc., each of which can be used in various combinations.

There are hundreds of experiences using this process for a comparatively small-scale waste treatment, for both secondary and tertiary sewage treatment (including ammonium and nitric nitrogen reduction) in Japan. The process is applicable to wide areas, both in rural areas and areas of volcanic sandy soil.

The speed of penetration of course depends upon the quality of wastewater and the physical and geological quality of the soil. The rate of treatment usually in the range of 0.1 to 3 m^3/m^2/day.

CHAPTER IX

TRANSPORTATION

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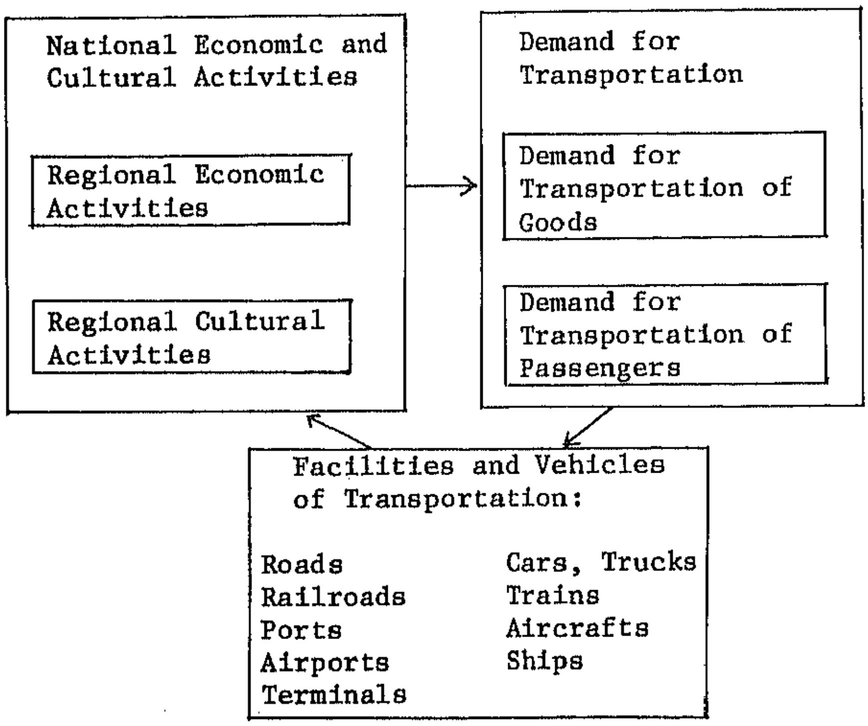
TRANSPORTATION

9.1 Role of Transportation as a Development Strategy

9.1.1 Functions of Transportation

As far as our economic and cultural activities are performed to a special degree and are inter-connected, we must prepare transportation facilities. We can depict briefly the relationship between our activities and transportation by the diagram shown in Figure 9.1.

Figure 9.1 Relationship between Economic and Cultural Activities and Transportation



Demand for transportation will be generated by the development of national or regional economic and cultural activities. Transportation facilities and vehicles will be needed to increase demand for transportation. In this case, transportation functions to stimulate regional development. On the other hand, if we supply some transportation facilities and vehicles in a region, new economic and cultural activities may appear there. For example, suppose that a road is constructed in an underdeveloped area as an accessory road to a major highway leading to a major urban area or important agricultural market. Then, in this area, agricultural production will rise. Thus, transportation has the function of serving regional development.

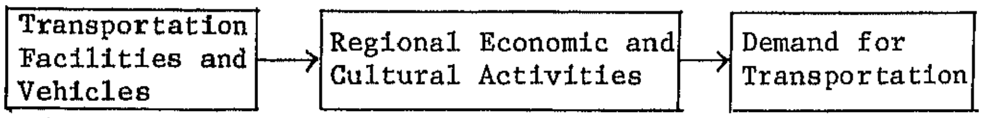
As noted above, transportation functions are classified into two kinds - one function preserves the development of a region, and the other function realizes regional development.

If we restructure the diagram in Figure 9.1, based on transportation functions, we can construct the following diagrams (Figure 9, 2).

Figure 9.2 Relationships between Economic and Cultural Activities and Transportation from a Functional Point of View

(1) Transportation Facilities and Vehicles as Equipment for Preservation of Regional Development (lagged investment)

(2) Transportation Facilities and Vehicles as the Driving Force of Regional Development (leading investment)



When transportation facilities and vehicles are regarded as equipment for preservation of regional development, they are supplied "subsequently," i.e. they are supplied after regional development has been realized. But, when they are regarded as the friving force of regional development, they are supplied "precedingly," i.e. they are supplied before regional development is realized. In other words, transportation facilities and vehicles are introduced into a region either as a "leading investment" or a "lagged investment."

Therefore, if we want to develop a region, we can use transportation facilities and vehicles as a strategic tool for development.

Table 9.1 Population, Area, Population Density, and Length of Roads (1970)

Province	Population (1,000)	Area (1,000 km^2)	Population density (person/km^2)	Length of Roads (km)			
				Total	National	Regional	Local
San Jose	630.3	4.9	128.6	1,412.4	225.3	148.1	1,039.0
Alajuela	317.7	9.5	33.4	1,564.2	269.8	239.0	1,055.4
Cartago	203.8	2.6	78.4	1,085.0	229.5	201.5	654.0
Heredia	108.3	2.9	37.3	351.2	41.9	104.2	205.1
Guanacaste	194.8	10.4	18.7	849.9	318.0	16.9	455.0
Puntarenas	217.1	11.3	19.2	948.2	386.4	47.0	514.8
Limon	90.4	9.3	9.7	264.1	23.1	33.3	207.7
Total	1,762.5	50.9	34.6	6,475.0	1,494.0	850.0	4,131.0

Note: Calculated by Mario Herrera Flores and Edgar Dowian Kikat and based on data of Ministerio de Obras Públicas y Transportes, Dirección General de Planificación.

Table 9.1 breaks down population, area, population density and the length of roads by province. Based on this data, we can calculate the per capita length of roads and the density of roads by province. These calculations are shown in Tables 9.2 and 9.3. According to these tables, the per capita length of roads is not necessarily deficient in sparsely inhabited provinces. But, the density of roads (the length of roads divided by the area) is deficient in sparsely inhabited provinces. In San Jose, a densely inhabited province, the road density is incomparably high, approximately 290 km/1000 km^2. In sparsely inhabited provinces - for example, Guanacaste, Puntarenas or Limon - the road density is less than 100 km/1000 km^2.

The supply of roads leading to and vehicles in San Jose should be regarded as the preservation of development of this province. However, the supply of roads leading to Puntarenas, for example, should be regarded as a development strategy of the province, because this region has not yet realized its potential development capacity.

9.1.2 Transportation as an Industry

Transportation can be observed in two ways. Transportation can be regarded as an activity or function; it also can be regarded as an industry.

Imagine as an extreme case that all vehicles are individually owned. In this case, transportation as an activity exists. But, this activity is a mere physical phenomenon. On the other hand, imagine another extreme case that all vehicles are owned by transportation companies. In this case, transportation exists as a mere activity as well as an industry or a business. There are two types of transportation - transportation as action and transportation as industry.

The choice between these two types of transportation in a country depends on the national policy. If transportation as an industry is regarded as effective from an economic point of view, it should be encouraged by the government. Incidentally, transportation undertaken as a business will be effective, at least, in certain transportation of persons and goods. This is adequately demonstrated if we compare a privately owned truck which is inefficiently used and a truck that is owned by a transportation company and is used efficiently.

Moreover, if transportation in a country is undertaken as a business, transportation will contribute to the increase of GDP.

9.2 Natural and Socio-Economic Conditions for Transportation Systems

9.2.1 Topography and Climate

From the topographical point of view, Costa Rica may be divided into two parts, a wide plain and a large plateau. The plateau is

Table 9.2 Per Capita Length of Roads by Province (1970)

(km/person)

Province	Total	National	Regional	Local
San Jose	2.24	0.36	0.23	1.65
Alajuela	4.92	0.85	0.75	3.32
Cartago	5.32	1.13	0.99	3.21
Heredia	3.24	0.39	0.96	1.89
Guanacaste	4.36	1.63	0.09	2.34
Puntarenas	4.37	1.78	0.22	2.37
Limon	2.92	0.26	0.37	2.30
Total	3.67	0.85	0.48	2.34

Table 9.3 Length of Roads per One Square Kilometer (1970)

(km/km^2)

Province	Total	National	Regional	Local
San Jose	288.2	46.0	30.2	212.0
Alajuela	164.7	28.4	25.2	111.1
Cartago	417.3	88.3	77.5	251.5
Heredia	121.1	14.4	36.1	70.7
Guanacaste	81.7	30.6	1.6	43.8
Puntarenas	83.9	34.2	4.2	45.6
Limon	28.4	2.5	3.6	22.3
Total	127.2	29.4	16.7	81.2

located in the middle of the country. The plain is C-shaped and spreads around the plateau as shown in Figure 9.3. As the altitude rises the temperature drops. The temperature of the plain is very high, because this country is proximate to the equator. On the other hand, the temperature of the plateau is lower, and its climate is comfortable. The population is concentrated in this latter region (see 9.2.2). Because the country has both hot and temperate regions and lacks frigid regions, it is conducive for constructing and maintaining networks of road and railroad systems. If there would be a frigid climate, roads would be sometimes freeze or possibly be covered by heavy snow. Under such conditions traffic accidents would occur frequently and the cost of road and railroad maintenance would be high. Airports also profit from this non-frigid climate.

From a meteorological point of view, Costa Rica has two seasons, a rainy season and a dry season (or summer). In the rainy season, heavy rain falls in a short time span. The heavy rain is the achilles' heal in Costa Rica's road system. If the roads are unpaved, their surface easily deteriorates in the heavy rain. But, this weak point can be strengthened by paving the roads, although paving is expensive. Of course, paved roads require a large expenditure for outlay and maintenance in places where the temperature is hot and where there are heavy rain falls. But this is not as serious as upkeep costs in frigid regions. Therefore, heavy rains can not comparatively be considered to be a great weakness.

Even in the rainy season, the coastal temperature does not become very low. Therefore, the country has no frozen ports.

In general then, Costa Rica has considerably favorable natural conditions for transportation networks.

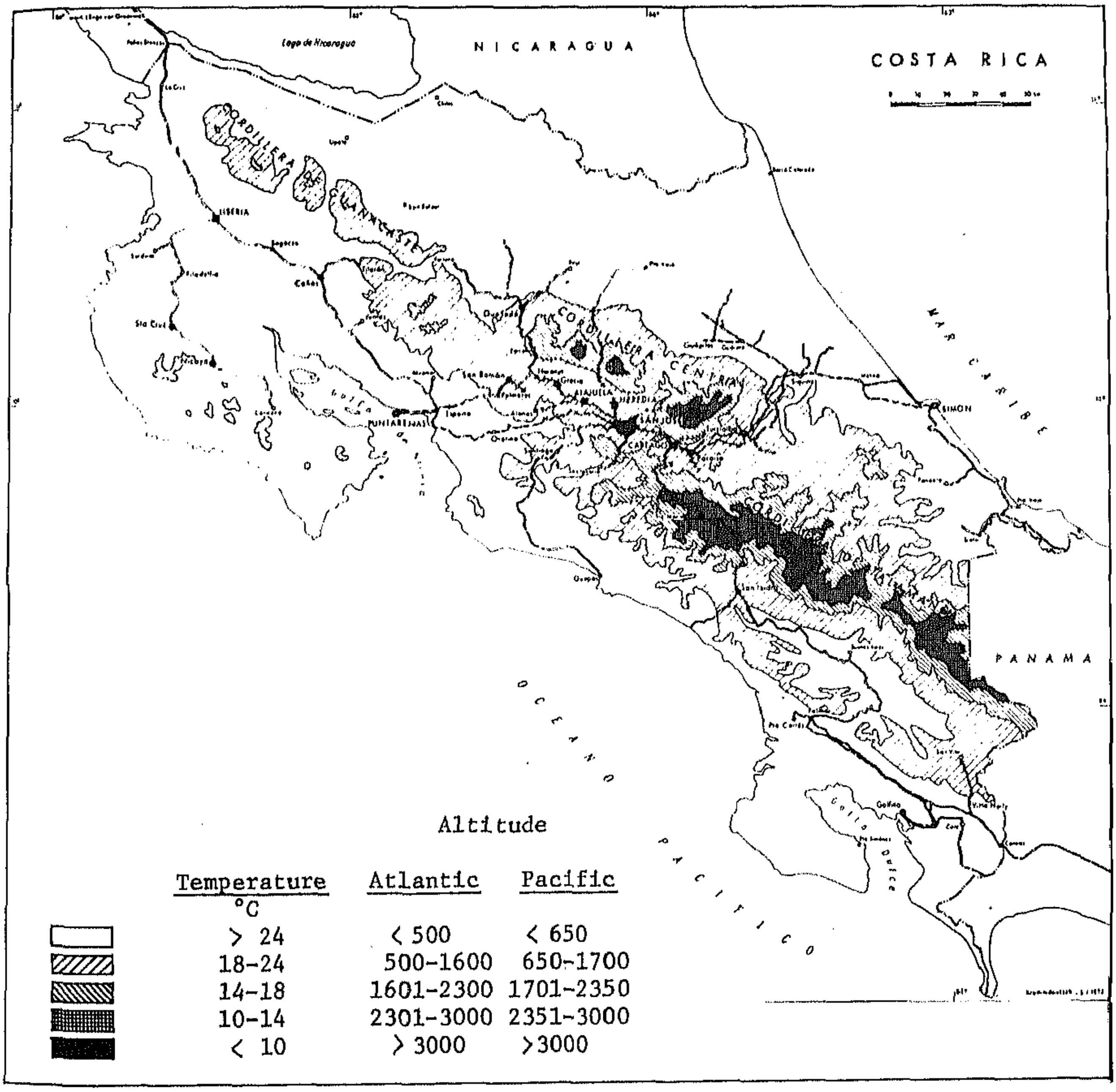
9.2.2 Population Distribution and Transportation

When we consider transportation problems, it is most important to pay attention to the population distribution, because transportation is the activity of connecting dispersed persons and the goods produced by them.

The population of Costa Rica is concentrated in the plateau region, because its climate is more comfortable than that on the plain.

This concentration is demonstrated in Table 9.4. The populations in this table are those of districts (districtos) which have more than 10,000 persons. But, the populations of San Jose, Cartago and Heredia belong to the Canton Central and have been included because they form densely inhabited adjacent districts in the Canton Central and massive urban areas. In this table the districts are classified by altitude, that is, the height above sea level. The average population

Figure 9.3 Temperature and Topography of Costa Rica



Source : H. Nuhn : Regionalization de Costa Rica, La Planificación del Desarrollo y la Administración, 1973 of each classified district is noted at the bottom of Table 9.4. As shown in Table 9.4, the average population of district becomes larger, as the altitude rises.

It is interesting to find a regular population distribution in districts having a large population, even if the population is concentrated in regions on the plateau. Table 9.5 shows the relationship between the populations of districts listed in Table 9.4 and their log ranks. Their relationship can be demonstrated clearly by the graph shown in Figure 9.4. The relationship may be expressed by the functions:

$$P = kR^{-a} \qquad (9.2.1)$$

or

$$\log P = -a \log R + b \qquad (9.2.2)$$

where R is the population rank of the district, P the population of the district which has rank R, and k, a and b (=logK) are parameters. If we draw a graph which shows the relationship between the logarithms of the population and the rank, we can get a linear relationship between them as shown in Figure 9.7. This relationship can be expressed by

$$\log P = 5.0606 - 0.7292 \log R \qquad (9.2.3)$$

This relationship, which is called "Zipt's rank size rule," is also found in the U.S.A. and Japan and is not a phenomenon particular to Costa Rica. It can be deduced that, even if the population in Costa Rica is concentrated on the plateau, the regularity of the district population is normal.

Moreover, districts having a large population are connected to each other by highways or railroads, with the exception of the Calle Blancos district which is near San Jose and has no highway or railroad. This means the main districts are already effectively connected by main roads or railways.

9.2.3 Heterogeneity of Regional Industrial Composition

As already pointed out, transportation is generated because of the spatial distribution of population. However, even if the population is distributed sparsely, the industrial composition of each region are almost similar to each other. Thus, the quantity of inter-regional flow of goods will not be large. But, if the industrial compositions of each region are different from each other, the quantity of goods transported from one region to another will be large.

To analyze and compare the industrial composition of each region quantitatively, we can use the location quotient, Q, which is defined by the following equation.

$$Q = \frac{y_i}{y} \Big/ \frac{Y_i}{Y}, \qquad (9.2.4)$$

Table 9.4 The Relation between Altitude and the Population in Large Districts (Distritos) in 1973

Altitude	0 - 500 m		500 - 1,000 m		1,000 - 1,500 m	
	Name of District	Population	Name of District	Population	Name of District	Population
Name of District and Population	Limon	40,830	Alajuela	33,122	San Jose	215,441
	Puntarenas	26,940	San Isidro	32,929	Cartago	65,310
	Nicoya	20,915	San Pedro	23,721	Herredia	36,487
	Turrialba	18,873	C. Quesada	17,029	Desam-parados	30,659
	Liberia	16,823			San Juan de Tibas	18,670
	Golfito	13,611			San Vicente Moraria	15,552
	Cañas	12,779			Guadalupe	27,016
	Santa Cruz	10,672			Calle Blanco	12,408
					Aserri	11,653
					San Rafael Oreamuno	10,434
					Paraiso Cartags	10,211
Average of Population		19,260		26,699		41,258

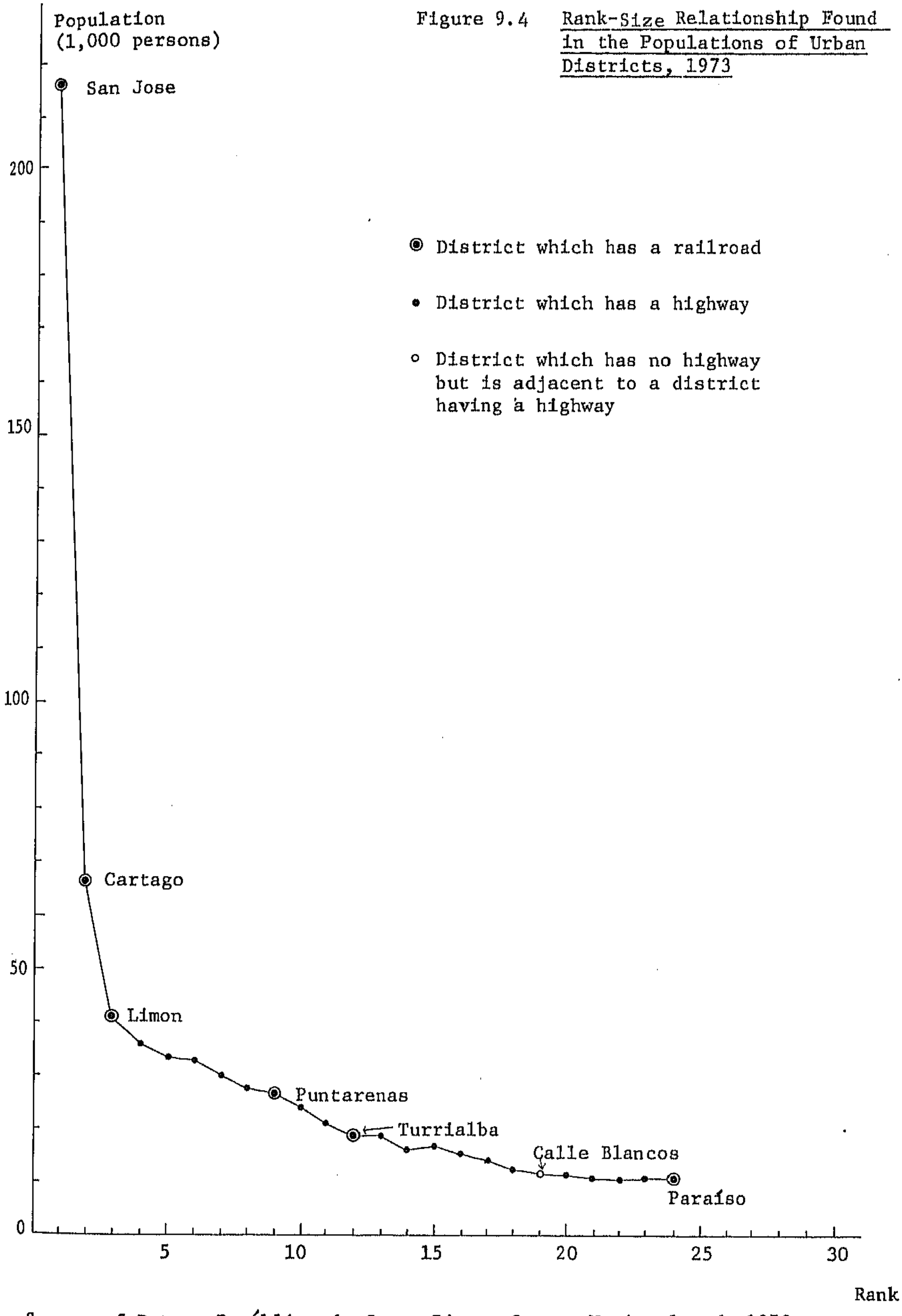
Note: These districts have populations larger than 10,000.

The populations of San Jose, Cartago, and Heredia are not those of districts, but those of Canton Central.

Table 9.5 Relationship between Population of Districts and Its Rank

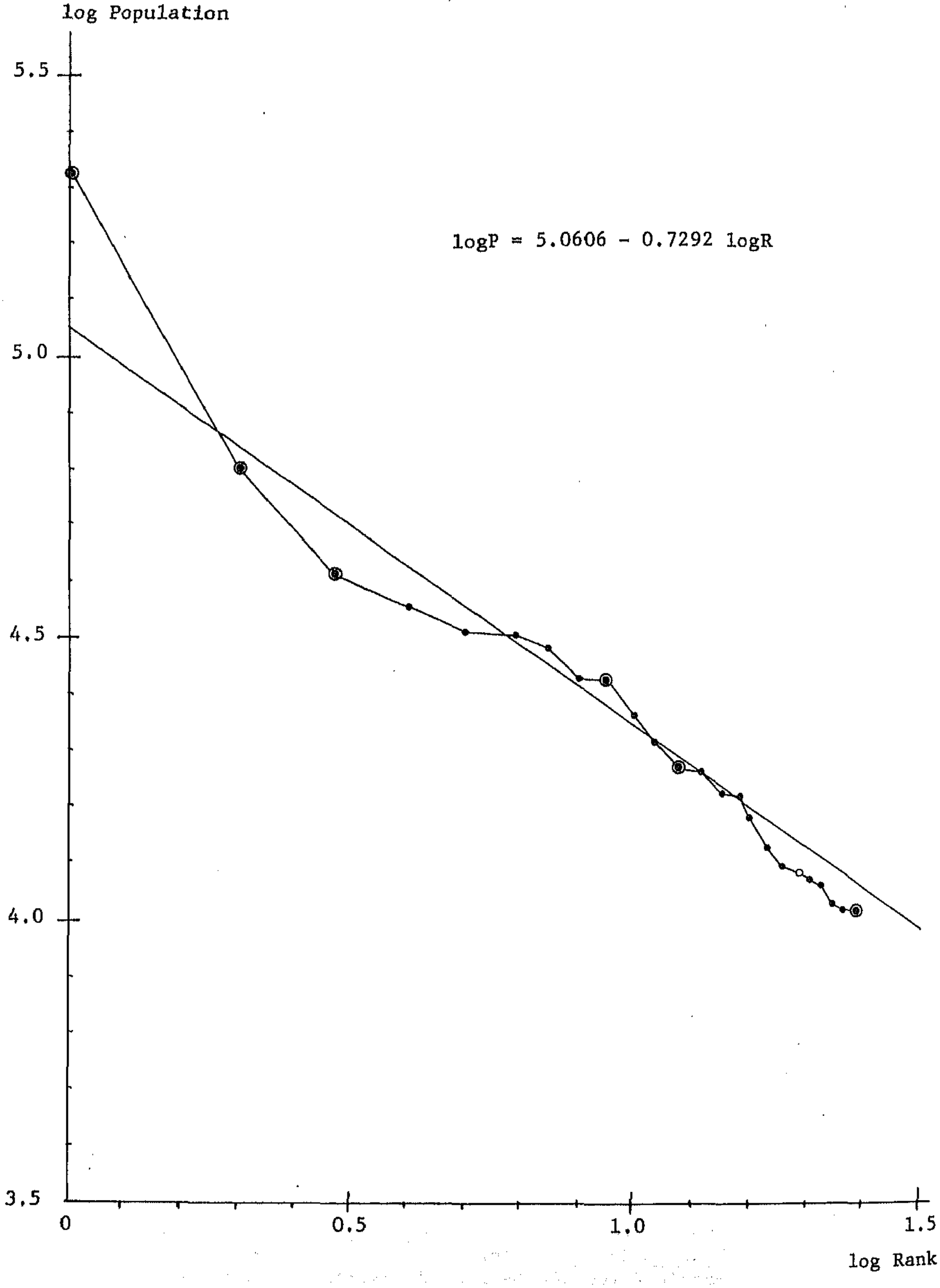
District	Rank	Log Rank	Population	Log Population
San Jose (Canton Central)	1	0.00	215,441	5.33
Cartago (Canton Central)	2	0.30	65,310	4.81
Limon	3	0.48	40,830	4.61
Heredia (Canton Central)	4	0.60	36,487	4.56
Alajuela	5	0.70	33,122	4.52
San Isidro de el General	6	0.79	32,929	4.52
Desamparados	7	0.85	30,659	4.49
Guadalupe	8	0.90	27,016	4.43
Puntarenas	9	0.95	26,940	4.43
San Pedro de Montes de Oca	10	1.00	23,721	4.37
Nicoya	11	1.04	20,915	4.32
Turrialba	12	1.08	18,873	4.27
San Juan de Tibas	13	1.11	18,670	4.27
Ciudad Quesada	14	1.15	17,027	4.23
Liberia	15	1.18	16,823	4.23
San Vicente de Moravia	16	1.20	15,552	4.19
Golfito	17	1.23	13,611	4.13
Cañas	18	1.26	12,779	4.10
Calle Blancos	19	1.28	12,408	4.09
Parrita	20	1.30	11,901	4.08
Aserri	21	1.32	11,653	4.06
Santa Cruz	22	1.34	10,672	4.03
San Rafael de Oreamuno	23	1.36	10,434	4.02
Paraiso de Cartago	24	1.38	10,211	4.01

Figure 9.4 Rank-Size Relationship Found in the Populations of Urban Districts, 1973



Source of Data: República de Costa Rica: Censos Nacionales de 1973, Población Tomo 1. Ministro de Economía, Industria y Comercio Dirección General de Estadística Censos, 1974, pp. 1-6

Figure 9.5 Zipt's Rank-Sized Rule Found in the Population of Urban Districts (1973)



where y_i is the population employed in the i th industry in a region, y the population employed in all industries in the region, Yi the population employed in the i th industry in all the regions questioned, and Y the population employed in all industries in all the regions questioned. Therefore, when a region specializes in the i th industry, the value of the coefficient becomes greater than 1.

We will analyze the industrial compositions of provinces by this method. Industry is classified in 3 sectors - primary, secondary, and tertiary sectors. In this case, the number of families is used instead of that of population in the definition of the coefficient of localization.

The number of families by province in 1973 is shown in Table 9.6. Based on the numbers presented in Table 9.6, we can obtain the location quotient. The quotient numbers are shown in Table 9.7. Accordingly, San Jose and Herredia specialize in secondary and tertiary sectors and are regarded as non-agricultural regions. Other regions are regarded as agricultural regions (see Figure 9.6). Therefore, the inter-regional flow of goods between these regions, i.e., between non-agricultural and agricultural regions, will necessarily occur. Roads must be sufficiently provided for the inter regional flow of goods.

In the future, OD (origin and destination) research for the whole country should be undertaken when a project for a road system is systematically planned, because as shown above consideration of the inter-regional flow of goods is most important in Costa Rica.

Table 9.6 The Number of Families Employed in Industrial Sectors in 1973 (1000 families)

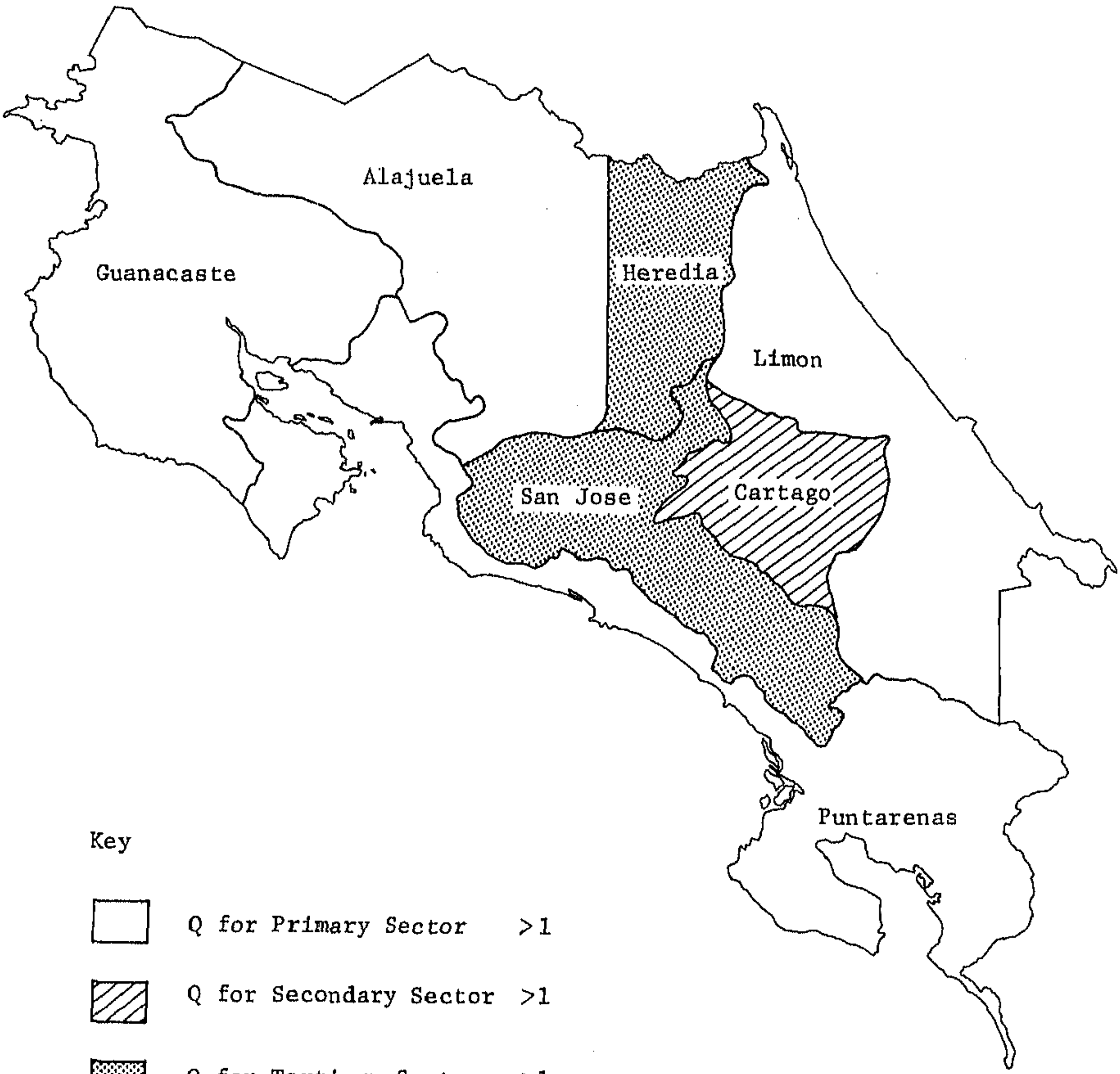
Sector \ Province	Costa Rica	San Jose	Alajaela	Cartago	Heredia	Guanacaste	Puntarenas	Limon
Primary Sector	115.0	21.9	25.2	12.7	6.2	15.3	22.5	11.2
Secondary Sector	58.4	29.0	8.4	7.0	5.3	3.0	3.8	1.9
Tertiary Sector	104.0	54.4	12.8	9.3	7.5	5.4	8.5	6.1
Total	277.4	105.3	46.4	29.0	19.0	23.7	34.8	19.2

Source: República de Costa Rica, Censos Nacionalas de 1973. Población, Tomo 2, (Ministro de Economía, 1975), pp. 3-4.

Table 9.7 The Location Quotient (Q)

Sector \ Province	San Jose	Alajuela	Cartago	Heredia	Guanacaste	Puntarenas	Limon
Primary Sector	0.501	1.308	1.055	0.786	1.557	1.559	1.405
Secondary Sector	1.303	0.858	1.142	1.322	0.602	0.517	0.469
Tertiary Sector	1.379	0.736	0.856	1.053	0.608	0.651	0.848

Figure 9.6 Distribution of Location Quotient (1973)



Key

Q for Primary Sector >1

Q for Secondary Sector >1

Q for Tertiary Sector >1

9.3 Analytic Observations of the Present State of Transportation

9.3.1 General Facts

When we observe the budget of the central government of Costa Rica, we can understand that this country over the years has endeavored to prepare a good system of transportation. Budget allocation to the transportation sector approximates 20 percent of the total budget, after 1969, although it is only 18.9 percent and 16.8 percent for 1967 and 1968, respectively (see Table 9.8). On account of this investment, total length of roads is gradually but steadily expanding and the surfaces of roads are also gradually improving.

In the future, this effort must be continued, because, as stated above, transportation will expand more and more, -- i.e., the number of vehicles, the number of the passengers, and the quantities of good transported will without doubt increase, as the size of the economic activities is enlarged.

In the following sections, we will observe many aspects of the transportation industry in relation to the G.D.P., the size of the industry steadily increasing as the G.D.P. increases, and its strong correlation to the G.D.P. Therefore, the installation of transportation facilities such as roads, railroads, airpots, and ports must be maintained, improved, and expanded to meet the enlarged demand for transportation generated by the future economic prosperity.

Fortunately, this country, as already indicated, is making an effort to prepare its transportation system. This effort should be affirmed by the facts stated above.

9.3.2 Installed Facilities of Land Transportation

(a) Roads

The length of the roads in Costa Rica has steadily enlarged as shown in Talbe 9.9. In 1970, we can find a noticeable increase of road length. This is caused specifically by an increase of length of paved roads.

The relation between the length of roads, paved, improved and unpaved and G.D.P. is shown in Figure 9.7. By this relation we can say that in this country, the total length of roads increases by 2,352.3 km and the total length of roads paved does 238.8 km when the G.D.P. increases 1 billion colones measured by the price at 1962, during the period from 1968 to 1975.

Geographical distribution of the roads is shown in Figure 9.8.

Figure 9.7 G.D.P. and Total Lengths of Roads by Type of Surface

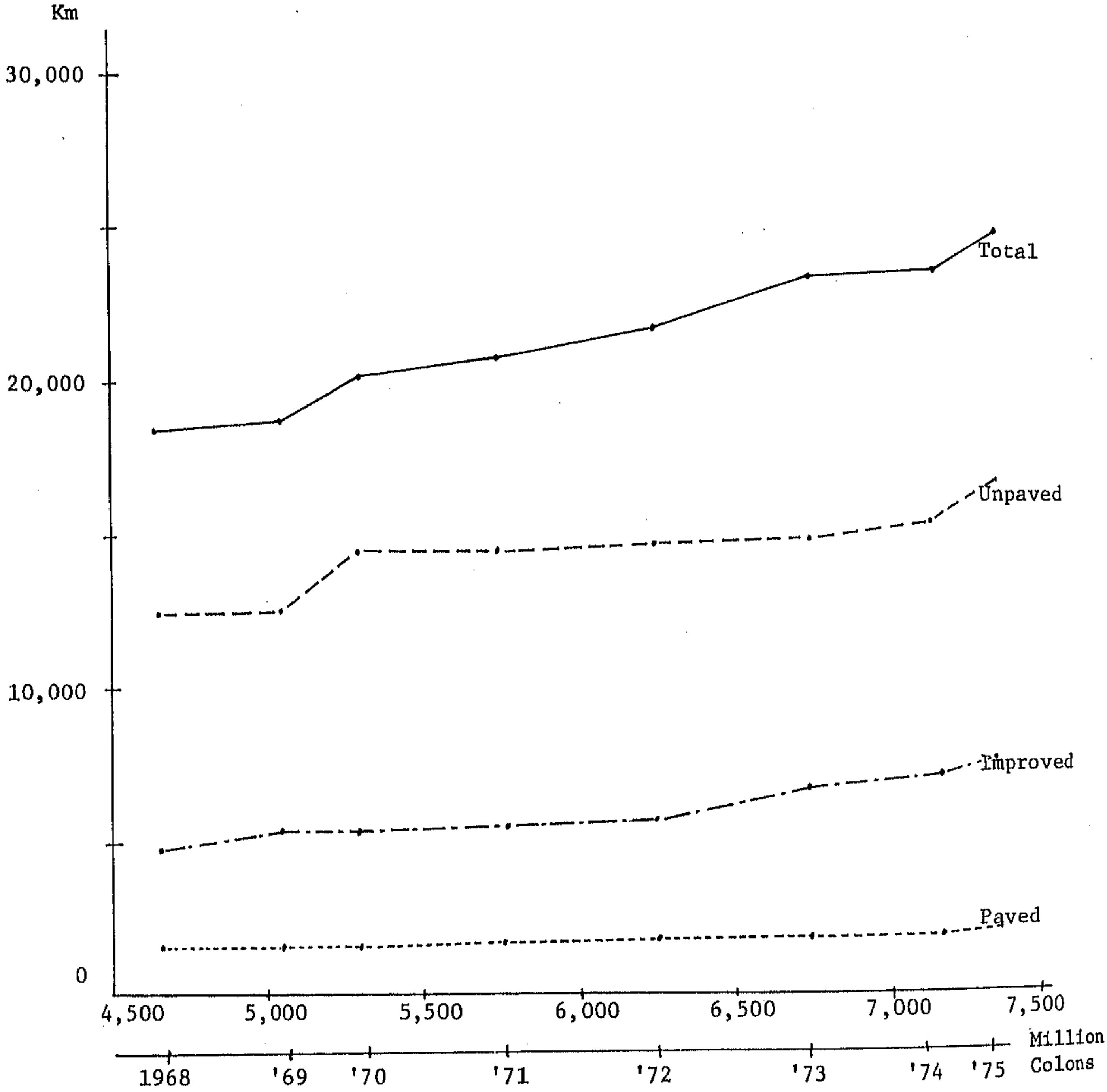


Table 9.8 Budget of Central Government and That for Transportation

(in thousand)

Year	Budget of Central Government	Budget for Transportation	Percentage of Budget for Transportation
	(million colons)		
1967	747,597	141,201	18.9
1968	790,821	132,894	16.8
1969	894,796	189,579	21.2
1970	976,669	238,927	24.5
1971	1,302,166	260,519	20.0
1972	1,432,900	348,697	24.3
1973	1,866,629	461,251	24.7
1974	2,268,800	512,719	22.6
1975	3,093,806	679,884	19.3

Source: Ministro de Obras Públicas y Transportes, Cuadros Estadísticos Sobre el Sector Transporte, 1973 y 1975, (San Jose, 1974 and 1976)

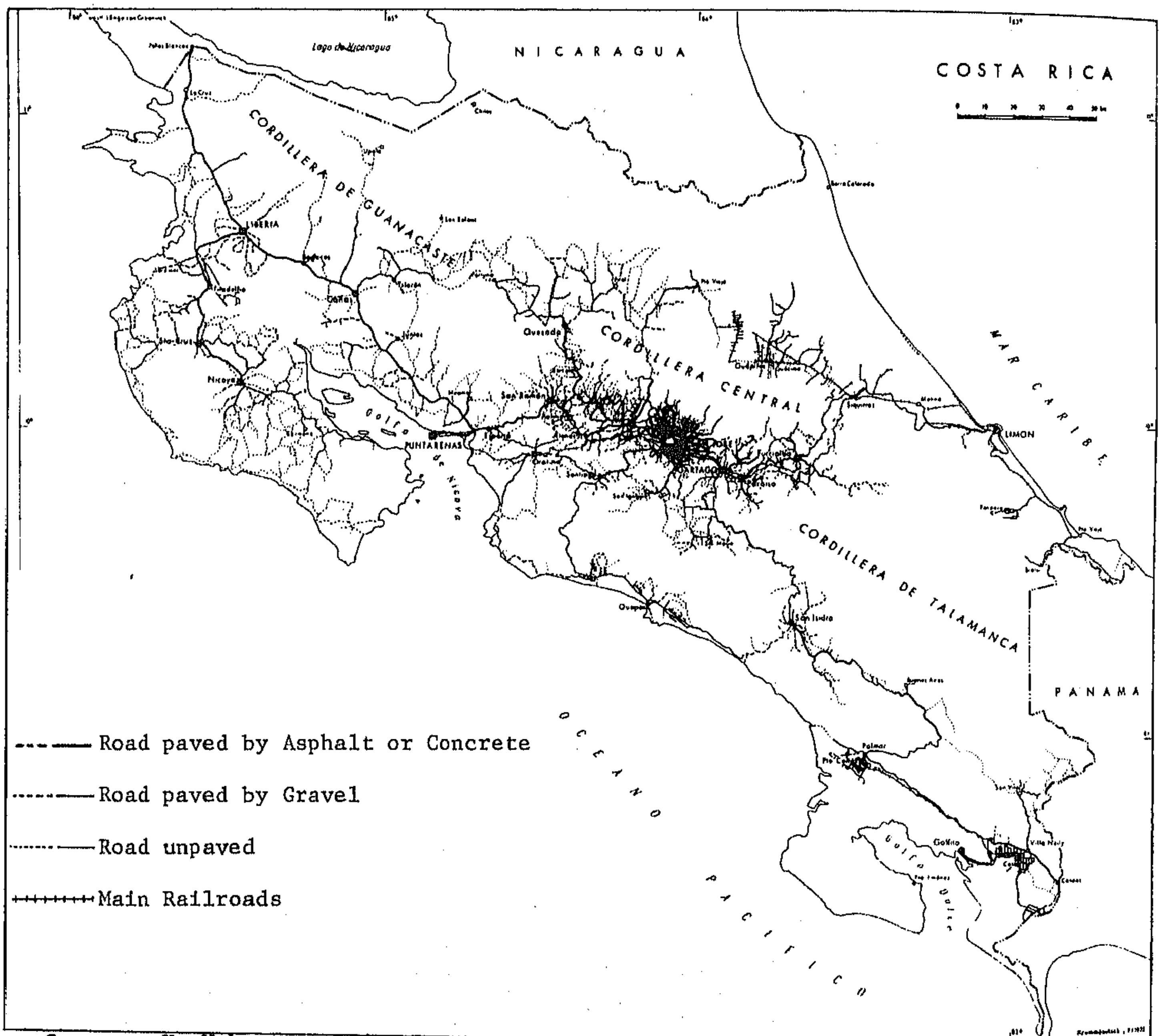
Table 9.9 Length of Roads by Class and Type of Surface

(in km)

Roads \ Year	1968	1969	1970	1971	1972	1973	1974	1975
Total	18,321	18,742	20,575	20,982	21,741	23,091	23,653	24,724
Paved	1,289	1,393	1,455	1,525	1,636	1,648	1,692	1,939
Improved	4,742	5,044	5,020	5,197	5,485	6,673	7,041	7,216
Unpaved	12,290	12,305	14,100	14,260	14,620	14,770	14,920	15,569
National Roads	1,475	1,494	1,494	1,465	1,508	1,508	1,573	1,638
Paved	752	767	841	895	997	1,009	1,052	1,279
Improved	723	727	653	570	511	499	521	359
Regional	850	850	850	866	853	853	985	1,073
Paved	416	503	503	519	519	519	457	469
Improved	434	347	347	347	334	334	528	604
Local	15,996	16,398	18,231	18,651	19,380	20,730	21,095	22,013
Paved	121	123	111	111	120	120	183	191
Improved	3,585	3,970	4,020	4,280	4,640	5,840	5,992	6,253
Unpaved	12,290	12,305	14,260	14,260	14,620	14,770	14,920	15,569

Source: Dirección General de Estadística y Censos, Annuario Estadístico Costa Rica, 1973, p. 208. 1976. CUADRO N°30

Figure 9.8 Network of Roads



Source : H. Nuhn : op. cit.

The necessity of roads will be expressed by the number of annual passenger - kilometer (number of passengers using the roads times the kilometer length of roads) of roads utilized by passengers. We can see rapid increases as shown in Table 9.10. The numbers are explained very clearly by the G.D.P. (see Figure 9.9). The numbers of passenger kilometers of national roads (L_N); regional roads (L_R); and the total (L_T) will be expressed by the linear function of G.D.P. (P):

$$L_T = a_T + b_T P \qquad (9.3.1)$$

$$L_N = a_N + b_N P \qquad (9.3.2)$$

$$L_R = a_R + b_R P \qquad (9.3.3)$$

where a_T, a_N, a_R, b_T, b_N, and b_R are parameters.

If we obtain the values of the parameters, using the data from 1965 to 1975, the results are as follows:

$$L_T = -363.2104 + 0.4700\ P \qquad r = 0.996 \qquad (9.3.4)$$

$$L_N = -214.1923 + 0.3466\ P \qquad r = 0.994 \qquad (9.3.5)$$

$$L_R = -149.6471 + 0.1235\ P \qquad r = 0.972 \qquad (9.3.6)$$

where r is the correlation coefficient. L_T, L_N and L_R are measured in million passenger-kilometer (number of passengers using the roads times the kilometer length of roads), and P is measured in million colones. Of course, these relationships are all statistically significant at the 5 percent level of significance. Using the regression lines we can estimate the future numers of passenger-kilometer. Moreover, if we suppose that the G.D.P. in Costa Rica becomes 35 or 40 billion colones in 2000, the numbers of passenger-kilometer will become as follows:

L_T : 16.1 or 18.4 billion passenger-km

L_N (National Roads) : 11.9 or 13.7

L_R (Regional Roads) : 4.8 or 4.2

The large number of passenger-kilometer will be generated not only (1) from the traffic on existing roads but also (2) from that on new roads connecting newly developed places in the country. In the former case, roads must be improved, enlarged or paved, and in the latter case they must be lengthened.

(b) Railroads

The length of railroads is almost fixed in Costa Rica as shown in Table 9.11 and Figure 9.10.

On the other hand, the number of passengers and quantity of goods transported by railroad increase steadily, as seen in Table 9.12 and 9.13.

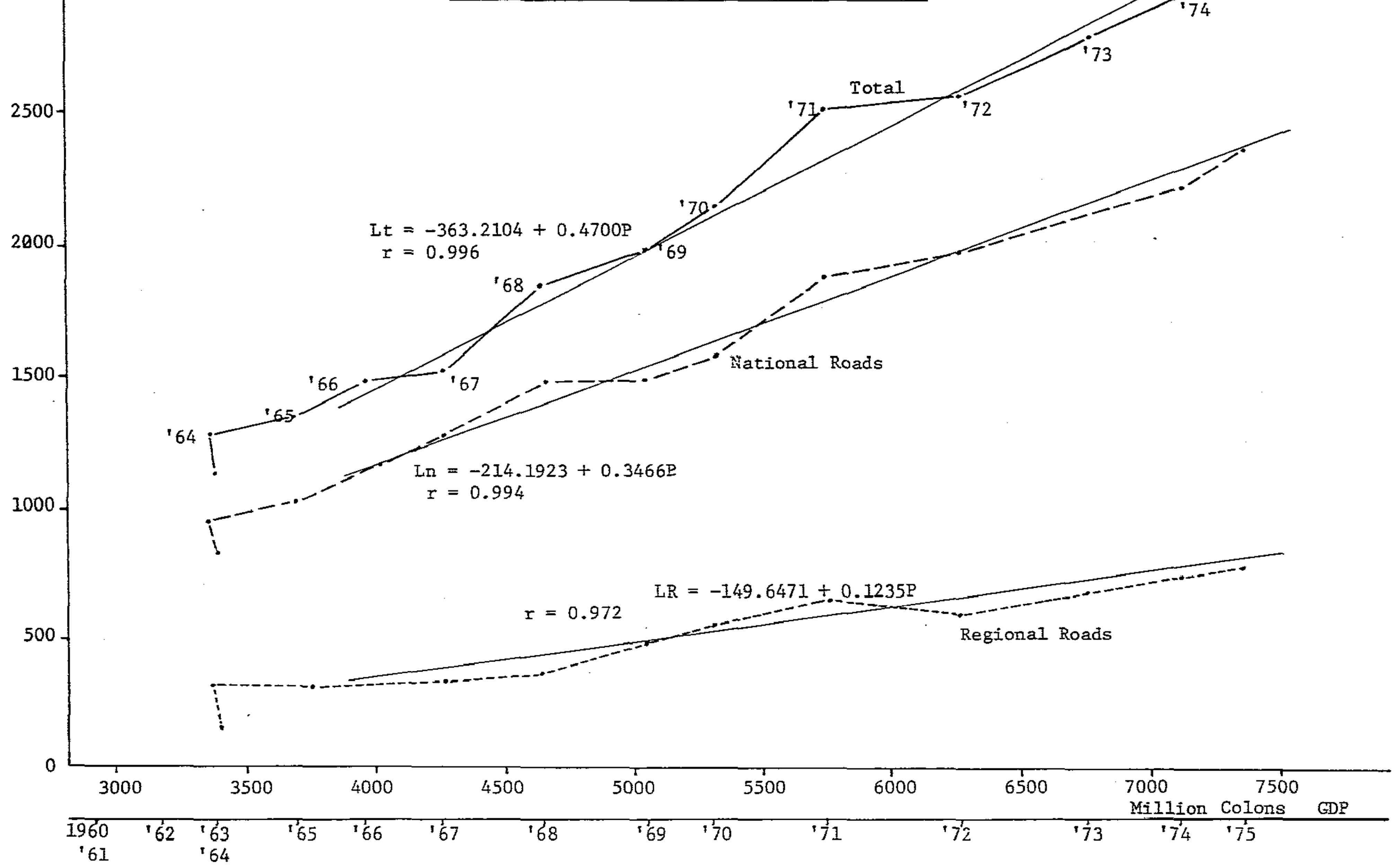
Table 9.10 Annual Passenger-Kilometer of National and Regional Roads in Costa Rica

(million passenger-km)

Year	Total	National Roads	Regional Roads
1963	1,134.58	849.53	285.05
1964	1,295.04	966.88	328.16
1965	1,355.12	1,028.40	326.72
1966	1,477.43	1,144.15	333.28
1967	1,627.09	1,279.48	347.61
1968	1,847.23	1,475.97	371.26
1969	1,990.99	1,496.77	494.22
1970	2,146.22	1,596.37	549.85
1971	2,511.08	1,867.75	643.32
1972	2,555.98	1,973.82	582.16
1973	n.a.	n.a.	n.a.
1974	2,934.21	2,213.89	720.32
1975	3,097.45	2,345.67	751.78

Source: Ministerio de Obras Públicas y Transportes, Dirección General de Planificación, Cuadros Estadísticos Soble el Sectr Transporte 1975, (San Jose, 1976).

Figure 9.9 Relation between GDP and Annual Passenger Kilometer of National and Regional Roads in Costa Rica



If we observe the relationship between the G.D.P. (in million colons) and the number of passengers (in 1,000 persons) and the quantity of goods (in 1,000 tons), we can see clear correlations between them.

The regression lines expressing the relationships are as follows:

$$N_T = 755.2940 + 0.2858\ P \qquad r = 0.932 \quad (9.3.7)$$

$$N_A = 219.8357 + 0.2125\ P \qquad r = 0.888 \quad (9.3.8)$$

$$N_P = 476.5835 + 0.0629\ P \qquad r = 0.885 \quad (9.3.9)$$

$$Q_T = 282.9364 + 0.2883\ P \qquad r = 0.897 \quad (9.3.10)$$

$$Q_A = -391.0451 + 0.2617\ P \qquad r = 0.966 \quad (9.3.11)$$

$$Q_P = 309.5235 + 0.0135\ P \qquad r = 0.387 \quad (9.3.12)$$

where N_T is the total number of passengers, N_A the number of passengers of Atlantic Coast Railroad, N_P that of Pacific Coast Railroad, Q_T the total quantity of goods transported, Q_A the quantity of goods transported by Atlantic Coast Railroad, and Q_P that of goods transported by Pacific Caost Railroad. (See Figures 9.11 and 9.12)

From the results written above, the existence of positive correlations between G.D.P. and the number of passengers or the quantity of goods transported are clearly confirmed.

Therefore, it can be said without doubt that the number of passengers and quantity of goods transported by railroads will increase as the G.D.P. increases in the future. In fact in 2000, these volumes will become as follows:

N_T : 10.8 to 12.2 (million persons)

N_A : 7.7 to 8.7

N_P : 2.7 to 3.0

Q_T : 10.4 to 11.8 (million tons)

Q_A : 8.8 to 10.1

Q_P : 0.8 to 0.9

Although the quantity of goods transported does not increase as rapidly as the G.D.P., it does show an increase. At the present time, however, because goods are transported by trucks on roads, the quantity of goods transported by railroad does not increase so much that we can say clearly it is becoming significantly larger as the G.D.P. increases. But, when the bulky cargo will be generated by the development of industry, the role of railroads will become very important. Railroads, then, must be sufficiently provided. In the future, all railroads will be constructed with a double-track, but at present, most railroads have only a single track. Unfortunately, in recent years, the

Table 9.11 Length of the Railroads in Costa Rica

(kilometer)

Year	Total	Pacific Railroad	Atlantic Railroad	Banana Company of Costa Rica
1965	973.9	135.9	520.8	316.9
1966	974.8	137.0	523.0	314.8
1967	970.3	137.0	529.1	304.2
1968	980.1	137.0	533.1	310.0
1969	1,074.5	162.0	562.5	350.0
1970	1,030.6	162.0	577.8	290.8
1971	1,040.6	162.0	581.1	297.5
1972	1,040.6	162.0	581.1	297.5
1973	1,031.1	162.0	581.1	288.0
1974	1,032.6	162.0	573.3	297.3
1975	1,032.6	162.0	573.3	297.3

Source: INCOP, JAPDEVA, Compañía Bananera de Costa Rica.
Ministerio de Obras Públicas y Transportes: op. cit.

Figure 9.10 Length of the Railroads in Costa Rica

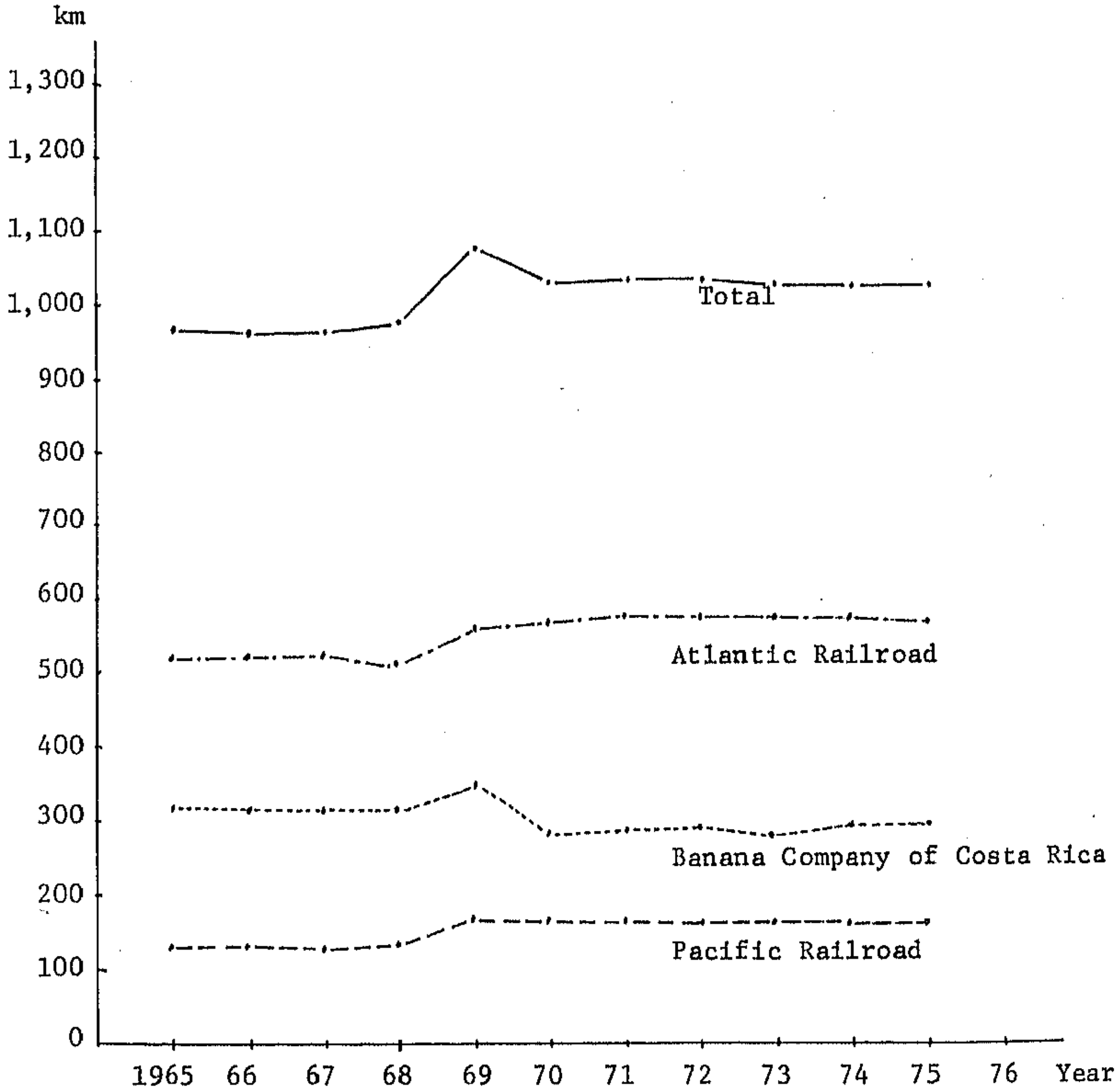


Table 9.12 The Number of Passengers Transported by Railroads

(person)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Total Passengers	1,818,740	1,876,785	2,133,018	2,310,444	2,321,847	2,383,877	2,576,443	2,770,681	2,980,227	2,563,506
Pacific Railroad	754,528	765,787	754,675	739,499	809,751	830,268	892,056	871,227	1,006,450	902,015
Atlantic Railroad	959,129	1,002,707	1,261,910	1,466,155	1,399,113	1,434,091	1,595,701	1,771,228	1,829,753	1,510,784
Railroad of Banana Company	105,083	108,291	116,433	104,790	112,983	119,518	88,686	128,226	144,024	150,707

Source: INCOP, JAPDEVA, COMPANIA BANANERA DE COSTA RICA.

Ministerio de Obras Públicas y Transportes: op. cit.

Table 9.13 The Number of Goods Transported by Railroads

(Ton)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Total	1,298,858	1,321,501	1,588,715	1,805,822	2,139,983	2,112,567	2,176,262	2,270,584	2,320,104	2,108,191
Pacific Railroad	340,100	344,792	348,077	379,203	436,901	439,053	399,870	436,041	398,849	337,845
Atlantic Railroad	617,819	627,127	783,816	1,015,479	1,060,569	1,200,490	1,344,203	1,371,087	1,517,806	1,367,565
Railroad of Banana Company	340,939	349,582	456,822	411,140	642,513	473,024	432,189	463,456	412,449	402,781

Source: INCOP, JAPDEVA, COMPANIA BANANERA DE COSTA RICA.

Ministerio de Obras Públicas y Transportes: op. cit.

Figure 9.11 **Relation between GDP and the Number of Passengers of Railroads**

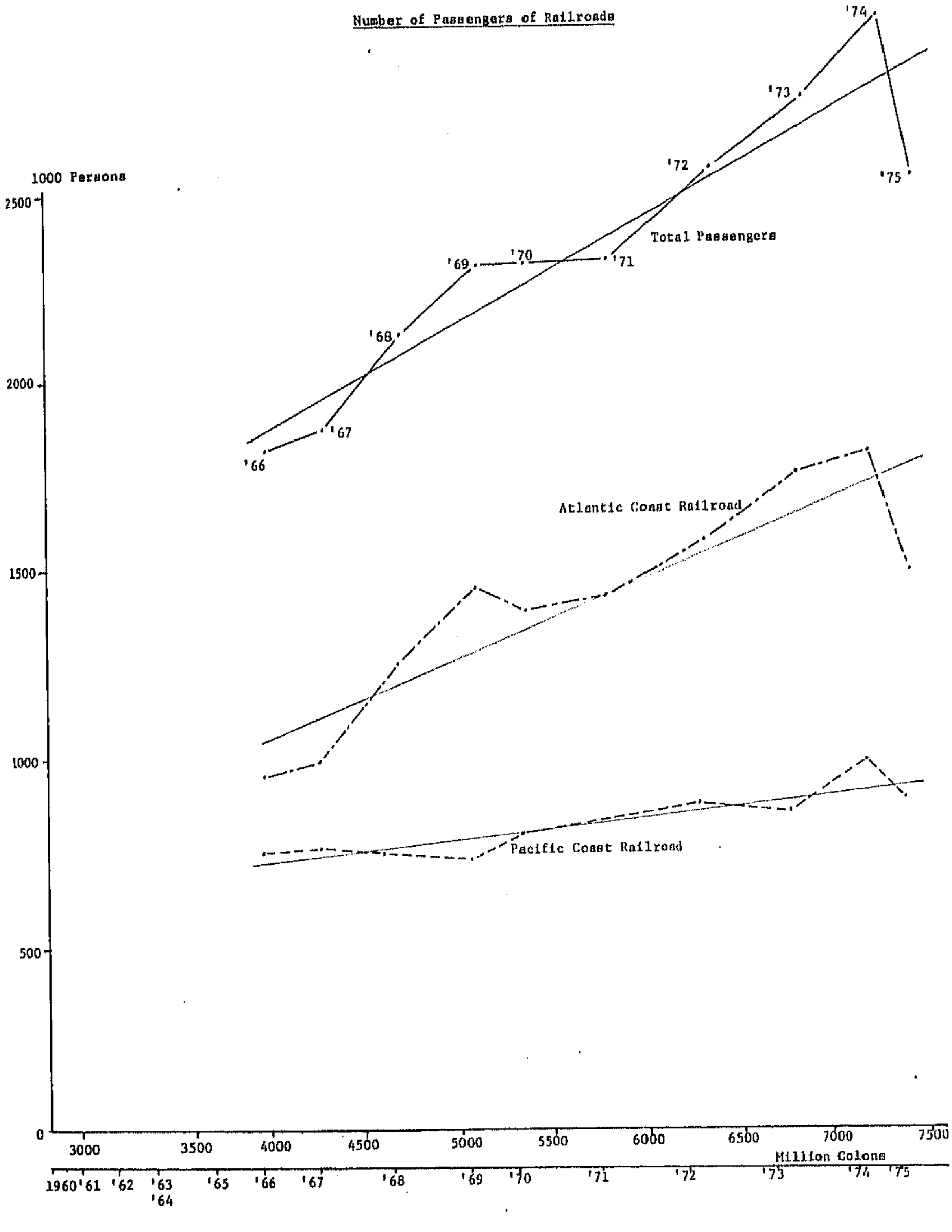
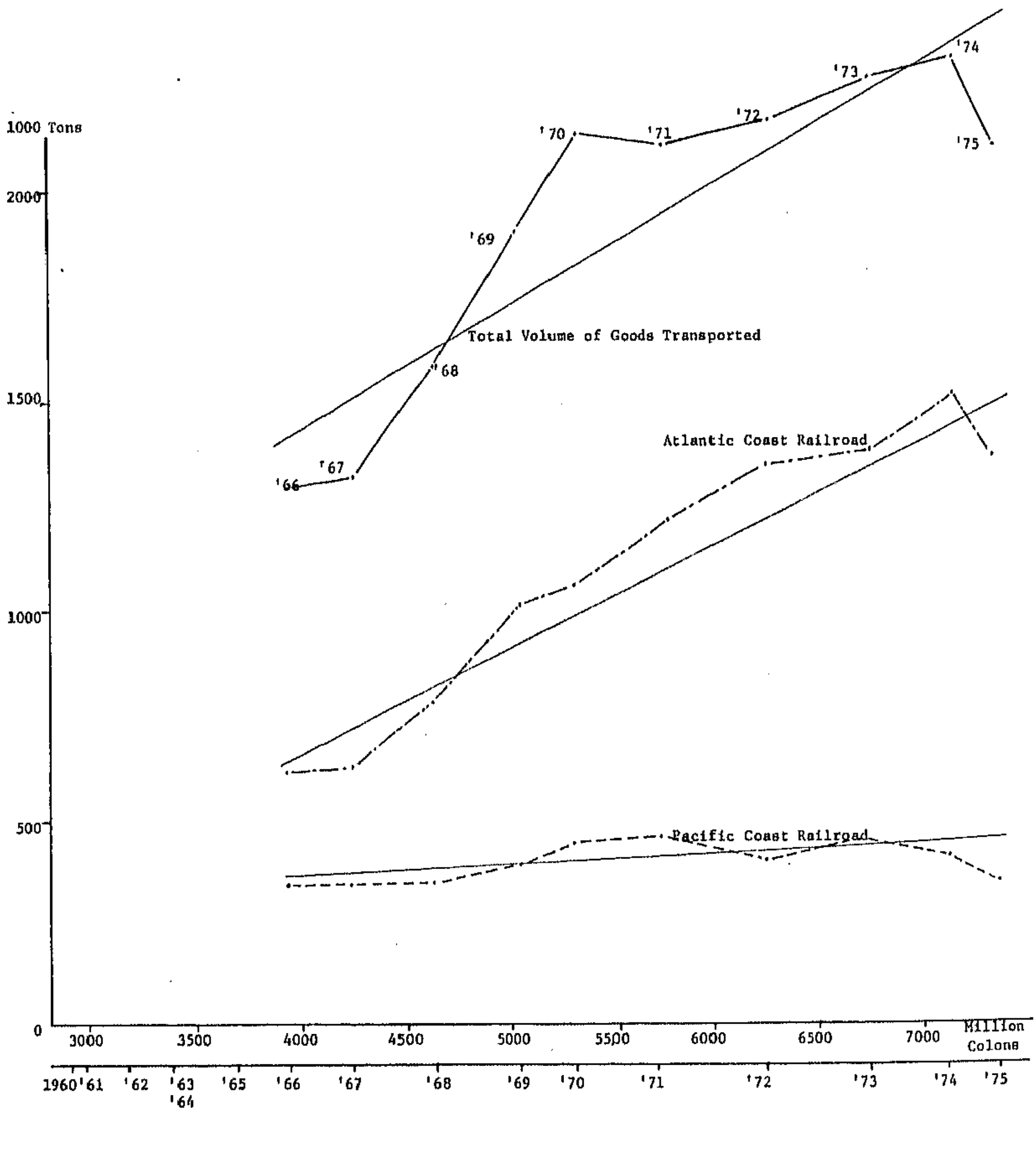


Figure 9.12 Relation between GDP and the Volumes of Goods Transported



management of the Pacific (INCOP) and Atlantic (JAPDEVA) Coast railroads have been seriously embarrassed by their low income and high costs (Table 9.14)[1/]

Table 9.14 Total Incomes and Costs of Pacific and Atlantic Railroads

(colons at current price)

Year	Pacific Railroad			Atlantic Railroad		
	Total Income (A)	Cost (B)	Coefficient (A/B)	Total Income (A)	Cost (B)	Coefficient (A/B)
1965	11,628,543	10,551,899	1.102	25,584,628	21,076,538	1.214
1966	11,162,050	11,012,923	1.014	25,778,911	24,405,497	1.056
1967	11,415,673	11,964,155	0.954	28,555,212	25,291,982	1.129
1968	12,464,708	12,290,498	1.014	34,414,796	30,355,870	1.134
1969	13,732,075	12,766,974	1.075	40,247,541	34,705,104	1.160
1970	16,399,128	14,677,374	1.117	41,843,040	50,559,779	0.827
1971	16,694,636	16,462,948	1.014	46,304,623	50,856,921	0.910
1972	16,058,265	17,621,211	0.911	60,435,201	55,202,459	1.095
1973	16,238,493	17,573,992	0.924	70,216,518	64,222,953	1.093
1974	17,932,075	20,319,187	0.883	78,628,823	74,377,203	1.057
1975	16,058,680	23,613,453	0.680	99,918,761	101,305,773	0.986

Source: INCOP, JAPDEVA.
<u>Ministerio de Obras Públicas y Transportes</u>: op. cit.

To improve this bad condition of railroad management, at the beginning of this year the two railroads (INCOP and JAPDEVA) were united with each other and a new management system, called Ferrocarriles de Costa Rica, was born. (See Appendix A) We hope that railroad management is improved by the new system, because the role of railroads is very important, as shown above.

1/ According to the report of the feasibility study of the INCOP, in recent years the average transportation cost of goods is 0.415 colon/ton/km while the income is 0.296 colon/ton/km; the average transportation cost of persons is 0.172 colon/person/km while the income is 0.162 colon/person/km. From these facts we can see relatively higher costs compared with the lower income.