Workshop on Systems Analysis: Summary Report (1984)

Pages
123

Size
8.5 x 10

ISBN
0309324483

Board on Science and Technology for International Development; Office of International Affairs; National Research Council; Agency for the Assessment and Application of Technology, Government of the Republic of Indonesia

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These proceedings have been prepared by the Board on Science and Technology for International Development, Office of International Affairs, National Research Council, for the Mission to Indonesia, U.S. Agency for International Development, under Contract AID 497-79-100-23.

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PREFACE

In 1982, Indonesia's Agency for the Assessment and Application of Technology (BPPT) invited the Board on Science and Technology for International Development (BOSTID) of the National Research Council (NRC) to join it in sponsoring a workshop on systems analysis (S/A). Held in Jakarta, Indonesia, February 8-12, 1983, this workshop explored the use of systems analysis as a tool for attaining development goals. The BPPT recently introduced this methodology as a significant interdisciplinary team activity within its organization with the purpose of integrating research and technology more effectively within the Indonesian economy. BOSTID addressed this subject in 1976 with its publication of Systems Analysis and Operations Research: A Tool for Policy and Program Planning for Development.

Systems analysis is a methodology that, when properly undertaken, permits policy decisions to be informed and based on the relative merits of alternative courses of action within complex areas of the Indonesian government's infrastructure. This methodology can also be used to reinforce the development of REPELITA IV, Indonesia's fourth 5-year plan (1984-89), and master plans for implementing the courses of action chosen.

Particular attention was given in the workshop to illustrative studies focusing on Indonesian concerns with solid waste management, urban transportation, and the food system. Addressing these concerns were scientists, engineers, development specialists, administrators, and educators.

These discussions were one activity in a larger program of cooperation between BOSTID and the Indonesian government. Begun in 1968, this program has featured a series of workshops on food policy, industrial and technological research, natural resources, rural productivity, and manpower planning. BOSTID's participation was supported in the context of a science and technology loan from the U.S. Agency for International Development (USAID) to the government of Indonesia. The project with BOSTID calls for two or three activities (panel discussions, workshops, seminars, or small advisory groups) to be organized each year.

ORGANIZATION OF THE WORKSHOP

BPPT organized the workshop to explore the overall applications of systems analysis as a tool in attaining development goals, focusing particularly on three studies being undertaken by BPPT: solid waste management, urban transportation, and the Indonesian food system. Dr. David B. Hertz, director of the Intelligent Computer Systems Research Institute, University of Miami, and member of the panel for the 1976 BOSTID systems analysis report, chaired the NRC panel. Other panel members, who were chosen for their experience in the specific problem areas, were: Abraham Michaels, consulting engineer, Osterville, Massachusetts (solid waste management); Professor Britton Harris, School of Public and Urban Policy, University of Pennsylvania (urban transportation); and Dr. Walter L. Fishel, assistant director, Ohio Agricultural Research and Development Center, Ohio State University (food systems).

The chairman of the Indonesian workshop organizing committee, Ir. Suleman Wiriadidjaja (BPPT deputy chairman for systems analyses), convened the workshop in plenary session on the morning of February 8 (see Appendix A). At the opening session, Dr. B. J. Habibie, minister of state for research and technology and chairman of BPPT, addressed the participants and stressed the need for further development of systems analysis in Indonesia (see Appendix A for opening remarks by Dr. Habibie and Dr. Hertz). Professor M. T. Zen for BPPT and Dr. Hertz also delivered lectures at this session on S/A approaches and needs for developing countries. Subsequently, the participants broke into three working groups, each addressing a different problem area (see Appendix B for the workshop agenda and Appendix C for a list of participants). Study team leaders in the three areas outlined their methodology and efforts, and the NRC panelists led discussions based on papers they had prepared on the utilization of systems analysis in those areas.

The following two days, NRC panelists accompanied small groups of the Indonesian study teams on field visits. The solid waste management group visited a composting plant, the solid waste improvement program pilot project, and the open dumping and sanitary landfill in Jakarta, and the composting plant and waste disposal equipment center in Surabaya. The urban transportation group visits included the Jakarta area and the Tool Road and Sidoarjo Corridor in Surabaya. The food system group concentrated on site visits in the Yogyakarta region, including rice producers, cooperatives, and distribution centers. These visits allowed firsthand observation and discussions at field sites and intensive interaction with Indonesian study members.

To address some of the general principles of systems analysis and their applications to problem solving, Dr. Hertz gave an informal lecture at BPPT upon the return of the waste management and transportation groups the morning of February 11 (see Appendix D). In the afternoon, following the return of the food system group, working group sessions were continued at BPPT to formulate recommendations. These were drafted by the NRC panelists on behalf of the working groups and were presented at the final plenary session at BPPT the morning of February 12.

Part I of this report includes the presentations made at the opening plenary session of the workshop; Part II, Indonesian studies of the three problem areas of solid waste management, urban transportation, and food systems which formed the basis for the working group discussions and comments by the NRC panelists; and Part III, the observations and recommendations of workshop participants on the application of systems analysis to the three problem areas.

This workshop report was prepared by Augustus Nasmith, Jr., of the BOSTID staff using the papers written by the Indonesian and NRC workshop participants. The papers have been edited to eliminate duplication, but they accurately reflect the discussions. The final draft was reviewed and approved by the members of the NRC panel and the Indonesian steering committee. Sabra Bissette Ledent, BOSTID consultant, edited the report.

Participants would like to acknowledge the valuable contribution of the workshop's organizing committee to the final arrangements for the workshop as well as the site visits to Surabaya and Yogyakarta. The organizing committee was chaired by Ir. Suleman Wiriadidjaja, deputy chairman for systems analyses, BPPT, and cochaired by Ir. Wardiman Djojonegoro, deputy chairman for administration. Dr. Untung Iskandar, leader, Basic Human Needs Project, BPPT, was coordinator. Organizing committee members included: Drs. Ansorudin, Dra. Habsari Kuspurwahati, Ir. Hariadi Wardi, Ir. Henky Sutanto, Ir. Jajang Hasyin, Drs. Komarudin, Drs. Lukman Sukarma, Ir. Soedarmodjo.

INTRODUCTORY NOTE:
SYSTEMS ANALYSIS, AN APPLIED RESEARCH PROCESS

David B. Hertz
Chairman, NRC Panel

Policy decisions and specific plans related to transport, food, waste disposal and sanitation, industry, export, and tourism, among other key systems, are in the long run improved by the application of S/A techniques. Systems analysis is an applied research process that includes the following key elements:

1. Statement of the problem. Systems analysis begins with a statement of the problems to be tackled, such as those presented to the NRC panel concerning solid waste disposal, urban transportation, and the food system in Indonesia.
2. The objectives of an S/A study must be outlined at the outset as well as the measures of performance used to determine whether the results of S/A recommendations would in fact improve the system outputs. These objectives may be modified as the study proceeds.
3. The structure or pattern of behavior of the system under study must be analyzed through the collection of data and information and by examining how the variables interact. This step provides the basis for the systems model or models.
4. The variables--elements of the system--must be identified and the general outlines of the system sketched out. The scope or boundaries of the system to be analyzed must be clearly understood by the analysts and policymakers.

5. The constraints on variables and performance, minimum or maximum, and the availability of resources establish the framework within which systems analysis is carried out.

6. The criteria used to evaluate the performance measures must be agreed on by the S/A team, in cooperation and coordination with the policymakers and agency leaders who have provided the statement of the problem. These criteria should be determined in conjunction with the decision makers prior to the study since they will directly affect the S/A study design.

7. The concept of trade-offs follows directly from the criteria applied to the performance measures. Two or more such criteria may be opposed to one another in the decision process and must be balanced in arriving at final conclusions.

8. Assumptions about the process, variables, objectives, and constraints must be spelled out explicitly if the results of the systems analysis are to be effective in the long term. Because the world constantly changes, assumptions that held at one time may no longer be valid in the future. Thus they must not be buried where they cannot be continually examined and realistically appraised and adjusted.

9. Hypotheses as to system relationships must be developed using assumptions, data, information, performance measures, and analytical methods. These hypotheses can be formulated from theoretical methods and algorithms, computer programs, and practical applications used and reported in the operations research/management science/systems analysis literature throughout the world, including the developing countries. From the analyses and hypotheses, a model or models to test the alternative courses of action evolve. The time span that the alternatives cover must be spelled out in terms of the statement of the problem and the objectives.

10. Real and simulated tests of the systems models and data analysis are then necessary to evaluate the analysts' approaches to the problem under study. The best alternatives will be those that are stable and resilient.

11. Recommendations to the policymakers, citing reasons for the choices suggested, show the visual outcomes of these studies. Because many will have multiple and nonquantifiable measures and objectives, trade-offs, requiring subjective judgments as to appropriate decisions, will be necessary. These, of course, will be modified by the final decision makers, giving consideration to policy issues that may not or could not have been included in the analysis.

12. Finally, it is incumbent upon the systems analysts to suggest plans for implementing any alternative suggested and controlling the decision's implementation.

This report seeks to demonstrate each of these steps as they are applied to the specific areas of the NRC panel's work with BPPT staff in Indonesia, both during and after its visit.

CONTENTS

OPENING PRESENTATION

A Systems Approach to Development Planning Processes*

M. T. Zen
Deputy Chairman for Natural Resource Development
Agency for the Assessment and Application of Technology (BPPT)

The world is facing transformation, but the greatest technical innovation of the future will not lie in the design of one nuclear reactor or one airplane. It will involve whole systems of energy development, transportation and communication, defense, human settlements, industrial complexes, food production, education, and public health.

The basic scientific factors that underlie the elements of the system will become ever more important. Basic science will lead us to new realms of innovations in which the life sciences, earth sciences, physical sciences, and behavioral sciences will be combined in new ways of learning and in new forms of societal life.

With the aid of the simulation techniques and computers that are now available, the time has come to seek more common languages and common concepts for a joint system of man and nature in the so-called Man-Society-Nature-Technology System.

A systems approach to development planning aims to (1) introduce a systems approach in the planning process, (2) show why a systems approach is needed in the process, and (3) indicate areas where the systems method can be applied effectively. Here we will focus on the need for systems thinking, becoming familiar with systems, understanding the systems approach, and some examples of application.

There are numerous definitions of a system, but all denote the interrelationship of components:

- "An organized or complex whole."--R. A. Johnson, et al.
- "An assemblage or combination of things or parts forming a complex whole."--E. W. Martin
- "An aggregation or assemblage of objects united by some form of regular interaction or interdependence; a group of diverse units so combined by nature or art to form an integral whole, and to function, operate, or move in unison and, often, in obedience to some form of control."--Webster's New International Dictionary, 2nd ed.

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*Professor Zen's animated oral presentation explored a number of relationships of systems analysis to the development process, with illustrative graphics to stimulate thinking and understanding. In the absence of a formal paper, his address has been summarized.

- "A bundle of relationships."--A. Rapaport
- "A configuration of components interconnected for a purpose according to a plan."--M. H. Grosz

Table 1 illustrates three types of systems, while Table 2 outlines the elements of the systems approach.

Some examples of problem areas where the systems approach can be applied effectively in Indonesia, as in other countries, are:

- Energy development, for example, large-scale coal mining, transportation, handling, processing and utilization, offshore gas pipeline network, solar energy system (see Table 3 for the systems aspect of an energy chain)
- Human settlement programs, for example, transmigration in Indonesia where approximately 500,000 families are being resettled in Sumatra, Kalimantan, and Sulawesi
- Transportation and communication systems
- Water resources development and management
- Food production, transportation, storage, and distribution
- Defense.

TABLE 1 Three Types of Systems

System	Physical	Biological	Man-made
Payroll			X
Data processing			X
Heating	X	X	X
Weapons			X
Transportation	X	X	X
Bell Telephone			X
Banking			X
Drainage	X	X	X
Penal		X	X
Legal			X
Portable life support			X
Weather	X		
Atomic	X		

TABLE 2 Elements of the Systems Approach

Element	Description
General systems theory	Concerned with developing a systematic, theoretical framework for describing general relationships of the empirical world
Systems philosophy	"A way of thinking" about phenomena in terms of wholes, including parts, components, or subsystems, with an emphasis on their interrelationships
Systems analysis	A method or technique used in problem solving or decision making. Closely related to scientific method. Involves awareness of a problem, identification of relevant variables, analysis and synthesis of various factors, followed by a program of action
Systems management	The application of systems theory to managing organizational systems or subsystems

CONCLUSIONS AND RECOMMENDATIONS

The Agency for the Assessment and Application of Technology (BPPT) is responsible for the assessment and implementation of technology in Indonesian development. Whatever action BPPT takes, therefore, will have long-range consequences. In this regard, systems planning is long-range thinking affecting action in the present. By including a systems design "laboratory" and functionally oriented divisions and departments, BPPT will incorporate the systems approach in all levels of its operations. Since this approach can only be mastered by doing it, it is strongly recommended that BPPT tackle projects where the approach can be fruitfully adopted, building upon experience and implementing the approach as widely as possible during the fourth 5-year development plan, REPELITA IV.

REFERENCES

Johnson, R.A., F. Kast, and J.E. Rozenweig. 1967. The Theory of Management Systems. McGraw-Hill, New York, New York, USA.

Martin, E.W. 1966. The systems concept. Business Horizons (Spring).

TABLE 3 Systems Aspects of an Energy Chain (Mineral Fuels, Fossil or Nuclear)

	Activity				
Resource	Harvesting Fuels	Upgrading Fuels	Transporting Fuels	Conversion to Electricity	Reprocessing and Managing Final Waste
Water	- Interaction with ground water resources - Land reclamation - Waste and water pollution	- Water for cooling - Process water - Liquid wasters	- Waterways - Coal slurry pipelines	- Water for cooling (once through or wet towers)	- Water for cooling - Process water - Liquid wastes - Possible interaction with runoff or ground water
Energy	At all the steps, energy is used and must be attained from the raw energy content of the fuel being harvested and used for obtaining the final primary energy efficiency of the whole chain.				
Land	- Surface mining - Deep mining infrastructure: roads, related facilities - Waste storage	- Facilities	- Roads - Right of way: railways, H.V. lines - Underground pipelines	- Facilities (siting problem) - Wood, lumber for construction	- Facilities (siting problem) - Waste storage
Material	- In equipment and facilities, materials investment at all steps (problem of future recycling)				
	- Consumed materials - Materials handling and control - Waste	- Materials control and balance - Chemicals - Waste	- Pipes, cars, tankers, etc. - Materials handling	- Consumed materials - Problem of recycling	- Consumed materials - Chemicals - Materials accounting (possible safeguard) - Waste

OPENING PRESENTATION

Systems Analysis, Companion to Economic Development

David B. Hertz
Director, Intelligent Computer Systems Research Institute,
University of Miami
Chairman, NRC Panel

In developing nations, systems analysis (S/A) can be an important companion of economic development at all levels. The course of economic development is guided by policy choices--good or bad, wise or foolish, sound or shaky--but, as one hopes, they are made at some intermediate level of good sense. To make important policy choices without analysis is sometimes the height of folly, and to ignore the opportunities that systems analyses offer is to put one's head in the sand.

Systematic collection of information about policy problems is the essential first step. Without systematic methods of analysis, however, the value of such information is severely limited. An understanding of the interrelationships among the factors involved in making and implementing any policy choice is critical. Systems analysis provides the methods for ordering and interpreting the collected information and, in fact, for directing succeeding phases of the implementation effort.

The key objectives are to make hypotheses about the variables and their interrelationships in order to (1) conduct any further investigations required, and (2) provide ultimate recommendations for action decisions. This applied research can provide a basis for decision makers extending their capacities to understand and use effectively the data and information that continually pour into the halls of government. Of course, some of the information may be incorrect, much will be misleading, and some of it may be outright nonsense. The task of the systems analyst is to sort the wheat from the chaff if possible, and to make sense out of the relationships among the remaining grains.

Why then is systems analysis crucial to decisions in the developing countries? How can one approach problems in Indonesia such as food production, transportation, and waste disposal, building on the work already done by staff of the Agency for the Assessment and Application of Technology?

CONTRIBUTIONS OF SYSTEMS ANALYSIS

To answer these questions, one must first examine what systems analysis offers decision makers not only in developing countries, but also in those nations whose economies, no matter how advanced, can run into various kinds of economic difficulties. Three results can be considered the key contributions of this form of applied science:

1. S/A can contribute to understanding the particular system under study, be it waste disposal, transportation, food production, or another key element of the economic system. Furthermore, beyond additional understanding about the specific system, it should be able to explain a great deal about how that system is hooked into, attached to, related to, or aligned with other such systems in the country and the world.

2. S/A can--indeed must--permit one to make predictions about the future state of the system under study, given what is known about its past and present structure. Naturally, such predictions are subject to errors and will hold, if at all, for only limited periods of time. One must also recognize the danger of overconfidence. It is, however, important to remember that the purpose of systems analysis is to permit a decision maker to move forward and take actions in reasonable anticipation that the future will develop approximately as the analyst suggests.

3. S/A can provide the specifics of alternative actions that "influence" the behavior of the system in ways that will agree with the policymaker's objectives. The process should increase the probabilities that those objectives will be met.

Understanding, prediction, and analyses of alternative courses of action are the key contributions of the systems analysis approach to the government executive. How are they accomplished?

COMPUTER-ASSISTED SYSTEMS ANALYSIS

In this computer-oriented age, the potential for systematic analyses of complex problems is greatly enhanced. It must be emphasized, however, that use of the tools of computer programming in a complex way does not mean that the solutions reached using the computer must themselves be complex. To the contrary, quite often the application of complex thought to difficult problems results in theories of extraordinary simplicity. For example, the application of computer-assisted systems analysis to the problems of agriculture will not necessarily point to complicated mechanisms for modernizing the food system. It often permits an early identification and efficient organization of major and interrelated variables.

The decision to undertake a man/computer analysis of a systems problem should be considered an investment decision in a form of research and development--applied research, to be sure, but research nonetheless—of perhaps the most important kind that a developing nation can undertake. The research investment will be in human resources, the primary component, and beyond these will come the ability to undertake the real experimentation that will provide the bases and information for the larger scale decisions. To this may be added, as a less significant but important element, the investment in time and effort of the decision makers themselves. No useful systems analysis can result from any study, no matter how elaborate or well designed, that the political policy apparatus cannot understand. If it must be supported outside such understanding, its long-term success will remain in doubt. If support is denied because the project results and recommendations were not understood, the entire exercise will have been undertaken in vain.

Nobel Laureate Herbert Simon, who has credentials in the fields of systems analysis, economics, and intelligent computer systems, has written that every decision involves "facts" and "values." Simon makes the point in Reason in Human Values (1983) that decisions are something more than factual propositions; they have an imperative quality; they select one future state of affairs (or I would here add, some desirable state of affairs that is considered by some reasonable and, I hope, rational process, to have some chance of occurring) in preference to another; and they direct behavior toward the chosen alternative. They have an ethical as well as a factual content.

Systems analysis can help public officials identify and define problems, and it can provide more information and data about possible solutions and more understanding about the problems that must be attacked and solved before improvement in the systems parameters is at hand. These are political decisions; no analyses or computerized programs can ever make final choices because in each instance the values that enter into the final decisions are quantifiable only with the greatest difficulty. That does not mean, however, that values must wait until the end of the analysis to be superimposed upon the proposed alternatives. The objectives as laid down in the terms of reference of a systems study should already reflect the values--a critical requirement of any analysis that is to stand a reasonable chance of implementation--of the decision maker. Thus a transportation study that gives water-based transportation maximization as the basic objective would be a different analysis than one that stresses air transportation. Confusing the objectives would certainly reduce the likelihood of acceptance and implementation.

UNDERLYING PRINCIPLES

What are the underlying principles that provide assistance in improving systems to meet local and national objectives? Two branches of mathematics, as well as the computer and the human intelligence of systems scientists, form the basis for most of the analytical work undertaken successfully: probability and statistical inference, and higher algebra including predicate (logic) calculus. Both play a key role in data analyses model building.

As to probability and statistical inference, the future is always uncertain, and the results of analyses hinge, more often than not, upon the outcome of extremely variable events. Thus probability and statistical mathematics are used to help cope with this inherent uncertainty. No matter how deterministic problems seem to be, no matter how clear nonstatistical models may seem, it is perilous to ignore the world's fundamental statistical nature. Many elegant and well-designed studies fail to achieve effective implementation because the world of variable events has not been taken into account.

This uncertainty, however, provides the very basis for achieving results from which sure-fire certainty would bar one. For example, genetic improvement in animals and foodstuffs is based solidly on statistical changes in genetic codes. Risk taking--and winning--through the construction of a new industry in a developing country depends upon a thorough understanding of the underlying variations in supply, demand, and quality, among other factors. Thus given the existence of uncertainty, the systems analyst must give it its proper due. The concepts of probability and statistical methods play a major role in the quantitative analyses of the risk of any investment recommendation.

Higher algebra is used for various kinds of programming that deal with problems of combining many variables or factors to achieve the combination that best meets a set of objectives and constraints. Programming tools can now be combined with statistical models and simulations in very versatile combinations to determine the best allocations of resources in situations where no one alone would be particularly useful.

Representations of the processes involved in the activities to be controlled by active governmental or industrial intervention, implemented by algorithms that can be programmed for computers and applied to specific operations or parts of activities--"models"--are among the fundamental building blocks of systems analyses. In using a systems analysis model to help make decisions, it is, of course, essential to quantify the elements of the decision process itself. The result should be a statement of the benefit/cost relationships of the probable consequences of alternative courses of action.

The key elements underlying the ultimate decision recommendations must be:

- Resources at hand
- Reasonable alternatives for action
- Commitments required for each of the alternatives
- Probabilities of results from alternatives (e.g., costs incurred, revenues or other benefits received)
- Interactions between alternatives chosen and prior and later choices, and other elements in the total system
- Constraints or bounds on resources or alternatives.

The inherent difficulties involved in quantifying alternatives, the results to be achieved from choices, and the interaction of past and future choices should not be underestimated. The decision maker needs to be able to analyze consistently and quantitatively the net effects of applying his resources in a chosen pattern.

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PART II

INDONESIAN PRESENTATIONS, WITH COMMENTS BY NRC PANELISTS

PRELIMINARY STUDY OF A WASTE DISPOSAL SYSTEM FOR CENTRAL JAKARTA

Team for the Solid Waste Management Study,*
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Agency for the Assessment and Application of Technology (BPPT)

The preliminary study of a waste collection and transportation system and the preliminary design for a waste incineration plant for Central Jakarta described in this report constitute part of the Study of the City Development System, conducted by BPPT's Directorate for Systems Analyses, in cooperation with the Special Government of Jakarta. (Jakarta is designated as a Special Capital Area and divided into five mayoral districts, i.e., Central Jakarta, Northern Jakarta, Eastern Jakarta, Southern Jakarta, and Western Jakarta.)

The sanitary landfill, composting, and incineration methods of waste disposal are currently being used in Central Jakarta. Incineration is a solid waste processing method that utilizes the chemical process of oxidation. A BPPT study of waste characteristics in Central Jakarta has revealed that the solid waste in that area meets the minimum requirements for its use as the basic material for a waste incineration plant (WIP), which will utilize energy recovery equipment. Several countries, unable to apply the sanitary landfill method because of insufficient space, have improved upon WIP technology to the point that it can process more than 30 percent of total waste.

In this chapter the technological aspects and requirements of a WIP are reviewed, keeping in mind that a WIP must be able to operate safely, must not disturb the environment, and must be in accord with the economic condition in general. The first section describes waste quantity, quality, collection, and transportation at present, and plans for their future improvement. The second section describes BPPT's study of waste incineration--location determination, investment costs, operational costs, and revenues gained from the sale of electricity to PLN (state-owned electricity corporation). The third and final section compares the advantages and disadvantages of the waste incineration method and the sanitary landfill method.

This study was conducted from October 1981 to May 1982 by the Directorate for Systems Analyses, with the assistance of Geopfert, Reimer und Partner, consultants, Hamburg, Federal Republic of Germany.

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*Sri Bebassari S., team leader; Djoko Herumartono; Endang Trihadiwati; H. B. Henky Sutanto; Lusina Waluyati; M. Ansorudin S.; Made Setiawan; Rachmat Wiranegara; Rahardjo; Siswanto Sewoyo; Sri Rahayu; and Tasmian.

WASTE GENERATION IN JAKARTA, PARTICULARLY CENTRAL JAKARTA

In 1981, waste generation in Jakarta was estimated at 1.2 million tons per year, assuming 2.5 liters (0.5 kg) of waste per capita per day, while that in Central Jakarta for the same year was estimated at 270,000 t/yr, assuming 3 liters (0.6 kg) of waste per capita per day. Future waste generation will increase proportionately to increases in population and people's living standard (see Annexes A and B). The growth rate of waste generation until 1995 is estimated at 4 percent per year, but it is expected to decrease to 3 percent per year for the following decade. The actual figures for waste generation are given below:

Year	Jakarta (thousand t/yr)	Central Jakarta (thousand t/yr)
1981	1,200	270
1985	1,400	300
1995	1,900	400
2005	2,300	470

As discussed and considered in the BPPT study, this waste consists only of domestic solid waste and similar waste from residential areas, offices, shopping centers, market places, and street cleaning.

Composition and Characteristics of Solid Waste in Central Jakarta

The BPPT study conducted in 1981 found out that 80 percent of solid waste from Central Jakarta consists of organic matter with the following characteristics (see Annex C):

	Rainy Season	Dry Season
Water content (percent)	63	58
Ash content (percent)	9	12
Heating value (kJ/kg)	4,500	6,152

The following influences will, however, change the above composition and characteristics of waste:

- A change in living standard. The prediction of a rising standard of living implies that more wrappings and packaging material will ultimately end up as domestic waste. In Central Jakarta, the waste from office and administration buildings will be especially high, particularly the amount of paper.
- An improved collection and transportation system. The projection of improved collection, for example, by enclosed containers and transportation in covered or closed trucks means that waste will not be exposed to rain. Thus its water content will decrease, especially in the rainy season.

Because of these influences, the water content will decrease, the amount of combustible matter will increase, and the density of solid waste will decrease, leading to an increase in the heating value. Such a trend thus has good implications for the basic materials of a waste incineration plant (see Annex D).

THE EXISTING SYSTEM OF COLLECTION AND TRANSPORTATION

The solid waste of Central Jakarta is currently collected directly from its sources--households, markets, commercial centers, home industry, and street sweeping--where it is usually stored in containers of different types and shapes. In residential areas with a single storage house, domestic waste is stored in concrete boxes, of which only a few have covers. In some areas, the solid wastes are thrown into an open site or into rivers and the surrounding area.

In general, solid waste is currently collected and transported by cart from its source to the temporary dumping ground, and then further transported by different types of trucks to the disposal site. In another collection and transportation system, the solid waste is stored in containers of different types and collected by a door-to-door service that uses different types of trucks such as compactors, open trucks, and dump trucks (tipper trucks) to transport the waste to the disposal site. These collection vehicles serve only about 7 percent of the total population of Central Jakarta.

A field survey conducted by BPPT in March 1982 found that:

- Only an estimated 490 t/day or 56.6 percent of the total 868 t/day of waste generated in Central Jakarta can be transported. The transportation of solid waste is carried out by the Cleaning Division of the Central Jakarta Administration and by the PD Pasar Jaya Corporation which is owned by the regional administration.
- A total of 143 trucks were used in March 1982, of which only 15 percent were not older than 5 years, the average service life of such trucks.
- Working 8 hours a day, the solid waste fleet averaged only 1.75 trips per day because of road conditions and heavy traffic and a lack of fixed routes from the temporary dumping site to the disposal site.

- Because the equipment being used in the existing system of collection and transportation is inadequate, both in quantity and quality, the working hour is indirectly prolonged, thus lowering transport capacity.

The capacity of waste transport can be increased by adding transport fleet and improving their system of collection and transportation.

An Improved Waste Collection and Transportation System

An improved waste collection and transportation system is also needed to ensure a continuous supply of waste to a waste incineration plant. To support this effort, six models of waste collection and transportation systems have been developed in the BPPT study. These models are based on established figures to be able to compare data from (more or less) equal sources:

1. One service unit equals one kelurahan (administrative unit) having an average population of 30,000, or approximately 6,000 households, assuming each household contains five persons.
2. Waste production is assumed to be 3 liters (0.6 kg) per person per day, so that the total production of each service unit is 90 m^3/day, or 18 t/day (at the density of 0.2 kg/liter).
3. Since 80 percent of waste easily decomposes within a few days, waste and garbage are collected at least twice a week.
4. Waste collection and transportation are carried out 6 working days a week (52 weeks a year, or 312 working days a year). The capacity of transport service required is 21 t/day, or 6,552 t/yr for each service unit.

The specification of each model is shown in Annex E. Model I uses the simplest equipment and working method, while Model VI uses more sophisticated equipment and working method.

Each model is designed according to three components: collection system, transfer system, and transportation system. The collection systems described in Models I-IV use carts, while Models V and VI use compactor trucks with a door-to-door collection system.

The transfer system described in Models I, II, and V is carried out manually; Model III uses a crane; Model IV uses containers; and Models V and VI use compactor trucks. Of the six models, Models IV and V are thought to be most applicable to Central Jakarta, with adequately low specific costs (see Annex F), i.e., Rp. 12,829 (rupiahs) per ton of waste (Model IV) and Rp. 12,412 per ton of waste (Model V). Model IV, however, which uses container trucks, requires land that is not always available for a container transfer station, while Model V, which uses a compactor truck, requires a wide road. The improved waste collection and transportation system will thus consist of a combination of these two models, adapted to the conditions of Central Jakarta. Using Model IV, the cost of waste collection and transportation in Central Jakarta in 1990 will be Rp. 4,448.5 million and Rp. 4,303.7 million for Model V.

SOLID WASTE TREATMENT BY INCINERATION (PRELIMINARY DESIGN)

The planned waste incineration plant will be equipped with discharging and storage space, a boiler, a slag bunker, a dust electrostatic precipitator, and wastewater treatment. Steam produced by the boiler will be used to operate the turbine which is connected to a power-generating set.

Waste with a minimum heating value of 4,500 kJ/kg and a water content of 62 percent must be incinerated to a temperature of at least 800°C to guarantee complete incineration and, at the same time, the elimination of any waste odor that may be emitted with the smoke. Solid waste from Central Jakarta meeting these conditions can reach the required temperature during normal operation without the assistance of additional fuel.

If the waste incineration plant is established in 1983 and commences operation in 1985, with 20 years of service life, the plant will be operational up to 2005. Should Central Jakarta's waste production reach 470,000 t/yr in 2005, and given the plant's incinerating capacity (efficiency) of 70 percent, four incinerator units must be built, each with a waste capacity of 20 t/h/unit. In 1985 (first year of operation) Central Jakarta's waste production is estimated at 300,000 t/yr; thus only three incinerator units will be needed that year, requiring 400,000 tons of waste. To meet this demand, waste from outside Central Jakarta can be used.

The first three incinerator units will generate 12.42 MW of electrical energy during the rainy season and 17.22 MW during the dry season, with an average annual generating capacity of 96,000 MWh. The incineration plant itself consumes 16,000 MWh of electric energy per year; thus 80,000 MWh of electric energy can be distributed yearly to the PLN network.

Another product of incineration is slag, which is estimated at 216 t/day, or 60,000 t/yr (from the first three units). This slag should be removed into a discharging location that will not pollute the environment. It can, however, be used for land reclamation and for building or road material.

The amount of flue gas produced by the plant will be 360,000 m^3/h, and the greatest pollutants are carbon monoxide at 2.648 mg/m^3 and nitrogen oxide at 935 mg/m^3. By using a chimney 90 m high, the concentration of pollutants will be lower than the acceptable standard applied by the Jakarta Administration.

Three alternative locations in Jakarta for the WIP have been discussed with regard to their geographic suitability, city development planning (land use, transportation, PLN network, etc.), available natural resources (processing water, cooling water), and airplane traffic: Cakung, Tanjung Duren, and Kebon Jeruk (see Annexes G.1 and G.2). It has been concluded that Cakung is the most optimal location for the establishment of a waste incineration plant.

Economic Analysis

The operational costs, which consist of fixed costs and variable costs, will change according to the inflation rate. Based on last year's inflation rate, the average increase in cost is calculated at 10 percent per year. Revenues from electric energy sales are also expected to increase in line with the inflation rate.

For economic calculation purposes, the average increase in both prices and revenues are estimated at 10 percent per year. The result of the calculation is shown in Annex H which describes operational costs and revenues for several years to come, assuming a sale price for electrical energy of Rp. 28 kWh and an interest rate of 9 percent per year (also see Annexes I and J). According to these calculations, the plant will suffer decreasing deficits from year to year until the deficit reaches zero at the end of the nineteenth working year. City waste incineration plants in other countries receive subsidies from the central government. In the Federal Republic of Germany, for example, the subsidy amounts to 20-40 percent of the total incineration cost.

COMPARISON OF A WASTE INCINERATION PLANT AND A SANITARY LANDFILL

In the following comparison of the sanitary landfill and incineration methods, it is assumed that the two methods are in service for a period of 20 years. It is also assumed that the waste incineration plant is located in Cakung, while the sanitary landfill is located in Pondok Ranggon.

Comparative Factor	Waste Incineration Plant	Sanitary Landfill
• Waste composition	Mixed waste	Mixed waste
• 20-year operation period	5,475 working days	6,240 working days
• Amount of waste that can be disposed of in 20 years	7,884,000 t	8,985,600 t
• Land area required	3.5 ha	297 ha
• Average transport distance	15 km	21 km
• Possible pollution	-In air -Slag	-Surface -Strong odor
• Revenues	Electrical energy	None
• Specific cost per ton of waste	Rp. 11,596	Rp. 10,838

CONCLUSION

It can thus be concluded that the establishment of a waste incineration plant for Central Jakarta is technically feasible. Should the WIP be established, the following matters should be taken into consideration:

- The continuous supply of waste demanded by the WIP must be maintained.
- Waste characteristics, i.e., heating value and water content, should be maintained to meet the requirements of the WIP. It is understood that the water content of waste in Central Jakarta is 60 percent of the total weight.
- The existing system of waste collection and transportation should be improved to both ensure a continuous supply of waste and decrease the water content of the waste.
- Of the six models of the collection and transportation system being developed, Model IV (using container trucks) and Model V (using compactor trucks) appear the most applicable. Model IV requires land, which is not always available, for a container transfer station, while Model V requires a wide road. Thus an improved waste collection and transportation system will constitute a combination of these two models. The specific cost of Model IV is Rp. 12,829 per ton of waste, and for Model V, Rp. 12,412 per ton of waste.
- Based upon Central Jakarta's projected waste production in 2005, the WIP will consist of four incinerator units, having a waste capacity of 20 t/h/unit, to be constructed in two stages. In the first stage, three incinerator units will be built, capable of incinerating 400,000 tons of waste per year and generating 96,000 MWh of electrical energy per year.
- The WIP will require an investment of about Rp. 49,962 million (based on the 1982 price level), with an operational cost of about Rp. 5,496 million per year for a period of 20 years, at an annual interest rate of 9 percent. If electricity is sold to PLN at Rp. 28/kWh, there will be a yearly deficit which will reach zero in the nineteenth year of operation. Thus the cost of incinerating 1 ton of waste will be Rp. 11,596. When compared with the sanitary landfill method, the establishment of a WIP in a densely populated area like Jakarta is more appropriate, both technically and economically.

REFERENCES

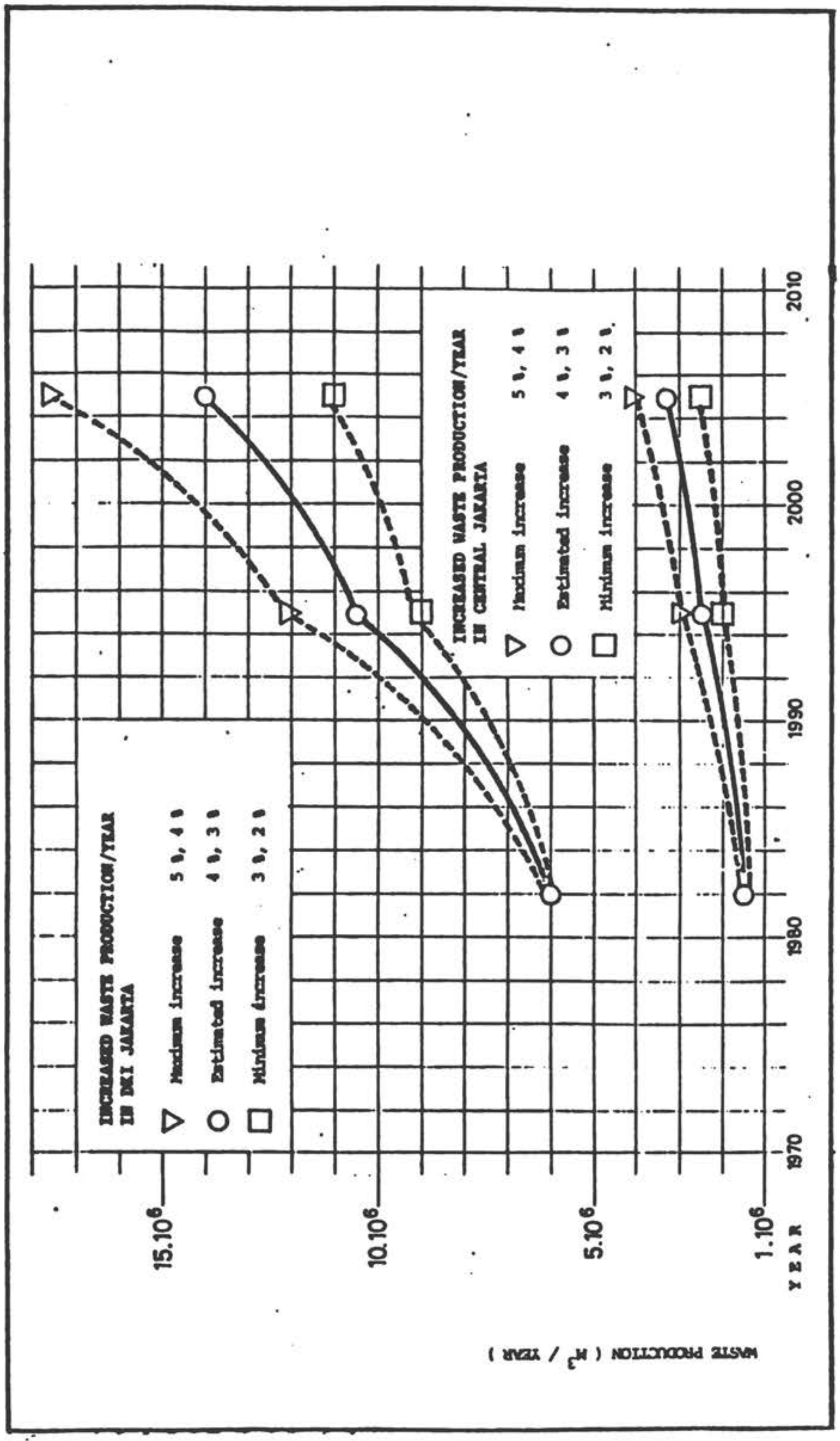
Studi Keterlaksanaan Permasalahan Sampah di DKI Jakarta (P4L-DKI Jakarta 1979).

Pilot Project SWIP (Solid Waste Improvement Program for Jakarta 1981).

ANNEXES

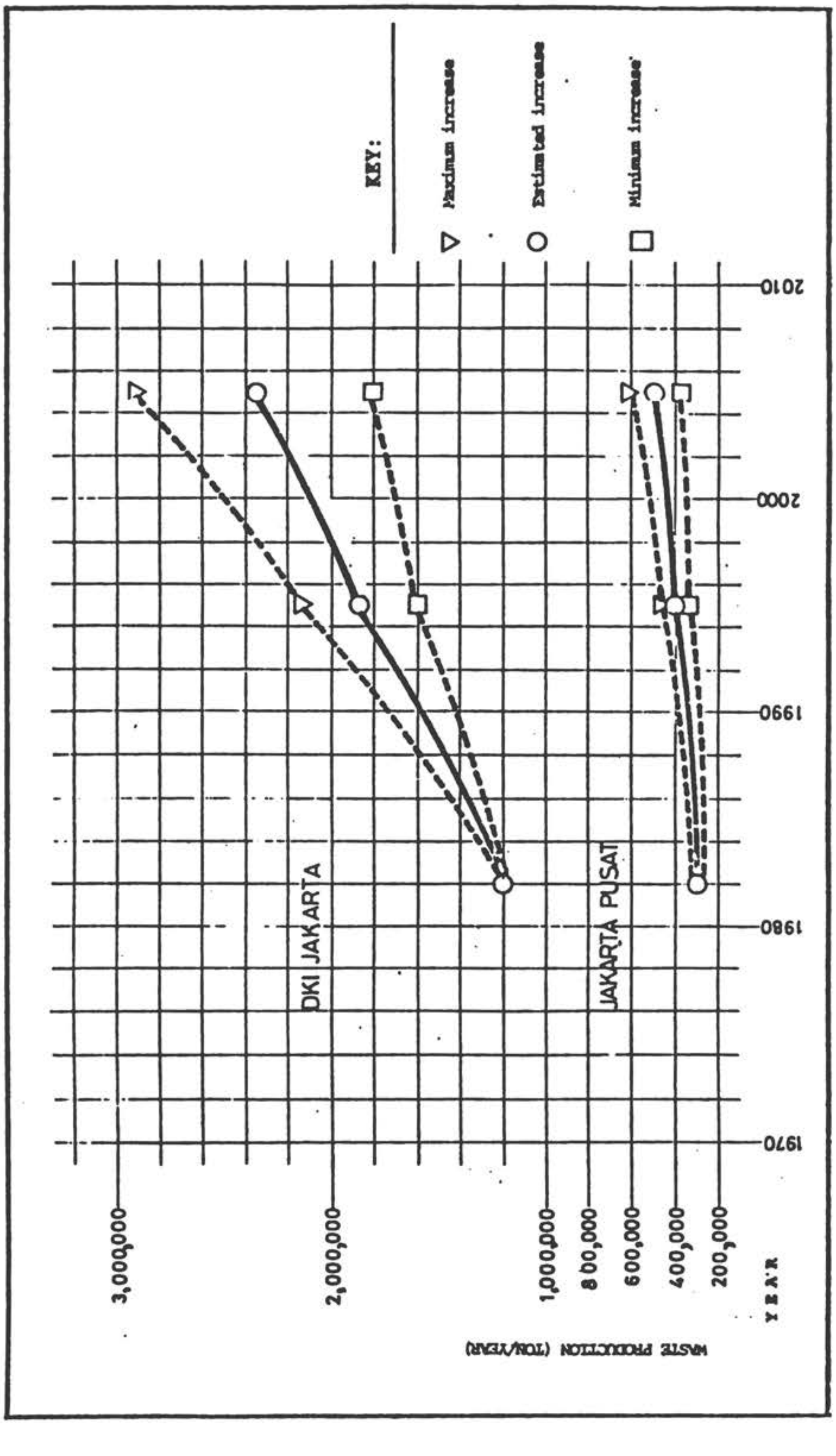
ANNEX A

WASTE PRODUCTION INCREASE (CUBIC METERS/YEAR), DKI JAKARTA AND CENTRAL JAKARTA



ANNEX B

WASTE PRODUCTION INCREASES (TONS/YEAR), DKI JAKARTA AND CENTRAL JAKARTA



ANNEX C

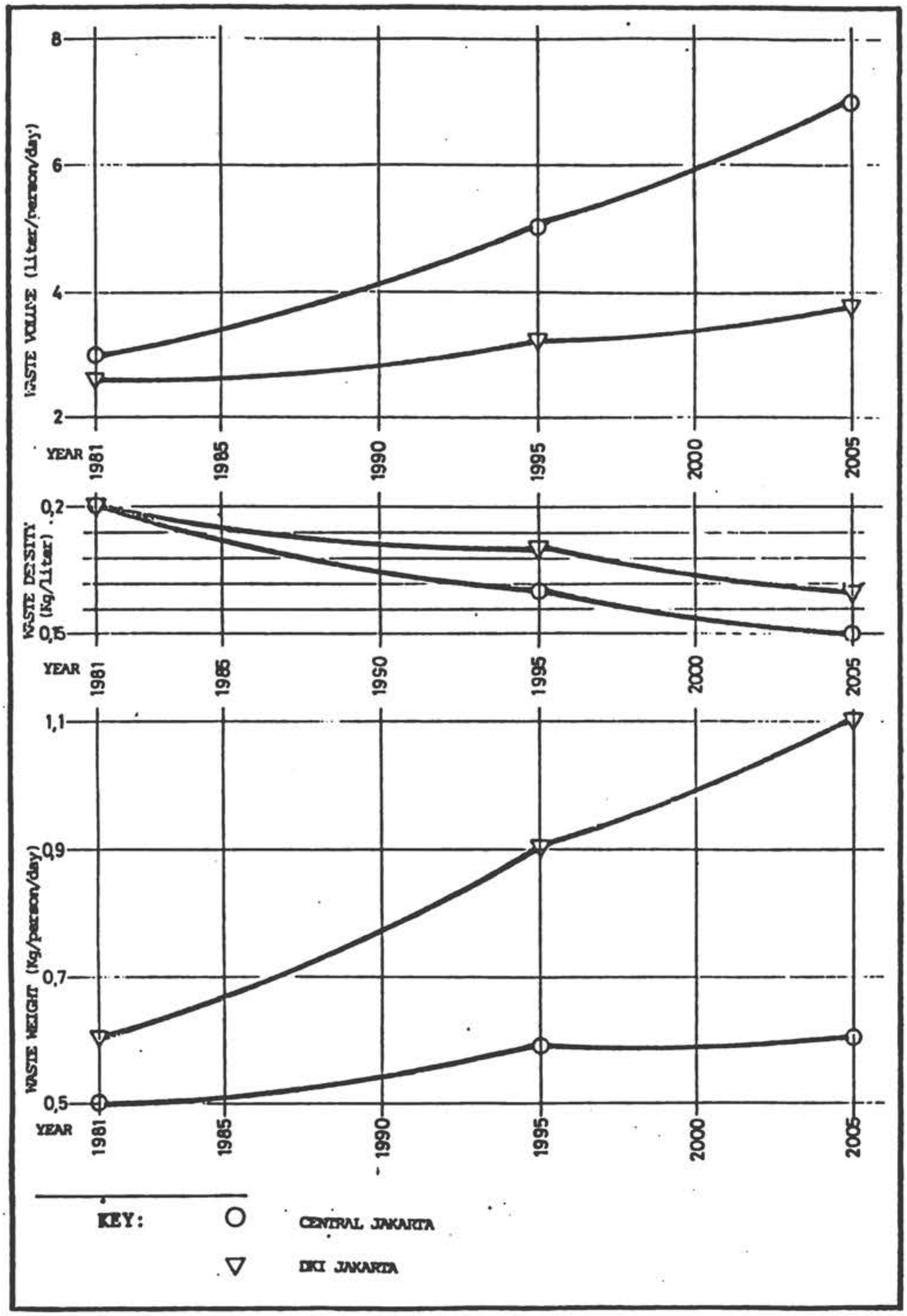
WASTE COMPOSITION AND CHARACTERISTICS, CENTRAL JAKARTA, 1981

	SEASON		
	DRY	RAINY	AVERAGE
I. WASTE COMPOSITION			
1. Organic waste	76.99%	81.99%	79.49%
2. Paper	7.83%	8.11%	7.97%
3. Wood	4.96%	2.33%	3.65%
4. Textile	2.74%	2.07%	2.40%
5. Rubber/imitation leather	0.40%	0.54%	0.47%
6. Plastics	4.02%	3.32%	3.67%
7. Metal	1.52%	1.22%	1.37%
8. Glasses	0.62%	0.38%	0.50%
9. Others (soil, stone, sand)	0.92%	0.04%	0.48%
II. WASTE CHARACTERISTICS			
1. Water content	57.51%	62.67%	60.09%
2. Ash content	12.44%	8.73%	10.59%
3. Heat value (kJ/Kg)	6,152.00	4,501.00	5,326.00

SOURCE: BPPT (1981) Brief Study of Waste Composition and Characteristics in Central Jakarta.

ANNEX D

WASTE SPECIFICATION,
DKI JAKARTA AND CENTRAL JAKARTA



ANNEX E

TECHNICAL DATA IN THE MODELS OF THE WASTE COLLECTION AND TRANSPORTATION SYSTEMS

MODEL		EXISTING BINS, CARTS, TRUCKS	ADVANCED BINS-CARTS-SYSTEM			COMPACTOR DOOR-TO-DOOR	ADVANCED COMPACTOR DOOR-TO-DOOR
			TRUCKS	TIPPER CRANE	CONTAINER TRUCK		
ACTIVITY	UNIT	I	II	III	IV	V	VI
COLLECTION SYSTEM							
1. Frequency	/week	3	3	3	3	2	2
2. Bin volume	liter	40	40	40	40	60	120
3. Bin amount	piece	6,000	6,000	6,000	6,000	6,000	3,000
4. Cart frequency	route/day	3	6	6	6	--	--
5. Cart amount	unit	30	15	15	15	--	--
6. Bin (125-liter)	unit	240	120	120	120	--	--
7. Crew	worker	60	60	60	60	--	--
TRANSFER SYSTEM		manual	manual	by crane	container	manual	manual/ automatic
1. Capacity	ton/hari	--	--	30	--	--	--
2. Units		--	--	1 x 1	9 x 1	--	--
3. Land area	m^2	5 x 150	5 x 150	800 x 1	3 x 250	--	--
4. Consumption	kWh/yr	--	--	26,208	--	--	--
5. Supervisor	people	--	--	1	--	--	--
6. Loader	people	4/truck	4/truck	2	3	2/comp	2/comp
TRANSPORTATION SYSTEM							
1. Volume x density	m^3 • ton/m^3	12 x 0.25	12 x 0.25	12 x 0.25	10 x 0.25	4 x 0.4	10 x 0.4
2. Load	ton	3	3	3	2.5	2	4
3. Load/day		7	7	7	8.4	10.5	5.25
4. Truck frequency	route/day	2	2	4	4	2	2
5. Truck performance		4.67	4.67	2.33	2.8	7	3.5
6. Drivers	people	4.67	4.67	2.33	2.8	7	3.5
7. Travel distance	km/yr	78,624	78,624	78,624	94,349	117,936	58,968
8. Fuel consumption	liter/km	0.3	0.3	0.3	0.3	0.25	0.3
9. Fuel consumption	liter/yr	23,587	23,587	23,587	28,305	29,484	17,690

NOTE: All data are calculated on the basis of a 30,000 population (1 kelurahan).

ANNEX F

OPERATIONAL COSTS OF THE WASTE COLLECTION AND TRANSPORTATION MODELS

MODEL	EXISTING BINS, CARTS, TRUCKS	ADVANCED BINS-CARTS-SYSTEM			COMPACTOR DOOR-TO-DOOR	ADVANCED COMPACTOR DOOR-TO-DOOR
		TRUCKS	TIPPER CRANE	CONTAINER TRUCK		
COST COMPONENT	I	II	III	IV	V	VI
COLLECTION SYSTEM (Rp/yr)						
Investment cost						
- Domestic use bin	10,080,000	10,080,000	10,080,000	10,080,000	20,160,000	35,280,000
- Cart (gerobak)	2,656,000	1,328,000	1,328,000	1,328,000	—	—
- Cart bin	17,107,200	8,554,000	8,554,000	8,554,000	—	—
Fixed cost						
- Workers	19,440,000	19,440,000	19,440,000	19,440,000	—	—
- Administration	1,944,000	1,944,000	1,944,000	1,944,000	—	—
Collection cost (Rp/yr)	51,227,200	41,346,000	41,346,000	41,346,000	20,160,000	35,280,000
Specific cost (Rp/ton)	7,819	6,310	6,310	6,310	3,077	5,385
TRANSFER COST (Rp/yr)						
Investment cost						
- Land	9,000,000	9,000,000	9,600,000	9,000,000	—	—
- Equipment	—	—	11,250,000	3,375,000	—	—
Fixed cost						
- Maintenance	—	—	3,750,000	1,125,000	—	—
- Workers	11,208,000	11,208,000	1,920,000	1,800,000	8,400,000	4,200,000
- Administration	1,121,000	1,121,000	192,000	180,000	840,000	420,000
Variable cost						
- Power consumption	—	—	1,363,000	—	—	—
Transfer cost (Rp/yr)	21,329,000	21,329,000	28,075,000	15,480,000	9,240,000	4,620,000
Specific cost (Rp/ton)	3,255	3,255	4,285	2,363	1,410	705
TRANSPORTATION COST (Rp/yr)						
Investment cost						
- Trucks	21,015,000	21,015,000	11,650,000	17,500,000	35,000,000	39,375,000
Fixed cost						
- Maintenance	4,203,000	4,203,000	2,330,000	3,500,000	7,000,000	7,875,000
- Workers	3,362,000	3,362,000	1,678,000	2,016,000	5,040,000	2,520,000
- Administration	336,000	336,000	168,000	202,000	504,000	252,000
- Insurance	841,000	841,000	466,000	700,000	1,400,000	1,575,000
Variable cost						
- Fuel	2,005,000	2,005,000	2,005,000	2,406,000	2,506,000	1,504,000
- Tires	755,000	755,000	755,000	906,000	472,000	566,000
Transportation cost (Rp/yr)	32,517,000	32,517,000	19,052,000	27,230,000	51,922,000	53,667,000
Specific cost (Rp/ton)	4,963	4,963	2,908	4,156	7,925	8,191
TOTAL OPERATION COST (Rp/yr)	105,037,200	95,142,000	88,473,000	84,056,000	81,322,000	93,567,000
SPECIFIC COST (Rp/ton)	16,037	14,529	13,503	12,829	12,412	14,281

NOTE: Every operational cost is calculated according to one service unit (30,000 people).

ANNEX G.1

EVALUATION OF LOCATION BASED ON PLANNING AND ENVIRONMENTAL CONSIDERATIONS*

ASPECT	VALUE	CAKUNG	TANJUNG DUREN	KEBON JERUK
City management	27			
1. Land use	10	30	20	10
2. Surrounding factories that will consume the electricity	4	8	8	8
3. Wind direction in the rainy season	8	16	8	8
4. Others	5	10	10	10
Air pollution before the waste incineration plant opens				
1. Dust	2	4	2	2
2. Smog	3	6	6	3
3. Noise	3	6	6	3
Air pollution after the waste incineration plant opens				
1. Dust	2	4	4	4
2. Smog	3	6	6	6
3. Noise	3	6	3	3
Hydrology	7			
1. Groundwater	4	12	12	8
2. Surface water	1	1	1	1
3. Drinking water	1	3	3	1
4. Waste water	1	2	2	1
Results	100	114	91	68

*The values are based on the team's agreement.

ANNEX G.2

EVALUATION OF LOCATION BASED
ON ECONOMIC CONSIDERATIONS*

ASPECT	VALUE	CAKUNG	TG. DUREN	KB. JERUK
Costs that are influenced by waste incineration plant locations	15			
1. Land cost	4	8	4	12
2. Roads	4	12	12	8
3. Water	4	12	8	4
4. Electricity network	3	9	6	6
Waste incineration plant, installation cost	10			
1. Preparing the land	4	4	12	12
2. Building	3	3	6	6
3. Infrastructure	3	3	6	6
Transportation cost	25			
1. Waste transportation	20	40	60	40
2. Slag transportation	2	6	2	2
3. Others	3	9	9	6
Results	100	106	125	102

*The values are based on the team's agreement.

WASTE INCINERATION PLANT, RESULTS OF THE LOCATION EVALUATION

ASPECT	VALUE	CAKUNG	TG. DUREN	KB. JERUK
Planning & environmental	100	114	91	68
Economic	100	106	125	102
Results	200	220	216	170

ANNEX H

INCREASED OPERATIONAL COSTS OF AND REVENUES FROM WASTE INCINERATION (Rp. 10^6)

YEAR / COST COMPONENTS	1982	1987	1992	1997	2002
1. Investment	5,496	5,496	5,496	5,496	5,496
2. Fixed + variable cost	1,383	2,227	3,587	5,777	9,304
3. Total cost (1+2)	6,879	7,723	9,083	11,273	14,800
4. Revenue*	2,240	3,607	5,810	9,357	15,070
5. Total deficit (3-4)	4,639	4,116	3,273	1,916	—
Specific cost (Rp./ton waste)	11,596	10,290	8,182	4,790	—

*Electricity selling price in 1982 is Rp. 28/Wh.

NOTE: The calculation is based on:
1. Interest rate, 9%/year
2. Operation cost increase, 10%/year
3. Increase in electricity selling price, 10%/year

ANNEX I

WASTE INCINERATION PLANT: INVESTMENT, OPERATIONAL COST, AND REVENUES

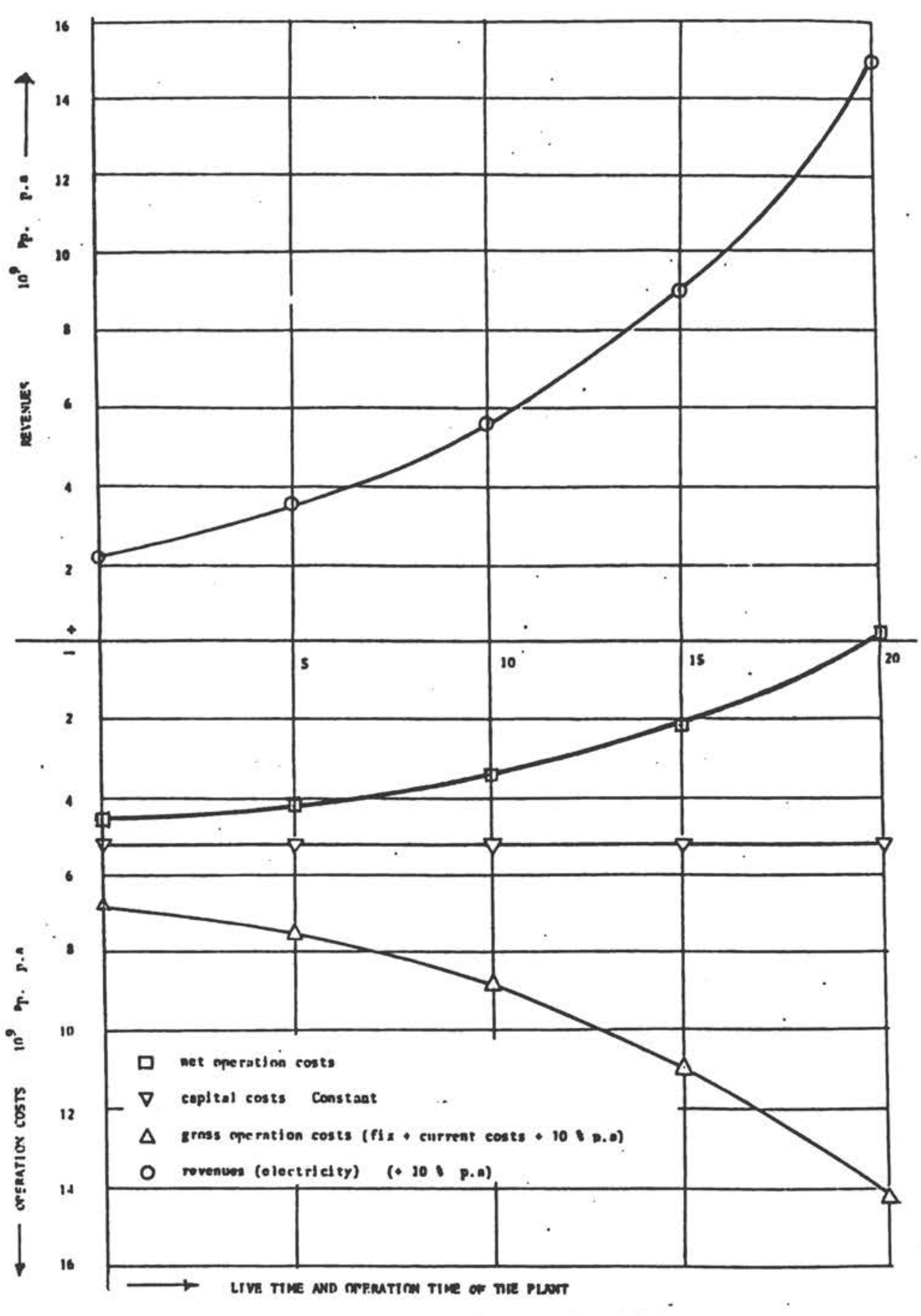
Interest Rate		6%/Year	9%/Year	12%/Year
1. Work Capacity	Ton/Year	400,000	400,000	400,000
Elec. Distribution	MWh/Year	80,000	80,000	80,000
2. INVESTMENT				
- Mechanical	Rupiah	24,292,000,000	24,292,000,000	24,292,000,000
- Electrical	Rupiah	5,258,000,000	5,258,000,000	5,258,000,000
- Building	Rupiah	10,757,000,000	10,757,000,000	10,757,000,000
Installation Cost	Rupiah	40,307,000,000	40,307,000,000	40,307,000,000
- Land	Rupiah	1,955,000,000	1,955,000,000	1,955,000,000
- Study & Supervision	Rupiah	4,000,000,000	4,000,000,000	4,000,000,000
- Loan Interest	Rupiah	2,400,000,000	3,600,000,000	4,800,000,000
TOTAL INVESTMENT	Rupiah	48,662,000,000	49,962,000,000	51,062,000,000
3. OPERATION COST				
Capital Cost	Rp/year	4,233,594,000	5,495,820,000	6,842,308,000
Fixed Cost				
- Machines 3%/yr	Rp/year	728,760,000	728,760,000	728,760,000
- Elec. Equip. 1.5%/yr	Rp/year	78,870,000	78,870,000	78,870,000
- Building 1%/yr	Rp/year	107,570,000	107,570,000	107,570,000
Maintenance	Rp/year	915,200,000	915,200,000	915,200,000
- Personnel	Rp/year	144,000,000	144,000,000	144,000,000
- Administration	Rp/year	14,400,000	14,400,000	14,400,000
- Insurance	Rp/year	120,621,000	120,621,000	120,621,000
Total Fixed Cost	Rp/year	1,194,521,000	1,194,521,000	1,194,521,000
Variable Cost				
- Fuel	Rp/year	68,000,000	68,000,000	68,000,000
- Slag	Rp/year	120,000,000	120,000,000	120,000,000
Total Variable Cost		188,000,000	188,000,000	188,000,000
TOTAL OPERATION COST	Rp/year	5,616,115,000	6,878,341,000	8,224,829,000

ANNEX I (continued)

Interest Rate		6%/Year	9%/Year	12%/Year
4. REVENUE				
Electricity sell price alternatives:				
Rp. 24.-/kWh	Rp/year	3,696,115,000	4,950,341,000	6,304,820,000
Rp. 28.-/kWh	Rp/year	2,240,000,000	2,240,000,000	2,240,000,000
Rp. 32.-/kWh	Rp/year	2,560,000,000	2,560,000,000	2,560,000,000
Rp. 36.-/kWh	Rp/year	2,880,000,000	2,880,000,000	2,880,000,000
Rp. 42.-/kWh	Rp/year	3,360,000,000	3,360,000,000	3,360,000,000
5. DEFICIT				
Rp. 24.-/kWh	Rp/year	1,920,000,000	1,920,000,000	1,920,000,000
	Rp/tons	9,240	12,396	15,762
Rp. 28.-/kWh	Rp/year	3,376,115,000	4,638,341,000	5,984,829,000
	Rp/tons	8,440	11,596	14,962
Rp. 32.-/kWh	Rp/year	3,056,115,000	4,318,341,000	5,664,829,000
	Rp/tons	7,640	10,796	14,162
Rp. 36.-/kWh	Rp/year	2,736,115,000	3,998,341,000	5,344,829,000
	Rp/tons	6,840	9,996	13,362
Rp. 42.-/kWh	Rp/year	2,256,115,000	3,518,341,000	4,864,829,000
	Rp/tons	5,640	8,976	12,162

ANNEX J

OPERATIONAL COSTS OF THE WASTE INCINERATION PLANT OVER THE PERIOD OF OPERATION



*) Note : The calculation is based on the 9% per year loan interest and Rp. 28/KWh.

SYSTEMS ANALYSIS AND SOLID WASTE MANAGEMENT PLANNING

Abraham Michaels
Consulting Engineer, Osterville, Massachusetts
NRC Panelist

The purpose of systems analysis is to achieve optimum utilization of resources using a systematic procedure for identifying and analyzing the elements that compose a total system. From this analysis, models of the system are developed, relevant data are collected, and elements of the system are studied in relation to each other and the total system within the control of the management body concerned. Factors outside the control are known as constraints.

Systems analysis does not necessarily require advanced mathematics or the use of computers. Where the number of variables is small, arithmetic and human judgment are sufficient. Systems analysis can assist in optimizing vehicle usage, crew size, and routing; locating transfer points; selecting process and disposal methods including site selection; and testing policies and decision criteria before implementation.

System constraints that should receive particular attention in Indonesia include:

- Climate
- Seasonal variation
- Financial factors
- Regional economy and process technology
- Environmental standards
- Public health and public awareness
- Management capability available
- Technical capacity
- Land use and availability
- Physical characteristics of the city including road system
- Social and religious customs.

In addition to these constraints, basic policies may need to be considered such as the necessity for labor-intensive systems to provide employment or existing practices such as scavenging or the use of waste as a soil conditioner.

Variables to be considered for analysis should include but not necessarily be limited to the following:

- Number, type, and size of container and collection dump sites
- Service density

- Topography and climate
- Frequency and method of collection
- Crew size
- Vehicle accessibility condition
- Vehicle types and sizes
- Type of waste (residential, food market, commercial, etc.)
- Changes in living habits and waste quality and quantity
- Resource recovery return variables.

Functions in which systems analysis can offer maximum results are:

- Refuse collection--crew size in relation to vehicle type and size
- Selection of transport, process, and disposal methods, including sites and size of operation
- Determination of types, sizes, and locations of containers
- Allocation of vehicle routes.

The successful implementation of new systems may require pilot programs to test systems and train personnel as well as incentives--financial, fringe benefit, status improvement--to employees to accept new and more efficient methods. Education of the public may also be necessary. Users and purchasers of recovered energy or recyclables may have to be surveyed and long-term contracts established with users of recovered products.

PUBLIC TRANSPORT
IN THE EASTERN CORRIDOR OF JAKARTA

Transportation System Study Group,*
Directorate for Systems Analyses,
Agency for the Assessment and Application of Technology (BPPT)

This study of public transport in the Eastern Corridor of Jakarta is but one of the studies conducted by the Transportation System Study Group, under BPPT's Directorate for Systems Analyses. As only a preliminary study, it will serve as the basis for a subsequent study of the entire public transport system, including an improved bus service system in the Eastern Corridor.

This study was based on the hypothesis that the level of service of public transport in Jakarta, specifically those that have fixed routes, has deteriorated. In this chapter, public transport is defined as that which has fixed routes, unless indicated otherwise.

What follows is a description of the characteristics of public transport in the Eastern Corridor, such as number of passengers, fare charged, daily trips, intervals between arrivals of vehicles, passenger waiting time, and length of trips.

BACKGROUND, PURPOSE, AND METHODS OF THE STUDY

Background

In the last few years, the population of Jakarta has increased rapidly. From 1971 to 1976, it increased at a rate of 4.48 percent each year, 2.5 percent of which was natural and 1.39 percent of which was due to migration. In 1978, the population of Jakarta was 6,081,963 (Special Government of Jakarta, 1979). The number of motor vehicles, especially privately owned, has also increased, at an average rate of 14 percent a year. These increases in population and vehicles have not been matched by the construction of additional roads, resulting in traffic jams in various areas and deteriorating services. Consequently, the cost of operating a vehicle has risen, as well as the demand for public transport services.

Public transport plays a significant role in the lives of the people of Jakarta, most of whom have low incomes. In 1978, it was estimated that 5 million trips were made each day: 54.8 percent by public transport, 0.5 percent by train, and 44.7 percent by private car.

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Although public transport is needed by the majority of the people, it has not increased as much as the number of private cars. This is evident during peak morning and afternoon travel periods when city buses always have more passengers than they are allowed, and passengers can be seen scrambling for a place in the bus.

Purpose of the Study

The purpose of this study of public transport in the Eastern Corridor is to try to solve the main problems it faces from day to day such as:

- Inadequate space for passengers using public transport, especially during the morning and afternoon peak hours
- Lack of direct routes (without having to change vehicles) from place of origin to destination for passengers using public transport
- Need to satisfy the rising demand for public transportation service, especially main road transportation.

Methods of Study

To obtain the necessary information, data were collected by interview and observation. Interviews were conducted to ascertain the point of origin and destination of passengers along the Eastern Corridor. Observation was used to determine passenger waiting time at the bus stop, number of passengers in public transport vehicles, and the length of intervals between arrivals of public transport vehicles at bus stops (headway).

CHARACTERISTICS OF THE AREA OF STUDY

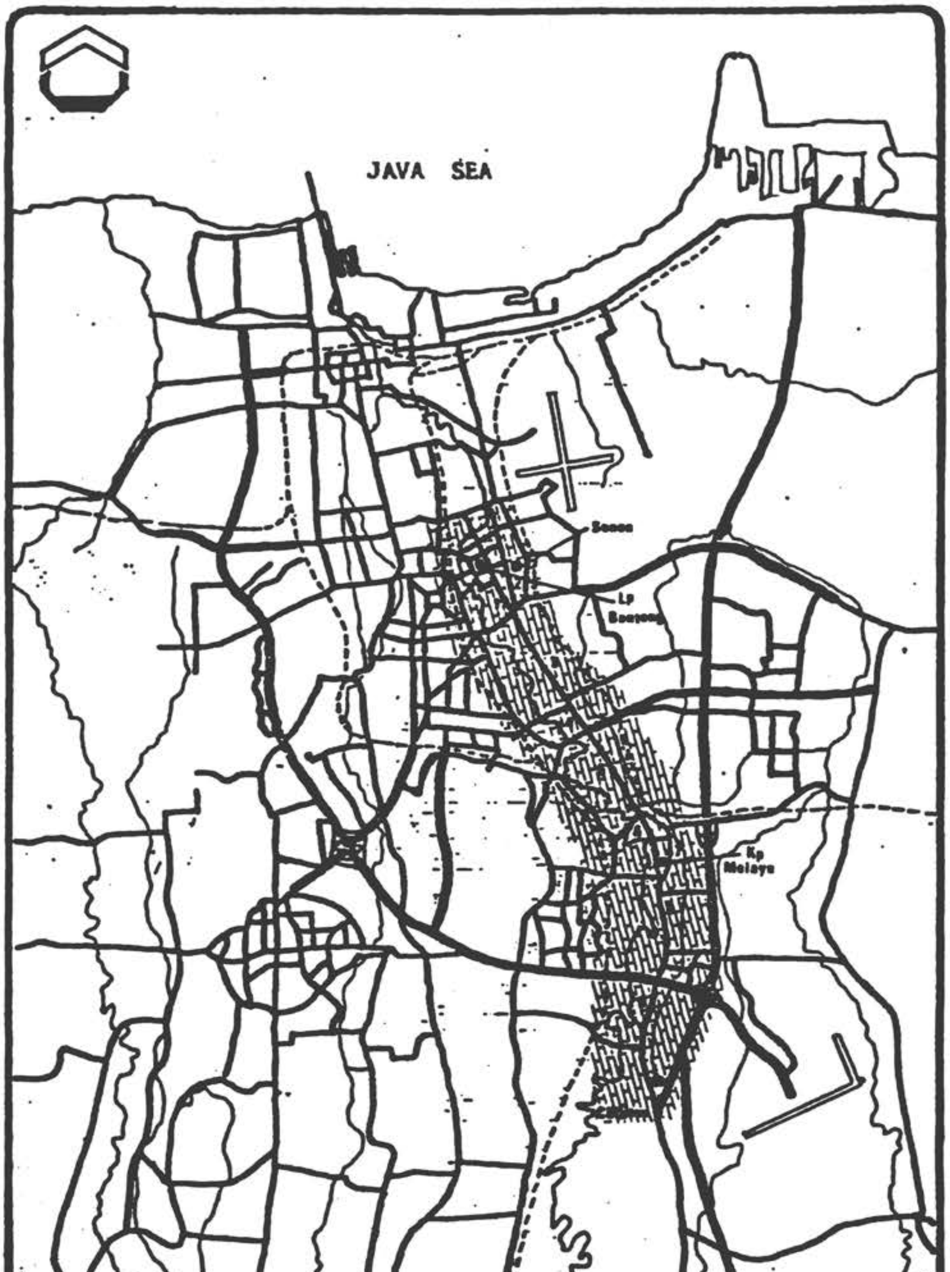
Location of Study

The study area, the so-called Eastern Corridor, is located in the eastern part of Jakarta, stretching from north to south (see Figure 1). On the north it is bordered by the Lapangan Banteng terminal and on the south by the Cililitan terminal.

Main Roads

Along this corridor there are nine main roads, some of which are used only for one-way traffic. Thus the traffic from Cililitan to Lapangan Banteng (northbound) and vice versa can choose from a number of different routes.

Table 1 lists the names, lengths, and number of lanes of the main roads connecting the Lapangan Banteng and Cililitan terminals. It is estimated that the length of the roads (seven in all) running north and



Eastern Corridor	1.Jl Senen Raya
● Terminal	2.Jl Pasar Senen
	3.Jl Kramat Raya
	4.Jl Salemba Raya
	5.Jl Matraman Raya
	6.Jl Jatinegara Barat
	7.Jl Jatinegara Timur
	8.Jl Otto Iskandardinata
	9.Jl Dewi Sartika

FIGURE 1 DKI Jakarta area map and the location of the Eastern Corridor.

south (including the roads entering the terminal) are 12 km and 12.6 km, respectively. Along this corridor there are 12 ground crossings and 1 two-level crossing.

Land Use

Land along the Eastern Corridor is generally used for planned housing, unplanned housing, public facility buildings, and businesses (see Figure 2). Most of the Eastern Corridor consists of residential areas, largely in the form of one-story houses. Multistory buildings along the corridor are generally used as public facilities such as government and private offices, schools and universities, and hospitals, and for business or trade such as markets, shopping centers, and shops.

Three business centers that stand out are in Senen, Jatinegara, and Cawang. Alongside the Salemba Raya, Kramat Raya, and part of Senen Raya roads are public facility buildings. Buildings or locations that are well known along the Eastern Corridor and often used as points of reference are:

- The Finance Ministry at Lapangan Banteng
- The shopping center at Senen
- The University of Indonesia complex at Salemba Raya
- St. Carolus Hospital at Salemba Raya
- The Ministry of Agriculture at Salemba Raya
- The shopping center at Jatinegara
- The East Jakarta Mayor's office at Jatinegara Timur
- The East Jakarta Youth Center at Otto Iskandardinata.

Bus Stops and Terminals

Along the corridor there are 64 bus stops--30 northbound and 34 southbound. The distance between bus stops is not always the same, the closest and the farthest being 120 m and 850 m, respectively.

Public transport vehicles must stop at determined points; microbuses and microlets/opelets (12-passenger vehicles that serve exact routes) may stop at any of the allowed points at the request of passengers.

There are four official public transport terminals along the Eastern Corridor at Cililitan, Lapangan Banteng, Kampung Melayu, and Senen. The unofficial terminal is located at Jatinegara Timur Raya.

CHARACTERISTICS OF THE PUBLIC TRANSPORT SERVICE

Types of Vehicles and Passenger Capacity

Almost all types of public transport vehicles and private cars are allowed to pass through the Eastern Corridor. Public transport vehicles include those with fixed routes such as city buses, microbuses, opelets/microlets, and bemos (3-wheeled motorized vehicles), and those

TABLE 1 Name, Length, and Number of Lanes of Main Roads Connecting Lapangan Banteng and Cililitan

Name	Length (m)	Number of Lanes	Main Road Number: Northbound	Main Road Number: Southbound
Dewi Sartika	2,263	2 lanes, 2-way without median + 2 parking lanes	I	VII
Otto Iskandar Dinata	2,192	6 lanes, 2-way with median + 2 parking lanes	II	VI
Jatinegara Barat Raya	1,455	4 lanes, 1-way + 2 parking lanes + 1 frontage lane	III	--
Jatinegara Timur Raya	1,200	5 lanes, 1-way + 1 parking lane	--	V
Matraman Raya	1,818	6 lanes, 2-way with median + 2 parking lanes + 2 frontage lanes	IV	IV
	545	5 lanes, 1-way + 1 parking lane		
Salemba Raya	1,401	6 lanes, 2-way with median + 2 parking lanes + 2 frontage lanes	V	III
Kramat Raya	1,235	6 lanes, 2-way with median + 2 parking lanes + 2 frontage lanes	VI	II
Senen Raya	1,100	5 lanes, 1-way + 1 parking lane	--	I
Pasar Senen	1,000	5 lanes, 1-way + 1 parking lane	VII	--

SOURCE: DKI Jakarta, DLLAJR, Travel Time Study Kota Jakarta 1979, 1979/1980.

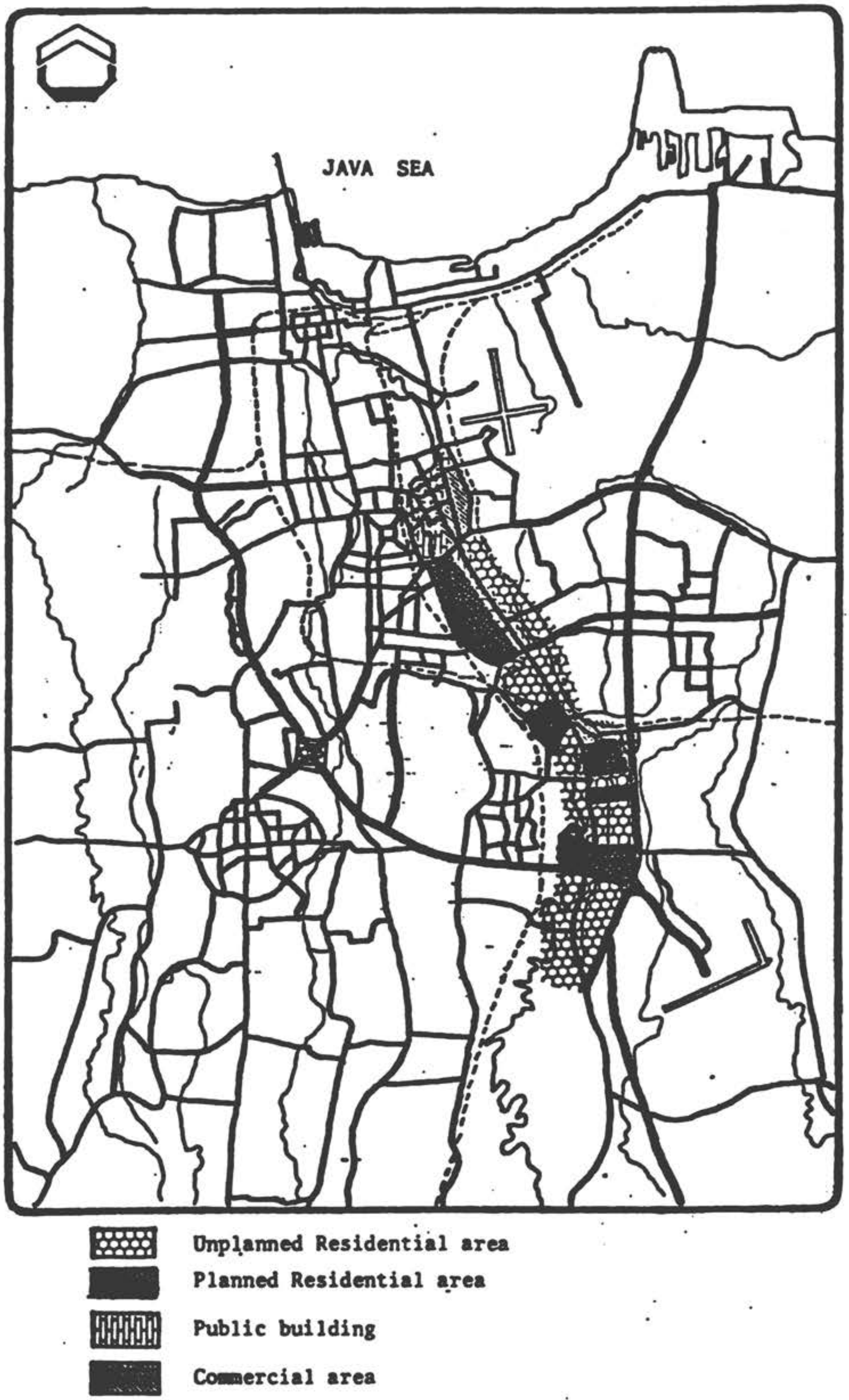


FIGURE 2 Existing land use along the Eastern Corridor.

without fixed routes such as taxis, public transport vehicles type IV, and becaks (3-wheeled, human-powered vehicles). Minibuses and pick-ups are unofficial public transport vehicles and have fixed or unfixed routes according to the requests of passengers. Both large and medium city buses operate in the corridor. Each public transport vehicle has a predetermined route which is signified by an exhibited code number.

Passenger capacity is defined as the number of passengers allowed according to the space available. All official public transport vehicles carry signs showing their passenger capacity. Table 2 shows the passenger capacity and number of seats available on each kind of public transport vehicle operating in the Eastern Corridor.

Fare

Some vehicles charge the same fare for a single trip regardless of the distance traveled, while others charge according to the actual distance traveled. Each means of transportation charges one fare for one trip which means that the more frequently a passenger changes vehicles, the more he pays. Table 3 shows the fare charged each passenger for one trip.

Routes and Characteristics of Passenger Trips

The routes of city buses and opelets/microlets are shown in Figure 3. In the morning, the number of passengers heading north is generally larger than the number heading south, while in the afternoon the opposite is true. This is explained by the fact that most activities are centered in the north, while the south is composed mostly of residential areas. Morning peak hours are defined here as 6:00-9:00 a.m.; morning off-peak hours are 9:00 a.m. to 12:00 p.m.

Daily Trips

The Jakarta Metropolitan Area Transportation Study (JMATS) has estimated that from 1972 to 1974, 3.6 million person-trips were taken daily in Jakarta using public transport and private vehicles (60.8 percent and 39.2 percent, respectively). Of this number, 619,000 trips were made in the Eastern Corridor. Figures compiled by the BPPT show that in 1978 the number of daily trips taken in Jakarta reached 4.995 million--55 percent by public transport and 45 percent by private car. These changes have resulted from the increase in population and a rise in the number of private cars in Jakarta.

Using data from previous studies, it has been established that daily trips taken in the Eastern Corridor in 1978 rose to 20 percent of all daily trips taken in Jakarta. Based on the 1978 figures, it can be estimated that the number of daily trips taken in the Eastern Corridor in 1980 was 667,800 using public transport and 546,380 using private cars.

TABLE 2 Available Seats and Passenger Capacity of Public Transport Vehicles

Type of Route	Type of Vehicle	Seats Available	Passenger Capacity
Fixed	City bus (large)	45	65
	City bus (medium)	32	50
	Microbus	20	20
	Microlet	11	11
	Opelet	7	7
	Bemo	7	7
Free	Taxi	4	4
	Three-wheeled	2	2
	Becak	2	2

Number of Passengers

By observing the average number of passengers on city bus route no. 40 and opelets/microlets, it was possible to determine the average space available in these vehicles (see Table 4).

Figures 4 and 5 show the fluctuation in the space available on city buses and opelets/microlets during peak and off-peak hours in the morning northbound; the same is shown for southbound in Figures 6 and 7.

An estimate of the number of passengers on all public transport going through the Eastern Corridor was made on the basis of direct observation sampling. Total number of passengers in vehicles on different roads, size of vehicles, flow of traffic, and times of vehicle operation were recorded. Figures 8 and 9, which show the density of passengers on public transport vehicles on every main road, were compiled according to the direction traveled and divided in half, for peak and off-peak hours.

Arrival of Vehicles on Each Road and Headway

Table 5 shows the number of arrivals of city buses, microbuses, and opelets/microlets on each road. Interestingly, the number of city bus arrivals is proportionately the opposite of the number of arrivals of opelets/microlets. Thus apparently the opelet/microlet fleet fills in the gap in city buses.

Public transport does not arrive at regular intervals at bus stops along the Eastern Corridor. It has been found that intervals on the northbound route are longer than those on the southbound route.

TABLE 3 Type of Public Transport and Fare Charged per Trip

Type of Route	Type of Vehicle	Minimum Fare (Rp)	Maximum Fare (Rp)	Explanation
Fixed	City bus	50	50	Per one trip close/distant. For students the charge per trip is Rp. 30.
	Microbus	50	50	Same as above
	Opelet/Microlet	50	125	Fare depends on distance traveled.
	Bemo	50	75	Same as above
Free	Taxi	250	--	Rp. 250 for the first km and Rp. 120 for every additional km. Total fare is determined by meter.
	Three-wheeled	150	—	Fare charged depends on distance traveled and bargaining between passenger and driver.
	Becak	100	—	Same as above

TABLE 4 Average Space Available on a City Bus (Route No. 40) and Opelet/Microlet

	City Bus		Opelet/Microlet	
Direction	Peak	Off-peak	Peak	Off-peak
North	-19	0	-1	-1
South	+2	+6	-5	-3

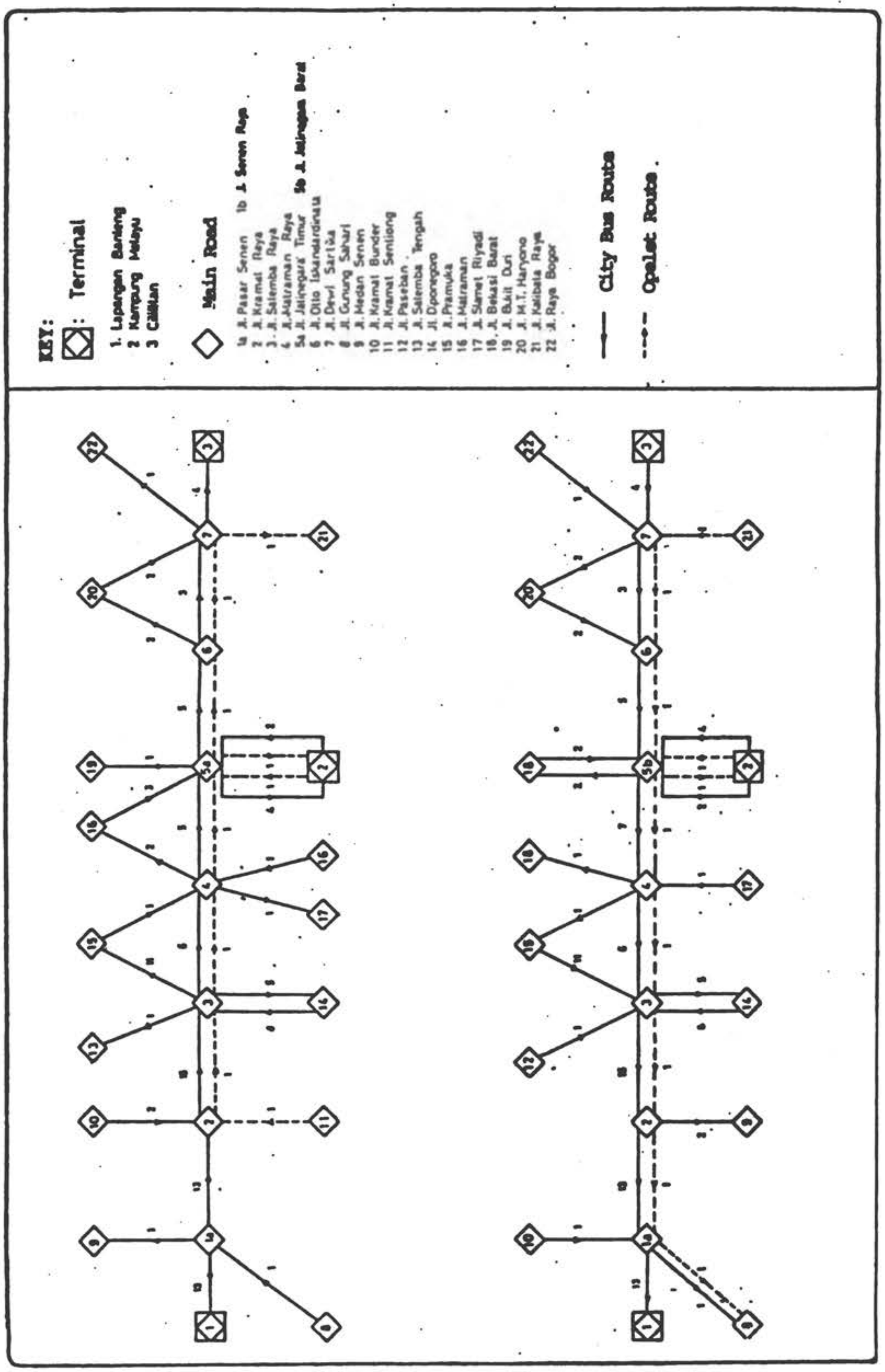


FIGURE 3 Number of public transport routes in the Eastern Corridor.

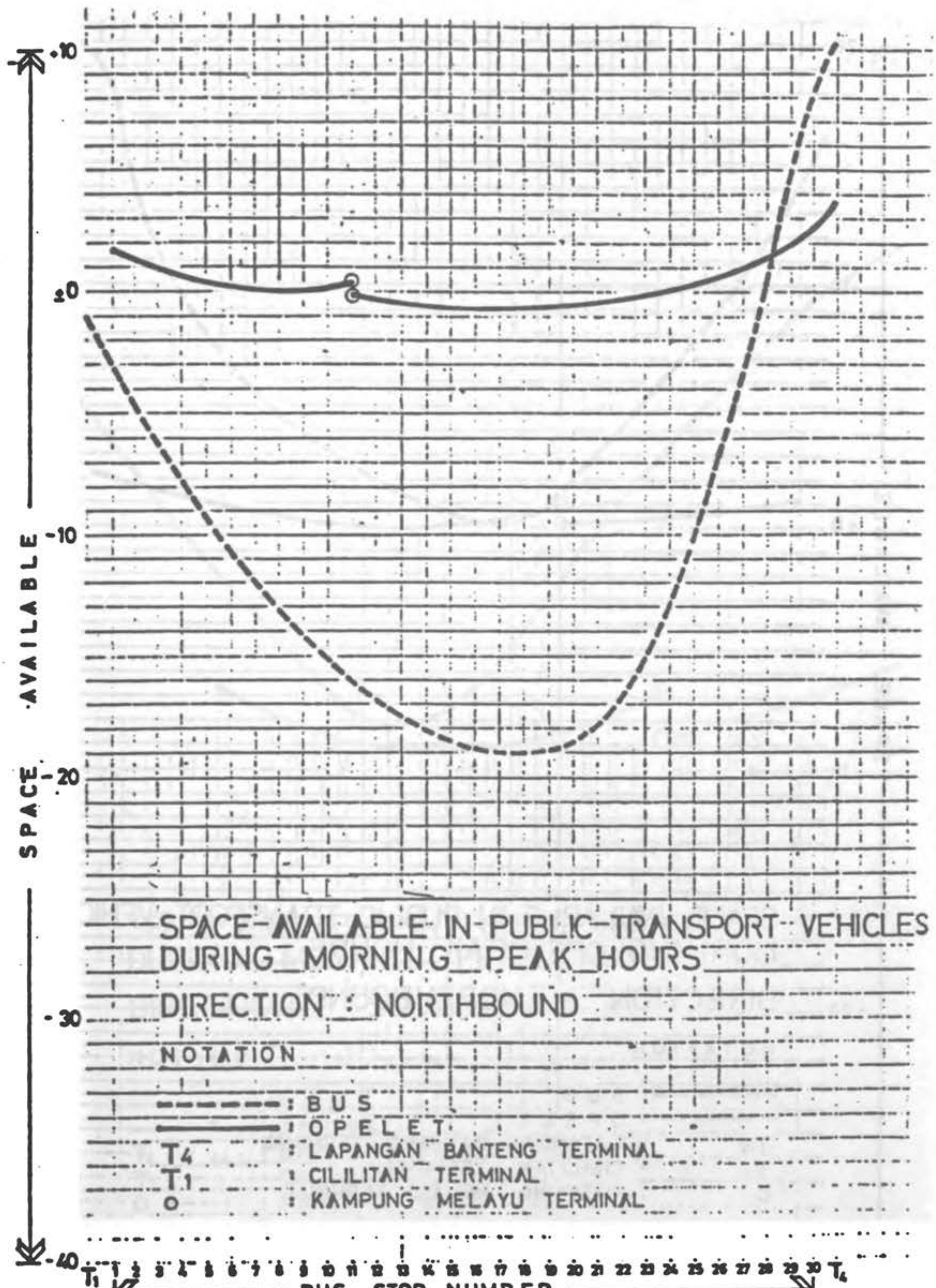


FIGURE 4 Space available in public transport vehicles during morning peak hours, northbound.

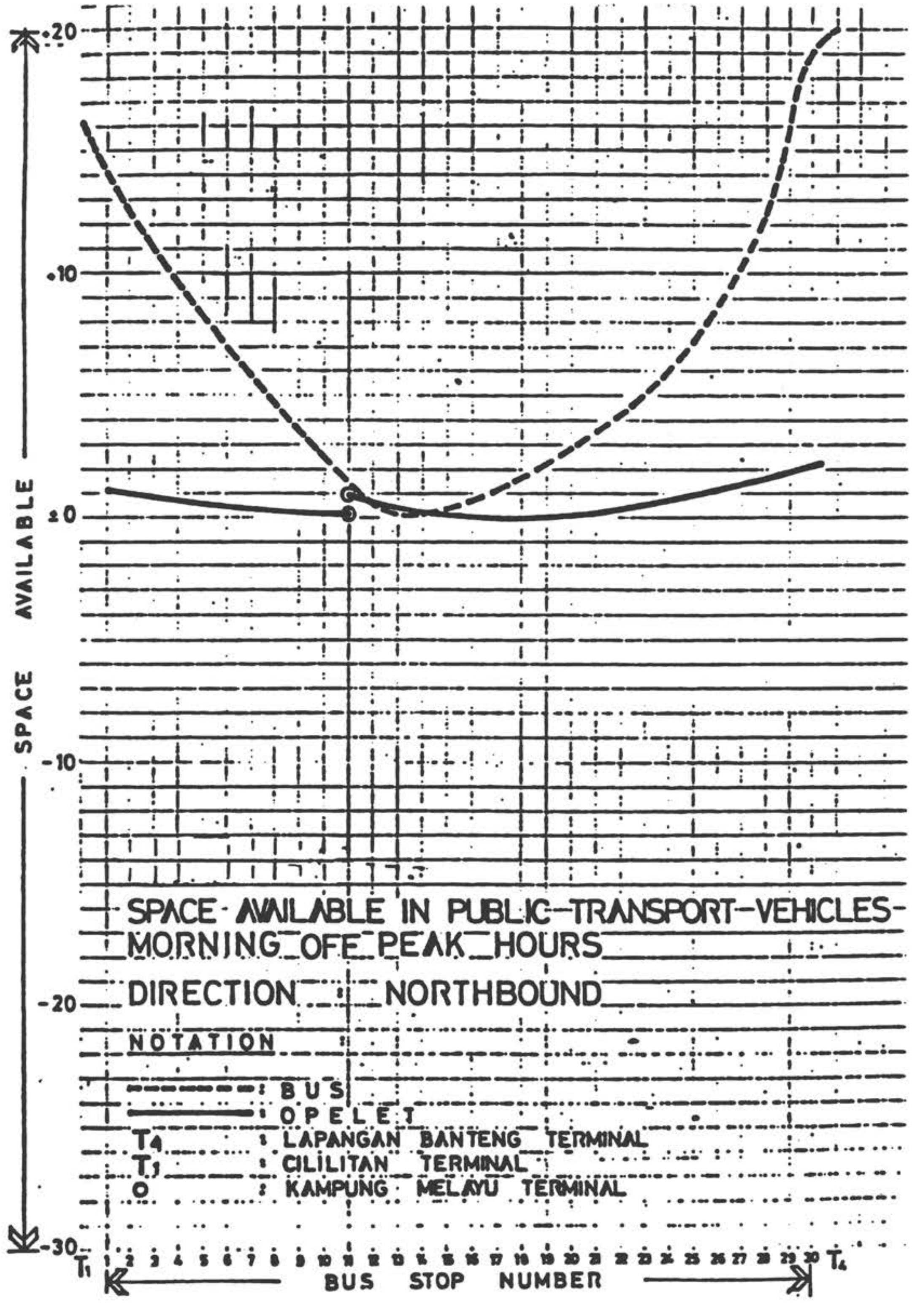


FIGURE 5 Space available in public transport vehicles during morning off-peak hours, northbound.

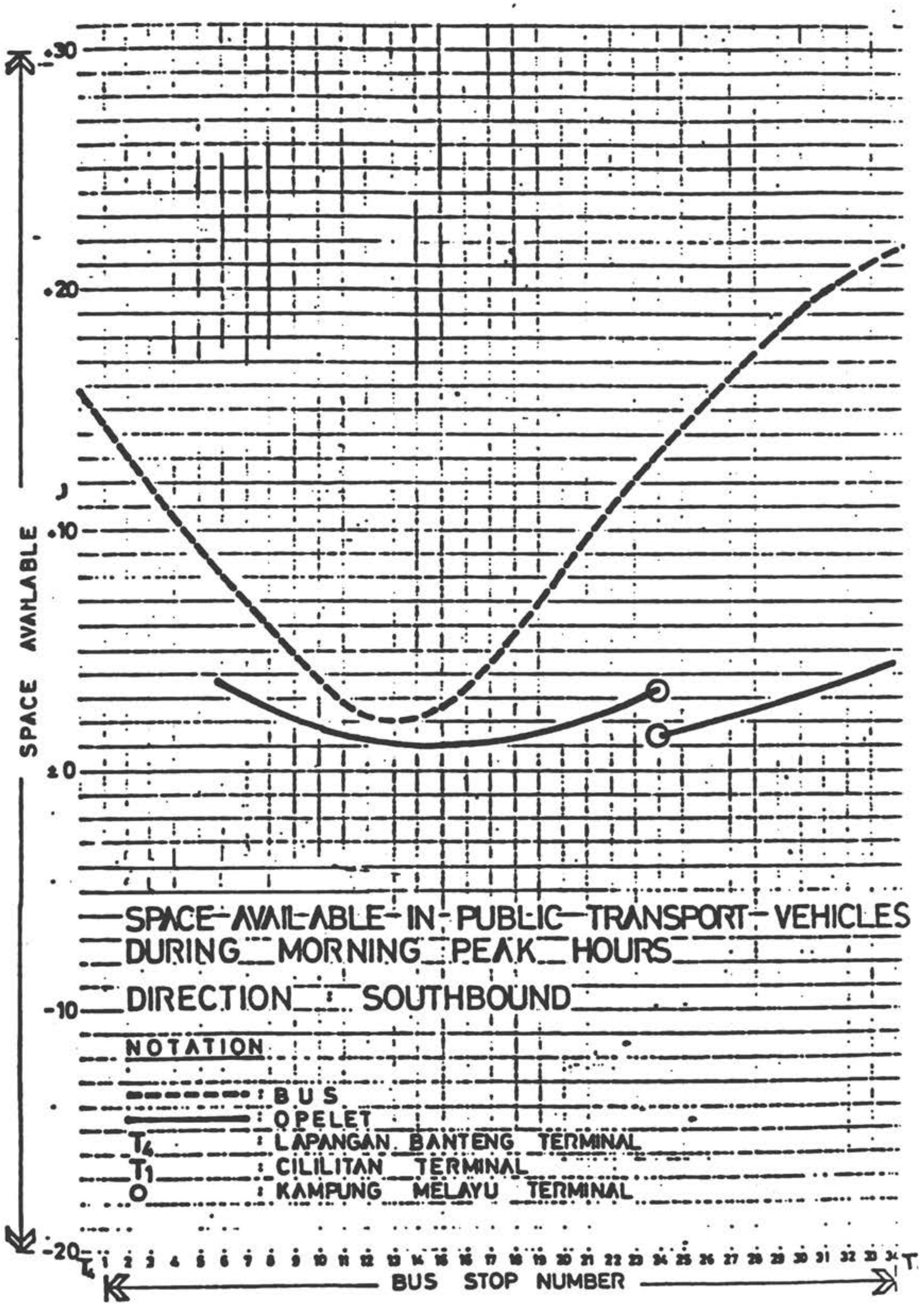


FIGURE 6 Space available in public transport vehicles during morning peak hours, southbound.

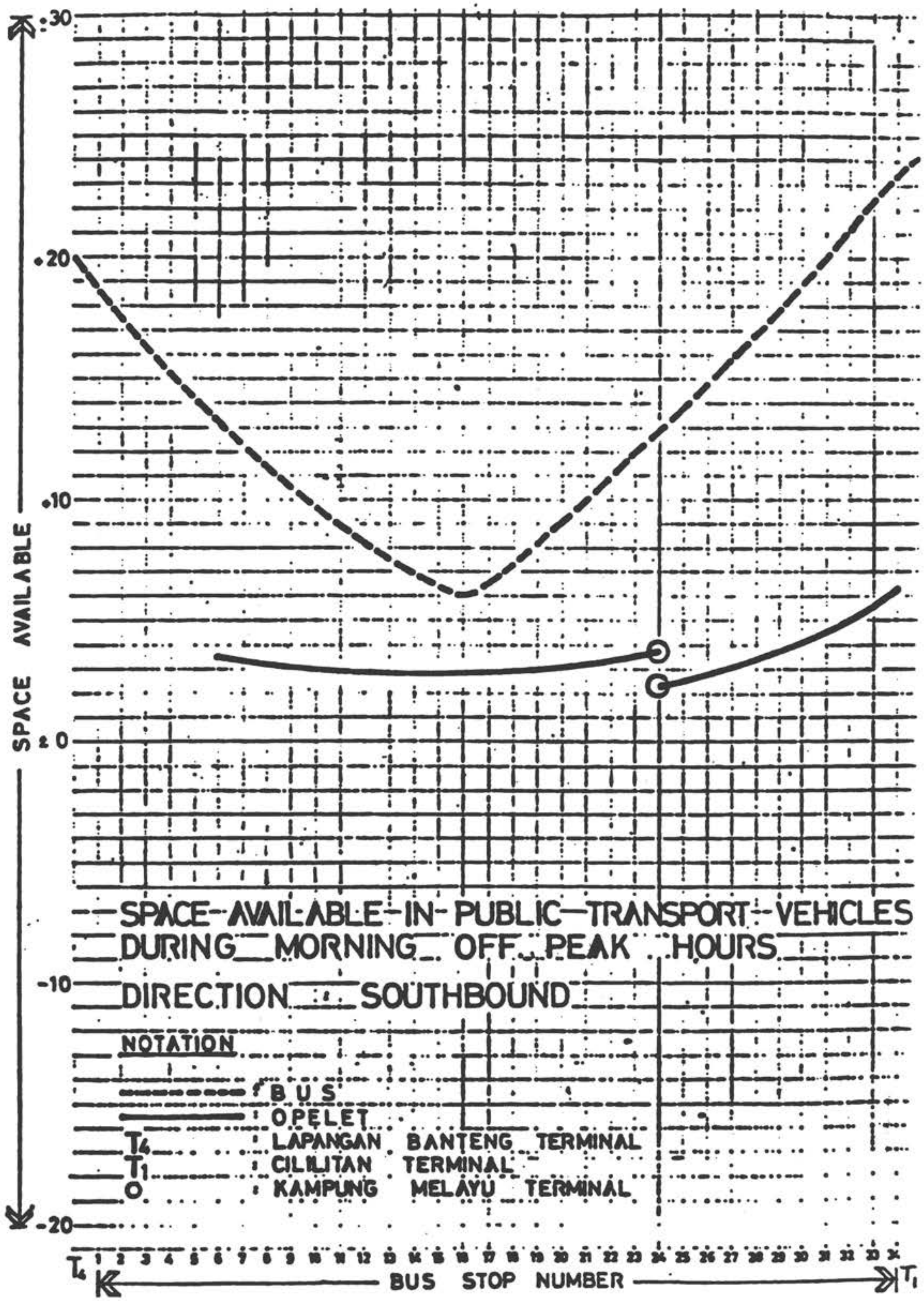


FIGURE 7 Space available in public transport vehicles during morning off-peak hours, southbound.

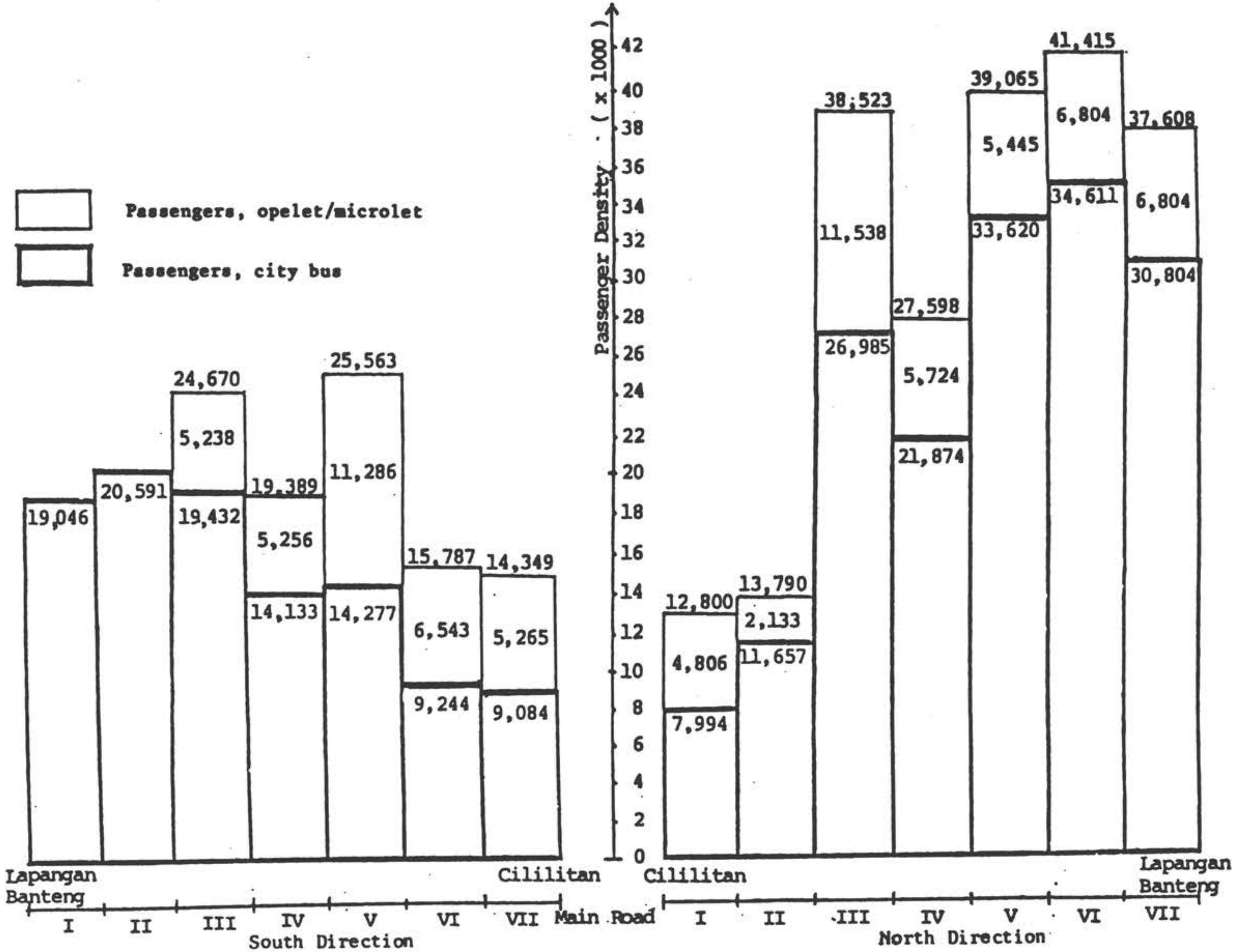


FIGURE 8 Passenger density of buses and opelets/microlets traveling on seven main roads during morning peak hours.

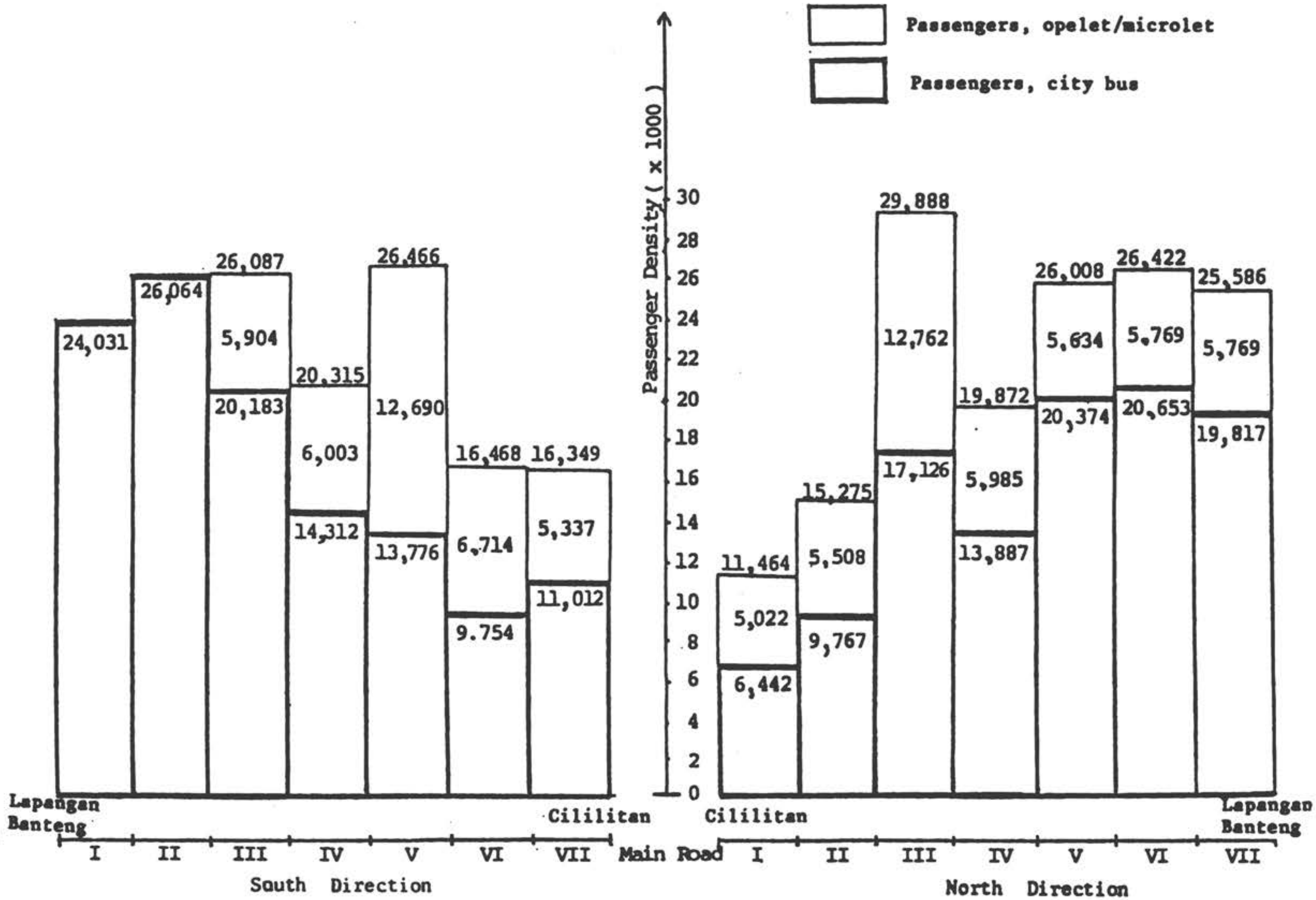


FIGURE 9 Passenger density of buses and opelets/microlets traveling on seven main roads during morning off-peak hours.

TABLE 5 Number of Arrivals of City Buses, Microbuses, and Opelets/Microlets

	City Bus		Microbus		Opelet/Microlet	
Main Road, Northbound	Off-peak	Peak	Off-peak	Peak	Off-peak	Peak
I	140	166	--	--	--	--
II	191	182	--	--	--	--
III	352	305	--	--	582	656
IV	267	238	--	--	584	667
V	401	339	403	384	1,254	1,410
VI	422	339	--	--	727	746
VII	--	--	3	9	585	593
Main Road, Southbound						
VII	205	218	--	--	--	--
VI	232	200	--	--	756	641
V	283	256	--	--	605	626
IV	243	263	--	--	636	665
III	420	435	452	433	1,282	1,418
II	415	422	--	--	611	612
I	--	--	3	9	534	558

Passenger Waiting Time

Length of waiting time is the time needed for a prospective passenger to get on the public transport vehicle of his choice, counted from the time the prospective passenger arrives at the bus stop.

The primary factor influencing the length of wait is the length of the interval before arrival of a vehicle and the space available in the vehicle. Other factors include the patience of the prospective passenger, his readiness to crowd in the public transport vehicle, and the possibility of his choosing another type of public transport vehicle.

Based on observation, it was determined that for prospective passengers in the Eastern Corridor the difference in the length of wait for city buses from the major fleet compared to the minor fleet was insignificant. It was also learned that during peak hours, the length of wait for prospective northbound passengers was shorter than that for those headed south. The opposite is true during off-peak hours. The length of the intervals between arrival of vehicles has a greater effect on the waiting period than the space available in vehicles which has very little effect.

Length of Trips

The length of trips for vehicles in the Eastern Corridor is the time needed for the vehicle to:

- Travel from the terminal of departure to the terminal of arrival
- Or to enter the Eastern Corridor and arrive at the arrival terminal in the Eastern Corridor
- Or to travel from the terminal of departure until leaving the Eastern Corridor area.

Table 6 shows the results of data gathered on the length of trips and speed of public transport as well as the flow of traffic in the Eastern Corridor. The length of trips made by public transport vehicles is estimated to be 1.6 times the flow of traffic as a result of the frequent stops made by public transport at predetermined points to pick up or drop off passengers.

CONCLUSIONS

Based on studies, observations, and interviews related to public transport--city buses, opelets/microlets, and microbuses--it can be concluded for the case of the Eastern Corridor that the rise in demand for public transport service is not being met by the number of public transport vehicles providing the service. This is especially noticeable in the demand for city bus service during peak hours. In certain situations, public transport has to carry more passengers than are allowed. This condition requires the appropriate attention, and it should not be allowed to continue without improvement in the public transport system.

In weighing possibilities for improving the system, their positive and negative effects on the system must be considered. Some possible structural changes include:

TABLE 6 Travel Time, Average Speed, and Length of Trips for City Buses, Opelets/Microlets, and Traffic Flow

Northbound

Kind of Vehicle	Route	Travel Time (min.-sec.) Peak	Travel Time (min.-sec.) Off-peak	Speed (km/h) Peak	Speed (km/h) Off-peak	Distance (km)
City bus	Cililitan-Lapangan Banteng	38' 5"	35'45"	19	21	11.96
Opelet/ microlet	Pasar Minggu-Kampung Melayu	12'44"	11' 5"	20	23	4.20
	Kampung Melayu-Senen	24' 2"	24'12"	18	17	7.00
Traffic flow	Cililitan-Lapangan Banteng	26'17"	21'24"	27	33	11.96

Southbound

Kind of Vehicle	Route	Travel Time (min.-sec.) Peak	Travel Time (min.-sec.) Off-peak	Speed (km/h) Peak	Speed (km/h) Off-peak	Distance (km)
City bus	Lapangan Banteng -Cililitan	35'15"	37'50"	21	19	12.05
Opelet/ microlet	Senen-Kampung Melayu	17' 5"	19'42"	18	16	5.10
	Kampung Melayu-Pasar Minggu	11'55"	12'	20	21	4.20
Traffic flow	Lapangan Banteng-Cililitan	25'24"	22'26"	28	32	12.05

SOURCES: BPP Teknologi Observed; DKI Jakarta, DLLAJR, Travel Time Study Kota Jakarta 1979, 1979/1980.

- Adding to the number of city buses in the armada
- Adding to the space available within a city bus unit (with double-decker buses)
- The use of a rapid and limited bus system.

One infrastructural change might be widening the roads in a few areas in the Eastern Corridor.

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BPP Teknologi Observed.

SYSTEMS ANALYSIS AND A STUDY OF URBAN TRANSPORTATION PROBLEMS

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The rate of urbanization is very rapid in many developing countries, including Indonesia. The City of Jakarta now has a total population of about 6 million persons, and other cities, especially in regions of overall high population density such as Java, are continuing to grow rapidly.

The economic health of urban concentrations depends on the division of labor and the effective organization of production and consumption. This organization requires the interaction of workers and households as producers and consumers with economic establishments that manufacture goods and produce services, thereby assisting the activities of other companies and households. The assembly of a labor force and of customers and the distribution of goods and services within the metropolitan region and beyond its borders imply various means of interaction.

Interaction is provided largely by means of transportation, although on occasion electronic and written communication can substitute for transport. There is no substitute for transportation, however, where the assembly of people and the distribution of goods are concerned.

This chapter focuses largely on the transportation of persons within the metropolitan region, although the transport of goods should not by any means be neglected and will be occasionally touched on briefly. From an economic point of view, the transport of people related to production and consumption processes is economically far more costly than most goods transport, primarily because of the perishability of the commodity being conserved--human time and effort--as well as considerations of comfort and safety. At the same time, the condition of the transport system in relation to all other aspects of production and consumption has a very powerful influence on the well-being and comfort of the residents of the metropolitan region. When conflicts between goods movements and persons movement arise in the metropolitan region, it is frequently possible to redistribute goods movement in time and thereby relieve the congestion that it generates and that adversely affects the movement of people. In ancient Rome, roadways became so congested that goods movements were restricted to a few hours in the middle of the night.

In this chapter, the nature of a systems analysis of metropolitan transport will be taken up from several different points of view.

First, the nature of the system will be noted, followed by an examination of the behavioral aspects of the uses of the system. Finally, there will be a brief discussion of the technological means that are available in computer software to analyze the system's problems as well as a general overview of the process of systems analysis of transport needs.

THE NATURE OF TRANSPORT SYSTEMS

A transportation system consists of three major components: (1) the technical or machine system components consisting of vehicles, guideways, terminals, interchanges, etc.; (2) the users of the transport system, together with their needs, desires, and modes of behavior; and (3) an institutional system that provides for the management of systems and the channeling of behavior. According to its varying degrees of articulation, this system may heighten the efficiency of the system and minimize the adverse effects to be expected from congestion and conflict of uses.

The different types of equipment and channels of movement are generally called modes of transportation; the principal modes may be distinguished as water-borne, air-borne, and land transportation. These could be subdivided into subsidiary types of movement; for example, water-borne movement can be by sea or by inland waterway, and ground transport can be on foot, in a variety of different vehicles that travel on roadways, by different types of rail transport, etc. The institutional setting provides that several of these different modes can be publicly or privately provided, or both. The behavior of different modes will depend jointly on their technical characteristics, their user behavior, and the institutional management.

Transport activities generally connect separated activities by way of a continuous route. There is, of course, an exception for air transport, where routes are usually continuous everywhere unless extremely high mountains or completely adverse weather intervenes. Typically, long continuous routes are made up of segments that differ in their technical operating characteristics and in their use. Also typically, in the urban setting, routes that connect points in different directions intersect each other and consequently mutually interfere with the free flow of movement.

Because of the evolution of the use of transport systems, and a concomitant evolution of the systems themselves and of transportation analysis methods, it is commonplace to refer to large classes of transport movement as movements in corridors. The most elementary system in transportation analysis, if not a single link, is at most a corridor of movement. Here one encounters all of the behavioral problems of individuals utilizing and participating in the flow of movement, the conflicts of different modes of travel, and the potential conflict between corridors at points of intersection. Finally, solutions to problems for corridor movement can usually be formulated in terms of relatively simple alternatives that can readily be subjected to a cost-benefit analysis.

At a higher level of complexity, the transportation system must be regarded as a network. At this point, the problems of representation, analysis, and problem solving become more difficult by an order of magnitude. Within a network, huge numbers of alternative paths can be taken by unconstrained vehicles such as private automobiles, taxis, and bicycles, and there are many points of extreme congestion owing to the crossing of routes. In addition, the number of potential interconnections between different pairs of points in a metropolitan region is greatly increased, largely because the number of points being considered is also increased: the interconnections rise with the square of the number of points.

From the point of view of system performance it must always be remembered that transportation is an intermediate good that is designed to produce other final goods such as efficiency in production and effectiveness or enjoyable aspects in consumption. For this reason, one must consider the social and economic system that the transport system is designed to serve. This is particularly true because the behaviors that can be identified in response to the state of a transportation system involve more than the day-to-day behavior in choice of mode, route, and destination. Adaptations over the longer run can take the form of the relocation of places of residence and places of economic activity. In the larger sense the transportation system contains a network of facilities of many different modes, some of which include the same rights of way and some of which do not, imbedded in a system of economic and social interaction in which many individual decision makers take actions. These actions in turn influence the state of the transportation system and this state influences future actions.

MODALITIES OF BEHAVIOR IN THE TRANSPORTATION SYSTEM

Different kinds of human behavior on the part of individuals, households, and economic establishments result in the differential performance of transportation systems. The framework for discussion of these behaviors comes from the standard terminology and modeling procedures used in transportation system analysis in the United States. This must be done with some caution, however, because the types of behavior that will be encountered in Jakarta or Surabaya are not altogether properly captured with U.S. analytic practice. Yet adaptations in this practice can be made and will be discussed briefly.

In a static situation where the status of the transportation system is known, the average user of the system in making a decision does not conclude that his behavior will change the state of the system. An exception to this, however, could be noted in the event that a large entrepreneur or government office was considering a new establishment on currently vacant land and had to take into account the impact that the load it will generate would place on the transportation system. In general, it is assumed that individual decision makers behave as if their activities would not affect the system. Of course over time, and given a large number of such decisions, this expectation frequently will not hold.

The necessary external connections that a household, factory, or office must make with other parts of the metropolitan region establish a broad pattern of trip generation. This variable measures the number of trips likely produced by any particular land use, and it depends on the activity levels of the land uses themselves. It may also vary according to the state of the transportation system, so that in a situation where there is a great deal of congestion, many users will find ways to curtail the number of trips that they make and the load that they place on the system. Some trips are less flexible in their adaptation to congestion in this regard than others; for example, work trips are practically obligatory for both the worker and his employer. It should also be noted that trip generation is strongly influenced by cultural conditions; for example, in many parts of the world it is customary for shops and offices to close at midday so that employees can go home for lunch. This doubles the number of work trips in a particular metropolitan area and creates a second set of peak-hour travel demands. Opening and closing times are set by custom, but can be staggered to reduce traffic peaks.

The choice of whether or not to make a trip is influenced by other considerations and other choices that have to be made. Perhaps the primary choice after a tentative decision to make a trip is mode of travel. For most trips, there is some choice among walking, cycling, bus, jitney, or private automobile. Such choices are influenced by the length and frequency of a particular kind of trip and the cost of the different kinds of modes--both in time and in money. In addition, some modes are not available in some locations because of the configuration of the transport system (for example, buses) or because of the socio-economic condition of the traveler. Not everyone, for example, can own an automobile or even in some cases a bicycle. Decisions regarding vehicle ownership are made over the long run, often in conjunction with decisions on where to live and where to work.

Choices are also made with respect to the destinations of trips. The decision about where to shop, for example, will depend on the distance and attractiveness of various shopping facilities. With an increase in family income and mobility, households will frequently make a smaller number of trips using an automobile, a jitney, or a borrowed car to larger shopping centers that provide lower prices and greater selection of commodities. Decisions about where to go for entertainment, visiting friends, and so on are subject to similar influences. The journey to work is obviously more constrained, because the decision to change jobs or to change residential location is not made very frequently. Nevertheless, clearly such adjustments are made, because short trips to work are far more prevalent than long ones.

In the long run, all of these patterns are influenced by changes in locational patterns. In a growing city like Jakarta, new residential areas are opened and new sites for the establishment of economic activities are likewise developed. These changes result in constant changes in trip generation, choice of mode, choice of destination, and other aspects of travel behavior. The state of the transport system and of the communication system influences this pattern of location and relocation. In the absence of good transport and communication, there is a strong tendency for economic activities to stay close together. This imposes a considerable extension of the journey to work as the city grows, and leads to additional costs of congestion and lost time in doing business. In this sense, congestion feeds on itself by making decentralization impractical. At the same time, the absence of adequate alternative means of communication becomes very important, for congestion could sometimes be overcome by decentralization that is made possible by improved telephone service and other aspects of economic development.

Frequently, the types of behavior sketched above are not well understood and some socioeconomic study of them becomes necessary. This kind of study is an underlying activity of the metropolitan transportation studies that have been conducted in the United States, but it is not clear that these extensive survey methods are necessary for the types of problems faced in a typical Indonesian city, or indeed for some of the problems faced in American cities. This is examined further in the concluding section.

MATHEMATICAL REPRESENTATIONS OF SYSTEM BEHAVIOR

From about 1950 to 1970, the mathematical representation of system behavior and of behavior in the use of transport as sketched in the preceding section developed very rapidly in the United States. Consequently, transportation system analysis is probably the best documented and most easily managed of a wide range of computer systems representations. Relevant computer systems are available from a number of consultants and through various U.S. transportation agencies including the Federal Highway Administration and the Urban Mass Transit Administration. These materials are not specified in detail at this point but are simply sketched.

A number of transportation phenomena are susceptible to mathematical and analytical representation in typical operations research style, but these are not discussed in detail in this chapter because generally they do not partake of systems characteristics. They do, however, sometimes lay a basis for small-scale improvements. For example, the stochastic arrival of vehicles at intersections and the behavior of different signalizing systems are well understood. When these signals are extended beyond a particular intersection to a route or corridor, some systems characteristics begin to emerge. Similarly, individual driver behavior in a "car following model" can be analyzed using numerical simulation, differential equations, and other methods. This analysis leads to the conclusion that above certain levels of traffic density, instabilities appear and there are apt to be standing waves of congestion even though the highest possible levels of congestion have not yet been reached. Once again this is an isolated phenomenon and not a general system phenomenon. The relationships among the engineering characteristics of guideways, the mix of traffic, the volume of traffic, and the speeds on the links are complex ones that are well understood at an empirical level. These relationships are sometimes used to examine in detail the behavior of transport systems considered as networks. All of these small-scale phenomena are only touched on at this point and will not be the principal objective of the discussion.

The most important focus in transportation analysis is on the utilization of transport systems by household decision makers. The three processes of trip generation, choice of mode, and choice of destination (also called trip distribution) are modeled in all of the standard analysis packages. The results of these behaviors are applied to the transportation system through processes known as "tree tracing" and "assignment." Tree tracing finds the shortest paths between all pairs of points on the network, and assignment sees that all movements between pairs of points are attributed to the shortest route or to some combination of best and second best routes between pairs of points. Behavioral models depend in part on the costs of interaction between pairs of points and the availability of services. The two processes of systems analysis and behavioral analysis interact since it is necessary to find the shortest paths in order to determine how households behave, but the behavior of households may lead to congestion on the network and thus change the supposed times. Finding an equilibrium between the behavior and the state of the system is an additional problem or level of systems analysis that can be solved at some added expense.

The tracing of the shortest paths in the network and the assignment of trips to different modes and links in the network are greatly simplified if the network consists principally of a corridor with a very small number of parallel transportation routes. In this case, the tracing of routes is extremely simple and, instead of a full-fledged assignment process, one ordinarily engages in a diversion analysis that measures the extent to which trips will be divided between the few existing alternatives. This methodology was well developed even before 1950 and was indeed the principal methodology of transportation analysis before methods for tree tracing and assignment were discovered and applied in large-scale computers about 1955.

The analysis of trip generation by different types of household and different types of economic land use is ordinarily based on a survey and regression analysis that takes into account various characteristics of households such as size and income, number of wage earners, and availability of owned vehicles. The analysis for economic establishments involves such matters as the number of employees per square foot of floor space, the character of the activity, and the necessity for direct contact with customers or with the suppliers of services.

The analysis of choice of mode and choice of destination is more complex. The general economic model used here is a choice model called by various names depending on its origin. In transportation analysis the model is called a "production-constrained gravity model," while in economics the same model is frequently referred to as a "multinomial logit model." In essence, decision makers are perceived as making choices that are proportional to some function of the attractiveness of different opportunities. This attractiveness is affected by the size and quality of the opportunity as well as by the inconvenience that would be encountered in extended travel. In an established model these calculations are quite straightforward, but choosing a model and estimating its parameters once again require survey materials and, in this case, more effective statistical techniques.

A wide variety of statistical survey techniques exists for collecting data and deriving the parameters of behavior that are necessary for the operation of all of these models. The simplest and most traditional is a household survey on a sample basis. The old U.S. Bureau of Public Roads standards for these sample surveys involved a very heavy sampling rate, but it is currently believed that (given other information to be discussed below) much smaller samples of perhaps as few as 3,000-5,000 households can provide satisfactory information. Alternatively, surveys can be made at places of business and offices, covering both the employees and customers of these establishments. This form of survey is somewhat more difficult to relate to household behavior, which is critical in the analysis of transport problems. A much more limited and more ad hoc kind of survey material is based on cordon counts and interviews. In this process a number of cordon lines and screen lines are set up in the metropolitan region, and counts are made of vehicles and passengers crossing them, together with roadside interviews of sampled individuals. In heavily congested situations the sampling and interviewing are very difficult, and in any case the amount of information that can be elicited in such an interview is always much smaller than what can be discovered in a household or establishment survey. Nevertheless, in the absence of other feasible methods of survey, adequate information can sometimes be obtained from this source.

An entirely different type of information is required in addition to this survey material to operate models once they have been fitted to the data, or calibrated. This information is on the present and future location of activities of various kinds of households in various categories, and information as to levels of income and vehicle ownership that will prevail in different localities during the dates for which the analysis is being made. This kind of information is universal, covering all locators and all households, and it must be exhaustive even on a sketch plan basis if estimates of the response of the total transportation system are to be made. The preparation of these estimates can be undertaken in a very sketchy way by projecting present trends and making guesses as to future locational patterns, or it can be undertaken more systematically through the estimation of the actual locational preferences of households and businesses in future periods of time. These locational preferences would have to be analyzed on the basis of different kinds of surveys from those sketched above, and the operation of models based on these surveys depends on the differential behavior of different transportation plans. This level of analysis is within the reach of most large urban planning agencies within a few years' time, but it is not necessarily congenial with the mode of planning and prospective development that is currently in effect. Its adoption is a matter of policy in itself.

It must be cautioned that an analysis of transport behavior--if it is to respond to a number of different policies in the analysis phase--must reflect the effects those policies may have on individual behavior. Thus, for example, gasoline taxes, parking taxes, changes in bus fares, and a number of other measures all reflect the economic desirability of shorter or longer trips and of choices between different modes. These choices are not well reflected in a policy analysis if the behavior of households and businesses in response to economic pressures is not well understood, and these matters cannot be well understood if data regarding them are not collected in a household survey or other analysis.

AN OVERVIEW OF TRANSPORT SYSTEM ANALYSIS

What has been sketched thus far lays the basis for a systematic evaluation of transportation improvement proposals. The proposals made require careful exploration of the options open to government. These may include the provision of facilities such as roadways, tram lines, and bus lines as well as economic incentives such as taxes and subsidies that have an impact on households and establishments. These policies may also take the form of regulations and enactments that change the supporting management structure of the transportation system by affecting the prevalence and operating conditions of buses and jitneys or other forms of public and private transportation. The process of planning transportation improvements will involve setting objectives, outlining alternative ways of reaching these objectives, and evaluating these alternatives. The experience gained in the planning process will, of course, mean that the objectives and the alternatives will be repeatedly modified in search of more accurate and better embodiments of public policy.

The general setting of objectives must be in terms of the desired social and economic outcomes as well as the objectives that can be properly served by a transportation system. These include accessibility to employment, a reduction or minimization of interaction costs for both businesses and households, and the effective operation of business establishments. At the same time, public policy probably requires a minimization of investment and operating costs. All of these objectives have to be specified in terms of the operating characteristics of transport systems and of the burdens or benefits that they confer on the users of this system.

In specifying alternatives, a serious problem will be encountered with the proliferation of alternatives if several different steps are considered jointly. This can only be avoided by artful planning, but care must be taken not to exclude useful alternatives in the process of imposing limits.

The technical methods discussed above consist of computer methods for exploring the consequences of various decisions. The outcomes of those computer models display congestion in various parts of the transportation system and the costs to individuals and establishments of making use of the system. If the decisions would result in a curtailment of trip making, this too can be taken into account as an inconvenience imposed on users of the system. Similarly, trips that are lengthy either in miles or in time are readily analyzed by these various devices. In short, detailed analyses can be made, and, if the objectives are clearly defined, a post-processing phase can be used to summarize the impact of each alternative plan on the users of the transport system. The choice between plans then becomes a matter of executive action guided by the inputs of transportation planners and possibly of affected users.

TOWARD A CONCEPTUAL FOOD SYSTEM FLOW MODEL FOR RICE IN INDONESIA

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The objective of the Indonesian food system study is to build an Indonesian food system model for use in assessing the impact of government programs and new technologies on the food system (BPPT and SRI International 1979). The flow model that has been designed for rice will help Indonesian policymakers evaluate the impact of a wide variety of program alternatives by simulating the impact of food policies and new technologies and determining the optimal policy.

Because of the comprehensive nature of the model, it must be applied by many agencies in Indonesia, and this feature of the food system model will provide a base for intra-agency cooperation in food policy development. Other benefits derived from application of the food system model include:

- Training of both systems analysts and food experts through direct participation in policy analysis
- Identification of specific problems that need immediate action and will be assigned to short-term task forces
- Organization of information and data on agriculture into a manageable format for decision analysis.

APPROACH

Construction of the flow model for rice began with a general description of the rice system from producer to consumer. This was compiled on the basis of discussions with experts from the universities and research centers, policymakers from Jakarta and region, and "key persons" from regional institutions. To formulate subsystems of the model, it was necessary to enumerate (1) the functions performed by individuals or groups in the flow of rice from producer to consumer, (2) the kinds of

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commodities handled by them, and (3) the kinds of activities they perform:

- Functions
  - -- Farmer
  - -- Local assembler
  - -- Koperasi Unit Desa (KUD, village unit cooperative)
  - -- Non-KUD
  - -- National Logistic Agency (BULOG)
  - -- Private processor
  - -- Wholesaler
  - -- Retailer
  - -- Private household
  - -- Farmer household
  - -- Civil servant
  - -- Hotel
  - -- Restaurant
  - -- Other services

- Kinds of commodities
  - -- Wet stalk paddy
  - -- Dry stalk paddy
  - -- Dry Gabah
  - -- Menir (brewer rice)
  - -- Hull rice
  - -- Milled rice
  - -- Pounded rice
  - -- Brown rice
  - -- Noodle rice
  - -- Rice flour
  - -- Dry paddy

- Kinds of activities
  - -- Irrigation
  - -- Land preparation
  - -- Seeding
  - -- Fertilizing
  - -- Planting
  - -- Cultivating
  - -- Protecting
  - -- Harvesting
  - -- Commodity selling
  - -- Field sorting
  - -- Threshing
  - -- Transporting
  - -- Drying
  - -- Storing
  - -- Sorting
  - -- Purchasing
  - -- Product selling
  - -- Hulling

-- Polishing
-- Processing
-- Packaging
-- Testing quality
-- Cooking
-- Serving
-- Eating

On the basis of these three categories and combinations of them, the Indonesian rice system can be characterized by five subsystems--producer, assembler, processor, wholesaler-retailer, and consumer--as indicated in Figure 1.

The five subsystems in the flow model are linked by the exchange of commodity for money through the pricing mechanism or simply exchanges in commodity.

The next step in the analytical flow model is to describe each subsystem by its major components. For each subsystem, a set of descriptors was established:

1. Producer subsystem
    1.1 Irrigation type
    1.2 Crop pattern
    1.3 Technology level

2. Assembler subsystem
    2.1 Commodity
    2.2 Ownership
    2.3 Integration
    2.4 Technology level

3. Processor subsystem
    3.1 Commodity
    3.2 Ownership
    3.3 Integration
    3.4 Technology level

4. Wholesaler-retailer subsystem
    4.1 Commodity
    4.2 Ownership
    4.3 Integration
    4.4 Technology level

5. Consumer subsystem
    5.1 Commodity
    5.2 Location
    5.3 Price
    5.4 Number of people

Each component can be modified by introducing additional subcomponents or deleting existing ones. For example, if a super high technology is introduced, four levels of technologies would then be used

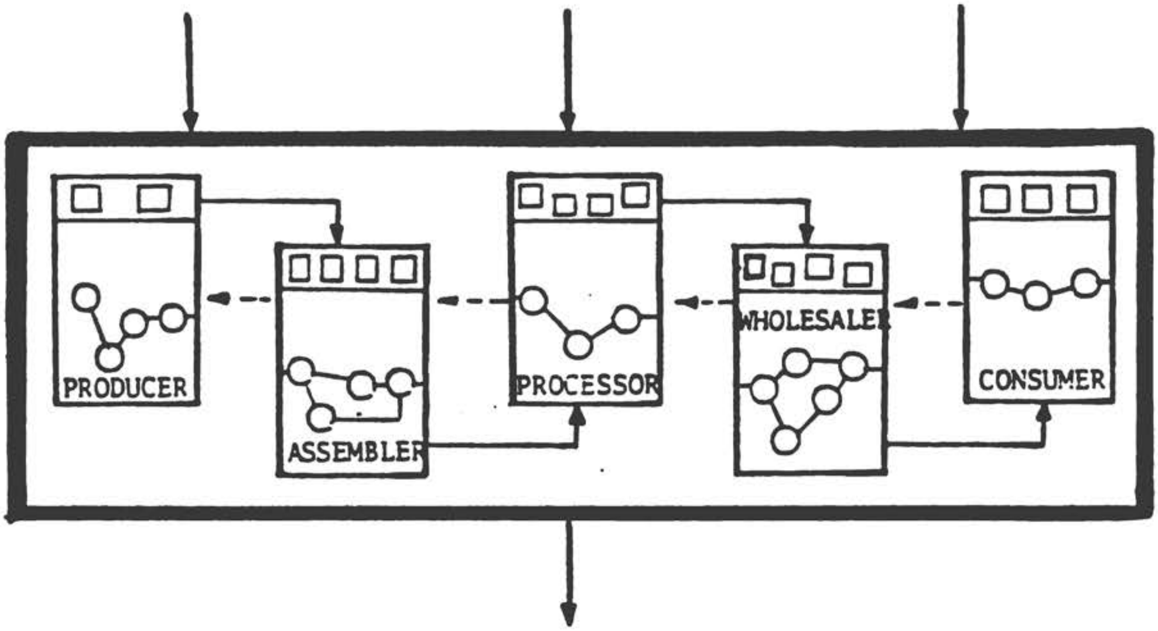

FIGURE 1 Five subsystems of the Indonesian rice system flow model. Individual or group as actor in the subsystem (☐); kind of activities by its actors (○); flow of commodity (→); flow of money (←--).

TABLE 1 Examples of the Producer and Assembler Subsystem Descriptions

Producer Subsystem Description			Assembler Subsystem Description			
Irrigation Type	Crop Pattern	Technology Level	Commodity	Owner-ship	Integra-tion	Technology Level
Not irrigated	Rice-rice	Low Medium High	Rice	Private	Assemble only	Low Medium High
Technical	Rice-maize	Low Medium High		Private	Pre-harvest assemble	Low Medium High

under technology level in the producer subsystem description (see Table 1 which shows examples of the producer and assembler subsystems).

PERFORMANCE INDICATORS

This section describes the performance indicators that measure the major components of each subsystem. A performance indicator should be distinguished from a goal or objective in that no specific level of achievement is predetermined.

For this food system analysis, representative performance indicators are shown below for each subsystem:

1. Producer subsystem
   - 1.1 Production
   - 1.2 Employment
   - 1.3 Net farm income

2. Assembler subsystem
   - 2.1 Volume out/in
   - 2.2 Employment
   - 2.3 Net income

3. Processor subsystem
   - 3.1 Volume out/in
   - 3.2 Employment
   - 3.3 Net income

4. Wholesaler-retailer subsystem
   - 4.1 Volume out/in
   - 4.2 Employment
   - 4.3 Net income

5. Consumer subsystem
   - 5.1 Daily consumption
   - 5.2 Food expenditure
   - 5.3 Percentage of total food expenditure spent on rice.

This set of performance indicators represents the major measure of performance for each subsystem, and each subsystem description component is measured in terms of each performance indicator. The sum of the performance indicators for each component becomes the performance indicator for the total subsystem.

New performance indicators can be added when necessary. A performance indicator is not valued in relation to another performance indicator. If the impact of a policy or technology improves the performance of one indicator and decreases that of another, the policy-maker must then make a relative evaluation of the indicators in order to make a decision regarding implementation of the policy.

Subsystem performance indicators can be changed merely by changing from one component to another in the subsystem. Changes in performance indicators result from decision makers making decisions in response to external environmental factors such as changes in the technology level, type of irrigation used, etc.

The model begins with the funds that the government expends via an institution on new programs or the development of new technologies and ends by projecting the impact of those funds on the designated performance indicator. The food system model provides a step-by-step approach to evaluating the impact of those expenditures (see Figure 2).

The performance indicators can be expressed mathematically once data are supplied to the matrices and the flow of rice is defined. The descriptions, quantification, and linkage among institutions; decision criteria; and the action taken by decision makers to change the mix of subsystem components that affect the performance indicators cannot be evaluated by this flow model, however. Because this model will be used to assess the impact of government programs (policies) and the application of appropriate technologies on the Indonesian food system, the linking of institutions and decision criteria to the components of the subsystem and performance indicators is very important.

COMPUTER PROGRAMMING

The Food System Modeling System (MOD II)* is a set of programs and files designed to model an agricultural system. It divides the overall system into subsystems and formats each subsystem's data into reports. The original version used the Statistical Package for the Social Sciences (SPSS) and the SPSS Report Generator for this purpose, whereas the latest version utilizes reports written in Fortran. Each subsystem communicates with the others by means of three or four Fortran programs. These programs distribute the commodities output from one subsystem to the other subsystems. Another Fortran program reads input data and distributes them to separate files. Each Fortran program reports on the distribution of the data, and these are known as Audit Reports.

Each subsystem within the model is designed to show the pertinent statistics for a portion of an agricultural system. The subsystems are: producer, assembler, processor, wholesaler-retailer, and consumer. Each subsystem is further broken down to unique processes which are described by unique combinations of key variables. Each line item within the subsystem reports is identified by unique combinations of four to six variables. For example, the assembler, processor, and wholesaler-retailer type subsystems use commodity code, ownership code, prime function code, integration code, and technical level code to describe uniquely each subsystem unit (or line item). The report programs can handle any number of these line items as long as each combination of the identifying variables is unique.

The limitation on how many line items a subsystem can have is set by the limitations within the primary distribution program FTN1. To

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*This program was written in November 1979 and rewritten in April 1981. The author was Robert C. Hoppin, and it was revised by Tri Djoko Wahyono, Muhadi, Supriyanto, Kasiran, Hariadi Wardi.

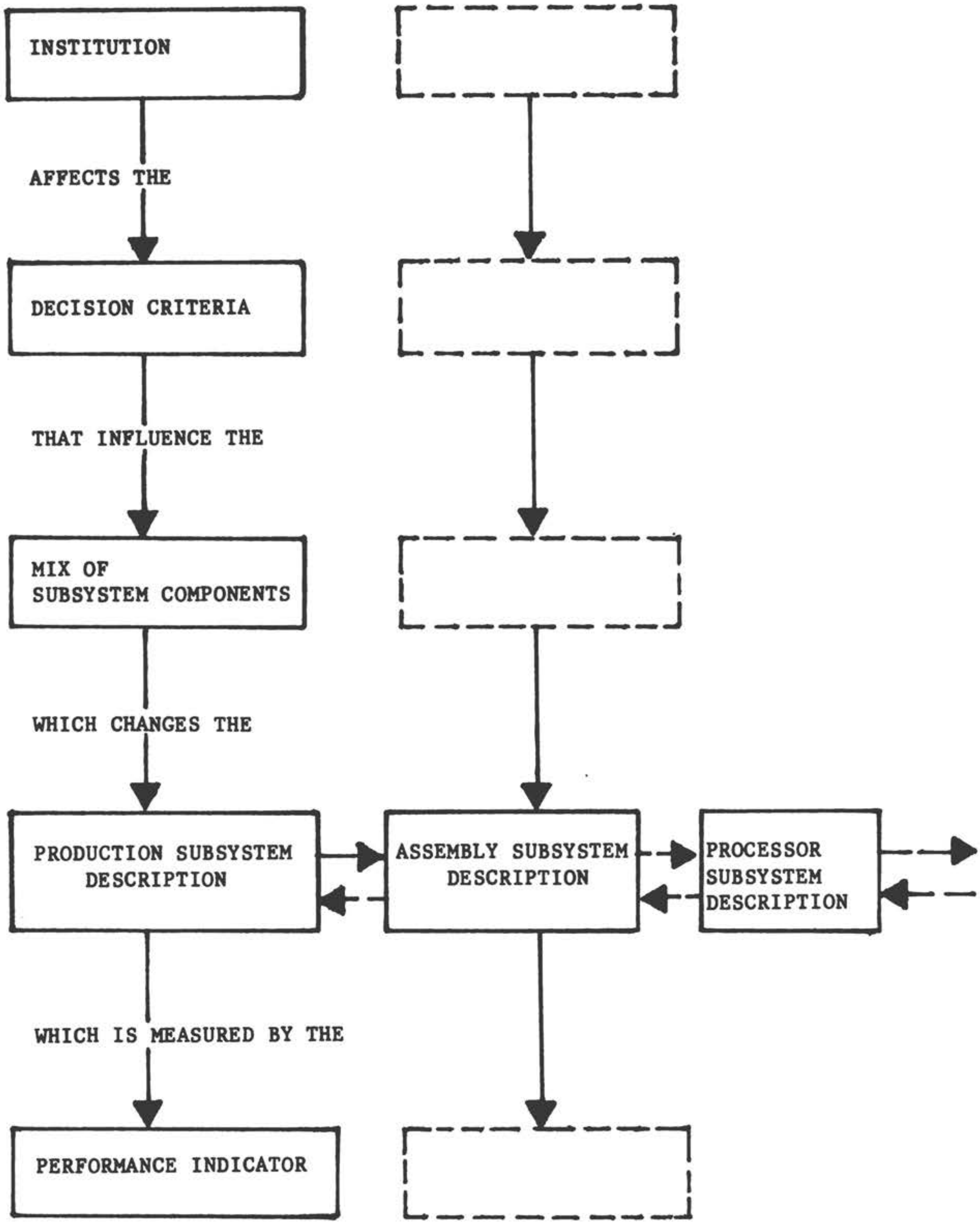

FIGURE 2 A schematic of the general model.

maximize the capacity of the system, the data distribution table is read from the Subsystem Transfer Matrix File, which is kept in a single table in the main memory. Given larger memory sizes, the table dimension may be increased for additional data distribution capacity.

The current version of FTN1 will fit within 512K on the host processor. FTN1 and FTN5 have the same restriction on data variables, even though they require less space for their tasks. The limitations dictated by FTN1 in its current form are stated in terms of the limits placed on the number of distribution links in the distribution commodity mapping. Currently, there is room for 2,000 such links. As a basis for comparison, the largest number of links used in testing to date has been 127. Two thousand links seem more than sufficient for any conceivable use of the model.

FTN1 currently provides for 30 different commodity groups, 10 commodity varieties, and 30 commodity forms within a subsystem. There is space for 30 each of the ownership codes, integration codes, and technical level codes. There is also room for 30 irrigation type codes. Within the data used on the system to date, these limitations seem more than sufficient. Note that space allocations have been set somewhat arbitrarily and should be adjusted (within the Job Control Language-JCL procedure files) if more space should be available and required. Blocking and other considerations of resource optimization were dictated by the host system and can be expected to change as experience is gained with the system.

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SYSTEMS ANALYSIS AND A STUDY OF THE INDONESIAN FOOD SYSTEM

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Why systems analysis? The human mind is the best and most efficient assimilator and analyzer of relationships into useful knowledge; however, whereas the capacity of the human mind is limited, the universe of knowledge is not. Systems analysis is nothing more than a conceptual approach to dealing with this problem by partitioning the universe into smaller and smaller sets of relationships, to a point at which the human mind can handle them. In other words, systems analysis is simply a method for organizing knowledge. Thus this methodology should never be used as a substitute for human judgment, but only as a way to facilitate its use in those situations in which human judgment is considered inadequate to deal with the complexity of the real world. In a very large sense, systems analysis is a mechanism for bringing intuition and analysis together.

A second concept to keep in mind is that the end purpose of this activity is to provide policymakers with information that will help them make very important decisions. The systems analyst must always be oriented to the information of the decision maker and subordinate his interests as a professional. Incidentally, a systems analyst never asks a decision maker what information he <u>wants</u>; he must determine what information the decision maker <u>needs</u>. Thus interaction with the decision maker is very important. A systems analyst must work hard to maintain this information orientation, especially when he is struggling so hard to understand something as complex as the food system.

CHARACTERISTICS OF INFORMATION

Information has five basic dimensions: identification, precision, reliability, timeliness, and cost. Identification refers to how completely all of the relevant variables in the universe studied have been included in the system model. Precision refers to how accurately these variables are measured. Reliability refers to how well the information conforms to the decision maker's perception about that information. Timeliness refers to the availability of the information relative to when the decision maker needs the information. And, finally, cost refers to the cost in terms of money and staff effort required to generate the information. Reliability and timeliness are the most important characteristics to the decision maker. Generally, and within reason, he is willing to sacrifice goodness in the other characteristics for an adequate performance by these two. Also, generally, this is exactly the opposite point of view of the professional analyst in dealing with the same information. These trade-offs should be kept in mind.

MODELING A FOOD SYSTEM

The mechanisms of systems analysis have been developed around the world to the point that almost anything can be done analytically, given time and money. However, can a single systems analysis model that will respond to all the needs for information by decision makers be developed for an area as complex as the Indonesian food system? The obvious answer is that it might be possible but it is not practical. The food system is simply too complex in terms of its size, the number of components and variation in functions, the fact that human beings are involved at every level, the biological systems and weather, and the multidimensional values that are frequently exactly opposed to each other. Many implications of these attributes relate to how well one can structure one's knowledge about the food system, how much effort can be afforded to devote to data collection, and ultimately how difficult it will be to provide the information needed.

To look more closely at two of these implications, first and most important it is necessary to take the time and effort to define the universe to be studied by determining at the start what questions the system model, once completed, should answer or what information it should provide. On the one hand, the complexity of the areas studied will limit the questions it will be possible to ask. On the other hand, determining which questions one wants to ask will in turn determine the size and scope of the structure of the system model and its data requirements. It is critical to the success of a systems analysis study to make this determination early in the study. This author's approach is to develop a paper that addresses the issues of problem definition, to review it with decision makers, and to change it based on these reviews. This also gives the systems analyst an extra chance to educate the decision maker, another of his major roles.

Second, the analyst can give data too important a role in the development of system models. Especially in an area as complex as the food system, the analyst can become overwhelmed with data. Too frequently, analysts let data availability actually determine the system model, although the problem definition phase may indicate questions or information needs requiring a different model. Furthermore, because data collection is one of the less conceptual aspects of the study, the analyst may allow himself to become too taken up with acquiring it. For a system as complex as this one, it is often a waste of time to try to be too precise. A number of subjective estimation techniques can be used to obtain estimates from experts in each data area, and these would provide as good if not better estimates than published or collected data. This is the strength of partitioning in systems analysis.

Finally, the systems analyst should not strive for perfection in the system model and data, because it is simply not possible. It is also not possible to expect to conceive of the entire universe all at once; this leads to frustration. The strength of systems analysis is its ability to reduce unmanageable universes to manageable components. In this, it is important to think "simple"--first partition and then integrate.

A CAVEAT

An outsider can be of only limited help in the development of a systems analysis study of the Indonesian food system and only at certain stages of the study, in particular, the stage during which one learns what it means to undertake a systems analysis. Another is assisting with the selection and application of appropriate analytical techniques. At other times, it may be best to send the outsiders away as they would probably do more harm than good. One implication of this is that Indonesian systems analysts should not seriously consider using a systems analysis model that has been developed for application elsewhere in the world. Their study must be unique if it is to be useful and enduring.

PART III

OBSERVATIONS AND RECOMMENDATIONS

GENERAL RECOMMENDATIONS OF THE NRC PANEL

The intensive sessions and field trips held with the Indonesian team members and their leaders during this 5-day workshop gave the NRC panel an excellent opportunity to observe firsthand the capabilities of the Agency for the Assessment and Application of Technology (BPPT) for carrying out beneficial studies in the areas of solid waste management, urban transportation, and the Indonesian food system.

Members of these teams appear to represent a substantial portion of the perhaps 100 or more Indonesians with similar qualifications in the field of systems analysis (S/A). In general, the NRC panel found that these individuals are highly motivated, industrious, tenacious, and, within the limits of their training, capable. Indeed, the work that these three teams have undertaken has provided an excellent training ground for sharpening individual skills. For the most part, these individuals have the equivalent of a bachelor's and, in some cases, master's degree in widely varying subjects. Most have undergraduate exposure to mathematics and statistics, and some have carried on systems analysis-related studies beyond the undergraduate level. Because computer facilities are scarce, there is a lack of the computer sophistication that is needed to press forward with solutions to complex technical and social problems.

Present capabilities, though limited by number of personnel, levels of training, and computer availability, are nonetheless sufficient to undertake important projects and make significant contributions to the progress of the Indonesian economy. To maximize this potential, however, a number of aspects of this work need considerable strengthening.

MANPOWER AND TRAINING

Manpower

To enable the effective application of systems analysis in a large and complex society facing numerous technical, administrative, and social problems, the number of trained systems analysts in Indonesia must be increased severalfold. A target number for the fourth 5-year development plan (REPELITA IV) might be a total of 500 additional qualified individuals. At least 25 of these analysts should have Ph.D. degrees, and most, if not all, should have the equivalent of a master's degree. As noted earlier, working with teams such as those involved in this workshop provides practical experience and training that are often the equivalent of that gained from university courses.

Training

While this panel did not examine the curricula available at Indonesian universities and colleges, it is clear that much can be done to provide a stronger educational base for Indonesia's future systems analysts. In at least two locations, curricula leading to a master's degree in systems analysis or operations research should be established. This will require an adequate number of Ph.D.s who, it is hoped, will have had some practical exposure to S/A projects in fields relevant to the Indonesian problems. Increasing the number of S/A Ph.D.s who might serve as leaders and role models on Indonesian higher education faculties must be given high priority if the internal education program is to succeed. It is not necessary, of course, that all these faculty members be Indonesian. The hiring of several qualified individuals from countries where systems analysis is firmly established may add to the strength of the program.

Indonesia has significant contacts with European and North American universities and sends students to such institutions to obtain higher degrees. This practice is of key importance in the development of a S/A capability in Indonesia and should be accelerated as much as possible. Returning Ph.D.s in systems analysis will serve the internal educational objectives as well as provide important technical and administrative leadership to future Indonesian projects.

University Cooperation and Coordination

Indonesian universities and technical colleges already have contacts with major educational institutions throughout the world. Extending and focusing these relationships, both internally and externally, are the keys to achieving a successful educational program for, and the use of, systems analysis.

The International Federation of Operational Research Societies (IFORS), an organization of national systems analysis and operations research (SA/OR) bodies that maintains its Secretariat* in Denmark, is an ideal vehicle for Indonesian universities, BPPT, and other institutions to use in organizing essential contacts. Early steps are crucial to the effort aimed at permanently enlarging the pool of qualified S/A personnel in Indonesia. Identification, guidance, and programs on a cooperative basis with internal and external educational institutions should be established along with strong formal and informal linkages to the major international institutions in the field through IFORS. One

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*The secretary is Helle R. Welling, c/o IMSOR Building 349, Technical University of Denmark, 2800 Lyngby, Denmark. Lists of the country members of IFORS, IFORS officers, and information concerning other affiliates and the 1984 Triennial Conference have been provided to BPPT.

committee of IFORS, under the chairmanship of Arthur A. Brown, assists countries newly introduced to systems analysis in all aspects of educational and international cooperation and assistance.

BPPT should arrange to contact IFORS directly and begin to formally organize SA/OR personnel in Indonesia into an Indonesian SA/OR society which in due course could apply to become a member of the international federation. In any event, Indonesia should, in cooperation with the universities, send delegates to the 1984 Triennial IFORS meeting which will be held in August 1984, in Washington, D.C.

Literature

The panel found the literature resources available to the Indonesian teams (and those not represented at the workshop) to be very deficient. Work in systems analysis has been done in many countries on problems that confront Indonesia and has been widely reported. A large body of literature, including bibliographies and journals, exists, mainly in English but also in French and German, that could speed the process of applying systems analysis effectively in Indonesia. Many of the basic materials are now in inexpensive paperback form, and this panel recommends that a carefully chosen library, including such journals as Management Science, Operations Research, etc., be established in BPPT. It is also recommended that one or more of the comprehensive books on systems analysis be furnished to each team member.

Computers

The computer world has undergone a radical change in the past few years, and inexpensive but powerful small computers are available for individual use. These microcomputers provide analytical and computational power in small packages that until recently was available only in the larger expensive main-frame or mini-machines. General statistical and analytical as well as problem-specific (e.g., transportation analysis, resource allocation, financial spread sheets) programs are readily and inexpensively available.

Every BPPT systems analysis-related team should be provided with one or more microcomputers with appropriate training and applications programs for their exclusive use. At least one member of each team should be designated and trained as lead computer expert to assist in developing the programs necessary to support the analyses and models developed by the team. This panel must voice a note of caution, however. The acquisition of advanced software and hardware technology cannot ensure successful end results unless it is accompanied by extensive and intensive training.

LEADERSHIP OF S/A GROUPS

The choice of leaders for S/A projects requires bringing together all the forces pertinent to both the problem and its solution--administrators, government agencies, universities, and trained individuals--so that through cooperation, coordination, and the combined commitment of resources they may increase the likelihood of success and the value to the nation of the end results. The leaders chosen for projects must be able to manage the inevitable conflicts of interests and goals to yield maximum benefits.

The present and likely future leaders of the BPPT S/A teams are young and enthusiastic and not greatly experienced either technically or administratively. Thus they must be strongly supported by an administrative apparatus which, while it may not itself have a S/A orientation, should be able to guide the group leaders in the management process. Each group leader should have a supportive, mature, administrative alter ego who can help identify and define key issues and deal with management problems that might otherwise hinder a team's efforts. Management training exercises for present and potential team leaders led by such administrators can help achieve better results and appraise potential group leaders for new projects.

INTERAGENCY COOPERATION AND COORDINATION

There are four critical requirements in developing effective systems analysis for Indonesia, which can only be met by the fullest coordination and cooperation of the various government agencies.

First, information must be sought on situations in which systems methodology and computer technology have proven useful elsewhere and have a high potential. This means establishing a regular process for acquiring information from other countries and a regular reporting of program and project activity.

Second, there must be a careful review of the state of the art in a given sector, as this workshop was intended to do. An advisory role by outside experts in this evaluation would be both appropriate and valuable.

Third, there should be a widespread, sustained program of orientation and education for BPPT officials, regional administrators, and selected technical and educational leaders to increase their awareness of and sensitivity to the impact of change on the community.

Finally, there must be appropriate administrative action by the government and BPPT to strengthen the S/A research and development programs, to support the educational programs, and to initiate pilot projects designed to apply innovative techniques in solving problems.

Taken together, these elements can provide a solid base for trained systems analysts who wish to apply their skills to the maximum extent.

PROJECT PLANNING AND CONTROL

While the NRC panel experts found the three group projects competently managed, it was suggested that the end objectives could possibly be more effectively achieved with added doses of pragmatism and project control. It is difficult to create and maintain among diverse government agencies a staff of qualified analysts. Yet it is essential that the BPPT, as one agency dealing with the complex problems of Indonesia, secure the ability to work with these problems in a systematic way. BPPT must find ways to use outside consultants more effectively through correspondence and visits and to guide the consultants and their undertakings, whether at a distance or on the spot, into fruitful channels.

BPPT and other agency administrators must be willing to invest substantial amounts of time in their own teams and the consultants. They will then learn from exposure to the systems methodology as well as have the opportunity to communicate to the analysts the many constraints that surround public programs and policy decisions.

BPPT should also initiate a program of project planning and control to provide formal statements and definitions of the problems to be undertaken. These formal problem statements would be made available both internally and externally to (1) members of the agencies involved, other administrators, and analysts who may work with, be members of, or lead a team if the project goes forward; and (2) to such outside consultants, experts, and advisors as may be appropriate for the problem. Feedback from these individuals and modification of the problem statement as well as clarification of the approaches and plans to carry them out would be the expected result of this process. This panel suggests that the problem statements contain, at a minimum:

1. Problem definition
   a. Source
   b. Possible causes
   c. Who and what are affected
   d. Magnitude, extent, and future growth of problem
   e. Urgency

2. Objectives and evaluation criteria
   a. Key purposes for undertaking
   b. Positive and negative effects
   c. Measures of effectiveness of the results (measures of progress along the way)

3. Current status and who is involved
   a. Other agencies
   b. Community sectors
   c. Administrative levels
   d. Coordinate parallel or conflicting programs

4. Political, timing, and economic factors

5. What are possible solutions to the problem? Which of these should the S/A program consider undertaking?

6. Possible next steps (more than one, if feasible) and specification of alternatives chosen
   a. Timing
   b. Scope
   c. Data problems
   d. Resources required.

This document should be complete enough to permit all parties to comment effectively and for decision makers to arrive at a decision. S/A resources will be scarce for some time to come, and the selection of projects will be an important factor in the success of the BPPT systems analysis program.

A project management document should follow outlining detailed responsibilities and authorities. This document can provide the starting basis for project control, and by being kept up to date as the project proceeds, it can also be used by project managers, administrators, agency personnel, and consultants to follow and control the project's progress.

PROJECT IMPLEMENTATION AND DECISION REQUIREMENTS

This panel recognizes that the final decisions in virtually every S/A project involve judgments about what is most beneficial for the country. Clearly these are political decisions, properly matters for debate within the government, and no S/A or computerized operational effort should make final choices. These latter activities can, however, make those decisions more informed and expand the benefits to be gained.

While systems analysis provides the gateway to larger opportunities, and even shows the path by virtue of a detailed implementation scheme that is part of the final S/A report, implementation of projects is the task of government administrators. Without a regular source of educated analysts whose skills are continually being upgraded by education and outside contacts, effective computer support, good literature and correspondence resources, and appropriate communications with and the cooperation of the using agency, the systems analysis task in Indonesia will not be accomplished. These four implementation requirements must be undertaken by the BPPT and other appropriate government authorities if the excellent start that the NRC panel recognizes is to become the foundation for significant progress.

NATIONAL ORGANIZATION

This panel recommends that:

- A (formal or informal) State Council (Committee, Panel) on Systems Analysis be established to provide a focus for government efforts to increase the number of qualified systems analysts and the effectiveness of systems analysis with regard to REPELITA IV. Membership on the council should, of course, include BPPT representatives and university personnel, as well as any others selected by the Ministry of State for Research and Technology.

- The functions of the State Council on Systems Analysis should include but not be limited to:

-- Establishing goals and objectives for the enrollment of S/A candidates in Indonesian and other universities and technical colleges.
-- Collecting data and engaging in correspondence on educational requirements, curricula, and availability of S/A training in other countries.
-- Monitoring and evaluating progress in increasing the quality and quantity of Indonesian S/A education and the graduates it produces.
-- Stimulating, encouraging, and supporting the formation of a national SA/OR society and assisting in the affiliation of that society with the International Federation of Operational Research Societies.
-- Advising the Minister of State for Research and Technology on strategies, progress, and potential studies in the field of systems analysis.
-- Obtaining from each Indonesian university and from appropriate agencies and each BPPT S/A team an annual report describing the state of educational programs and the status of S/A projects.
-- Encouraging the publication within and outside Indonesia of work in systems analysis by individuals.
-- Establishing a program to develop an effective computer infrastructure and a library of S/A materials and to provide students and team members with materials for their own study and use.
-- Recommending workshops and national and international meetings that should be held in Indonesia on subjects relating to systems analysis.
-- Reporting annually to the Minister of State for Research and Technology on the council's activities, including progress made by the government, the universities, and the project groups toward increasing the use and effectiveness of systems analysis in Indonesia.
-- Maintaining an ongoing record of the applications of systems analysis and the impact on the services affected.

The establishment of a State Council on Systems Analysis would signal the government's serious intent to utilize systems analysis in attacking problems, as well as facilitate the coordination required to develop worldwide S/A contacts. The panel views this council as an advocate for systems analysis; a monitor of the quality of S/A projects, personnel, and education; a means of providing constructive assistance to Indonesian educational institutions in increasing their number of S/A students and expanding their curricula; and an important resource to the Minister of State for Research and Technology, BPPT, and other agencies in the development of S/A policies.

OBSERVATIONS AND RECOMMENDATIONS: SYSTEMS ANALYSIS AND SOLID WASTE MANAGEMENT

This workshop's emphasis on solid waste management was undertaken for the following purposes:

- To provide guidance in systems analysis and solid waste management
- To consider means of establishing continuing communications between the BPPT solid waste staff, the NRC panelist, and other U.S. experts
- To review work performed by the Agency for the Assessment and Application of Technology (BPPT) on incineration and refuse collection in Jakarta
- To discuss sampling procedures for studying solid waste characteristics.

FIELD TRIP OBSERVATIONS

Field trips were made by NRC panelist Abraham Michaels and BPPT solid waste team members to sanitation facilities in Jakarta and Surabaya. The visit to the Jakarta sanitation operations areas included the collection operations, depot transfer stations, transport operations, disposal operations at an open dump, and a sanitation headquarters and vehicle maintenance yard. The group was shown a slide presentation of the overall operations of the department. The plastic bag manufacturing facility was also visited, where it was learned that an impressive production rate of 4,000 bags per day is maintained. The high level of maintenance service was also noted.

A trip was also made to Surabaya to learn about its municipal solid waste operation and to tour its sanitation facilities, including collection operations, depot transfer operations, transport operations, the open dump site, and the compost plant. Their sanitation vehicles are owned, operated, and maintained by a private company. It was noted that both the publicly owned Jakarta and privately owned Surabaya vehicle maintenance operations reported equally good maintenance records --approximately 10 percent vehicle downtime.

The compost plant was out of service at the time of our visit because of a breakdown. Compost sold well for the first 5 years of operations but had no market during the last year. The compost plant reports a very high rate of reject material--70 percent--which appears to be attributable to the high content of thick, dense organic matter such as tree leaves, stalks, and fresh fruit and vegetable market waste. The rejected material was disposed of by open burning, and the burning condition was poor.

A solid waste management study for the City of Surabaya was discussed with managers of the Sanitation Department. The management reported that it was implementing some of the recommendations, but a major recommendation--the transport of waste in railroad cars--would not be implemented at this time because of the high cost. It was noted that the waste characteristics test data used in the study were probably inadequate, and that it would be desirable to conduct more extensive characteristics studies to ensure the validity of any plans based on the quality of the waste.

BPPT INCINERATION AND REFUSE COLLECTION STUDIES

In discussing the incinerator and collection and transport studies, NRC panel members and the BPPT's solid waste group agreed that the solid waste characteristics data used for the incinerator study were not an adequate basis for the results reported in the study. Specifically, the solid waste characteristics in the study describe food waste and vegetation as one group, and it is assumed that this waste is comparable to food waste when incinerated. In fact, a substantial part of that waste includes thick, fresh leaves, stalks, and dense vegetable market waste, a combination that is difficult to burn without prior processing. Furthermore, there is some question as to whether municipal waste containing 60 percent moisture is exothermic.

The NRC panel found that the waste characteristics test procedure used by BPPT is good and should be continued except that the category of waste identified as "organic" should be divided into food waste and heavy, dense waste such as leaves, tree and shrub trimmings, and fruit and vegetable market waste. It would probably be desirable to increase the frequency of sampling for test purposes to four times a year.

In view of the apparent high moisture content of the waste, the feasibility of using it as fuel in an incinerator designed to produce steam and electricity should be reexamined. It would be desirable to test samples of waste in existing incinerators such as those available in hospitals or industry. If the waste is not suitable for energy generation, the present Solid Waste Master Plan for Jakarta should be reexamined, and additional alternatives such as rail haul and barging to sea should be analyzed.

It was also agreed that the incinerator study for Central Jakarta is a limited systems analysis that emphasizes the feasibility of the incineration process. It is recommended that the study be expanded to include the results of additional waste characteristics test data and to examine additional alternatives. Among the latter are incineration without energy recovery; incineration in small, strategically located modular incinerators up to 200 tons per day capacity, with and without energy recovery; and baling prior to landfilling.

The collection study, which considers a number of alternatives, is recognized to be a systems analysis. The 30,000 population study size is an appropriate constraint that is based on the present organization of the city's Sanitation Department. It may be desirable to expand this study by adding alternatives such as the use of temporary container locations to be serviced in accordance with an appropriate schedule.

The BPPT solid waste group intends to test the recommended Models IV and V--container and compactor models--in several locations. One significant factor to be studied is the social and economic impact on the population, including the effect on scavenging at the depots and the attitude of residents in the community to the change in collection practices.

Finally, BPPT is fortunate to have a dedicated, competent group of young people working on this project under the direction of Group Leader Miss Sri Bebassari. They did, however, express the concern that their youth will make it more difficult to meet their goals. The addition of experience to the group may improve their ability to influence other agencies and organizations involved in the development and implementation of solid waste programs.

OBSERVATIONS AND RECOMMENDATIONS: SYSTEMS ANALYSIS AND URBAN TRANSPORTATION

As a result of a preliminary study of Jakarta's Eastern Corridor and of field investigations during this workshop, this study group recognized two broad aspects of the urban transport problem that must be linked through systems analysis.

First, in large Indonesian cities, especially Jakarta, there is a widely felt need for major improvements in the means of daily travel, at reasonable cost to the user and the government and with minimum demands for petrol and other energy sources. These improvements are particularly important for the welfare and mobility of the low-income population.

Second, at the same time, a large number of instruments or actions can be brought to bear on these problems, including:

- Traffic management (including bus system management)
- Facility improvement
- New facility construction
- New system construction (e.g., electric railways)
- Restraints on use of private vehicles
- Better coordination of job location and housing location through improved urban planning.

Each of these instruments has many subcategories.

The application of systems analysis to urban transport should result in a small set of well-formulated alternatives, together with their analysis, designed to solve as many problems as possible and to serve the appropriate decision makers. This group tentatively decided to focus on low-cost alternatives, a constraint imposed by the world economic situation and by the present weak demand for petroleum. If these matters improve, more ambitious alternatives can be explored. The three major problems identified in relation to developing and testing these alternatives can be overcome by related steps:

1. Securing additional data about the current location of people and jobs in the Jakarta metropolitan area and about their transport needs
2. Developing through research an understanding of several aspects of transport behavior and of the functioning of the transport system

3. Acquiring or creating comprehensive means for testing alternatives and improving them once they have been generated.

The transport group should begin work on these problems in cooperation with the Municipality of Jakarta, the Ministry of Communications, and the Department of Public Works. Studies might be begun in five areas:

1. Facility design, cost, and performance
2. Traffic characteristics and the consequences of management changes
3. User behavior (e.g., automobile ownership)
4. Location and relocation of employment
5. Large-scale computer methods for systems analysis.

These studies should be preceded by the assembly of available data from all possible governmental and nongovernmental sources. Studies should be planned in such a way as to develop skills, train personnel, improve interagency cooperation, and create a stock of data and computer software as the work proceeds. This means that simple studies well suited to the capacities of other agencies should be done in cooperation with them. The participation of appropriate university capabilities in Indonesia should be encouraged. The Agency for the Assessment and Application of Technology (BPPT) will serve as a coordinating agency and will spearhead the development and assimilation of new methods.

OBSERVATIONS AND RECOMMENDATIONS: SYSTEMS ANALYSIS AND THE INDONESIAN FOOD SYSTEM

From observations based on visits to individual farm communities, the village unit cooperatives (KUDs), the National Logistic Agency (BULOG), and the Agricultural Technical Development Center, it is evident that the decision by the Agency for the Assessment and Application of Technology (BPPT) to use systems analysis (S/A) to provide information for investment and other policy decisions is both appropriate and timely.

Clearly, the more, if not most, productive, cost-efficient activities related to agricultural technology have been or are being implemented. Systems analysis was not required to make the decisions that these activities would provide the highest return to the agricultural and food industry for the investment made. Future investment and other policy decisions, however, will not be so obvious with respect to selecting the highest payoff activities. Applied systems analysis will be a significant benefit in this respect.

In considering the application of systems analysis to the Indonesian food system, the NRC panel recommends that the fact that the nature and degree of complexity of the food system differ from those of the waste disposal and transportation studies be reflected in the general approach to implementing systems analysis in this complex area. While the latter two areas include some characteristics of systems engineering in which an ultimate objective appears achievable, the development of a model for the food system will of necessity be evolutionary in character, with gains in the total development made only in increments over time as additional sectors and functions of the system are included in the overall study. Even the objectives and purpose of the food system study will change over time as information requirements change. The logical progression from a statement of specific problems through the development of a single analytical model to the achievement of the desired state of the area studied implies some finality that should not be expected for the food system as a whole.

As suggested above, there could not be a more complex system to study in Indonesia than that of the food system. In terms of structure, data requirements and availability, policy issues involved, multidimensional value sets, number of components, potential impacts, etc., one cannot conceive of a more complex system that also has such important implications. In view of this, it would be unfair to expect the NRC panel and the BPPT food system study staff to develop a definitive system model, analytical methodology, or even a definite strategy for doing so within the limited time period available to them. Reasons for this are made clearer below. At best, it was felt that these individuals could jointly formulate the framework of an approach for developing these systems components. The following recommendations are offered in this context.

CURRENT STATUS OF THE FOOD SYSTEM STUDY

The NRC panel recognizes that a great deal of effort has already been made on the food system study and that the BPPT study staff and its leaders are to be commended on their achievements to date. The steps taken to this point have been both appropriate and necessary, and any systems analyst would have undertaken the same course of action at this particular stage in the development of a food system model.

Rice was the appropriate commodity to select for a pilot effort because of its relative importance and the degree of separation in production and handling. An evaluation of the product flow model indicates that production, processing, storage, distribution, and consumption are the appropriate functional areas for the rice food system. These are the natural separations of commodity flows that are commonly used in most analyses of this kind. It is also a natural separation in that external influences on each functional area are generally different and separate from each other. Further, these functions are most conducive both to integration into higher levels of aggregation or, contrarily, to further partitioning into, for example, discipline-related activities. It should be noted that even in developed countries this approach to modeling is frequently used when analysts encounter a new or unfamiliar area of study in the food system.

It is recommended that the food system study staff (1) continue work on completing the existing model in terms of identifying missing components and linkages in their product flow diagram and (2) complete data specifications for system components for the 2 years currently under consideration as well as start descriptions for another year. This will provide the basis for a more definitive analysis.

SUGGESTED FRAMEWORK FOR DEVELOPING SYSTEMS ANALYSIS

Although a generalized analytical S/A model of the Indonesian food system would be most desirable, it is not practical to develop a model that is intended to answer all questions or provide information on any policy issue that might be required of it. Considering this limitation, what should the food system study staff do next with regard to introducing analytical methods into their product flow model?

It is recommended that this staff begin immediately to develop a paper on the types of policy issues to be addressed by the S/A model. Such a paper is usually the first step in developing S/A models whatever the area of consideration. Once an initial draft has been completed, the paper should be reviewed and criticized by BPPT policymakers for accuracy, relevance, and some sense of priority. This paper will provide the necessary guidelines for selecting the appropriate analytical models to be developed, since analytical models and procedures design is inherently associated with the specific information characteristics for which the model is intended to provide.

An example of one consideration that should be covered in this paper is whether the systems analysis is intended to include only policy issues and other decisions relevant to the technology development and dissemination of BPPT or is intended to provide guidance to the food system regardless of in what ministry policy issues may arise. Beyond this, there is a wide range of issues at both the macro and micro levels of technology with which policymakers must contend, the highest level of which is contained in the third 5-year development plan, REPELITA III. Issues to be addressed by BPPT policymakers must be discerned from these as a start. In approaching this effort, the food systems study staff is reminded that the basic S/A process of partitioning also applies here.

The foregoing is not intended to suggest that no useful results can be expected from the extensive efforts to date without additional model development. On the contrary, it is important for the food system study staff to realize practical results from the foundation of effort completed to date as soon as possible. It is equally important to continue to report results at each stage of development. The following activities are recommended to accomplish this goal.

Suggested Activities

As indicated earlier, it is important to complete the flow model of the food system and to expand it to include an additional year. Based on these efforts, the food system staff should begin to prepare a report that will describe the food system as it exists, the dynamics of the system based on a comparison of data covering 3 years, and some conclusions on the implications of these findings to policy issues and BPPT activities and to subsequent refinement of the total food system model. This will provide some immediate and significant information to policymakers in BPPT and other ministries, while providing time for the staff to gain further experience in applied systems analysis.

In response to inquiries from the food system study staff about appropriate analytical methodologies that could be applied as a next step, it was indicated that such a determination required a more definitive specification of what information was required of the model to answer significant policy issues. It is possible, however, to select arbitrarily a few key policy issues--such as an alternative investment in food systems technology development and dissemination--that can be answered by relatively straightforward analytical methodologies. For example, a budgeting methodology might be applied to the commodity flow model in a manner described in the food system study base paper. A second type of analytical methodology that can be applied is an input/output model, requiring additional data on costs for each of the elements in each of the functional groups. A third type might be a relatively straightforward linear programming application, also requiring cost and price data, which might address questions of optimality given more than one incompatible policy goal. Others could be suggested, but these are sufficient to demonstrate that useful results can be obtained from a progressive expansion of the basic flow model as it exists. Again, this approach will also give the food system staff experience in S/A applications while continuing to develop their capabilities.

Another activity that must be undertaken in the near future is the further partitioning of the current model, especially in the production function area. A partitioning based on the principal activities contributing to increased production over time might be the most appropriate, although the food system staff may consider some other basis more suitable. The principal benefit of this activity, besides being able to identify more precisely technological possibilities, is to provide a means of effective communication with individuals at universities, agencies, and in the field who may have some concern about the implications to them of this new planning tool.

The food system study staff should also start outlining commodity flow models for other important food products in a manner similar to the rice model. This can be conducted in a piecemeal manner over time while some of the above work is being completed. There are many knowledgeable individuals in Indonesia who can provide the staff with good approximations of what these other commodity flow processes look like. As these take form, the approach needed to refine each commodity flow model will become evident. Having flow processes described for at least the major commodities, the food system staff will have a very substantive base on which to conduct a significant systems analysis of the entire food system.

DEVELOPING STAFF CAPABILITY IN SYSTEMS ANALYSIS

The ability to apply systems analysis successfully is not easily acquired by professionals who have not had prior training and some practical experience. For those who have been trained and are currently practicing in their particular discipline, it is not an easy task to reorient their way of thinking about problems to that of the systems analyst. Formal education and outside advisors can help, but S/A abilities are gained only through repeated exposure to actual studies conducted elsewhere and experience gained in conducting such studies. Three suggested ways of improving S/A capabilities of BPPT staff follow:

1. BPPT staff should individually or collectively review reports of previous S/A studies that have been conducted in the food and agricultural area. Such reports may be identified by establishing an informal communication with qualified systems analysts in one or more developed countries.

2. Outside specialists may be brought in for short periods of time to advise and assist BPPT staff on the aspects of systems analysis currently in progress.

3. BPPT should take the initiative in establishing an informal association of systems analysts in the Jakarta area to meet at least monthly to discuss various aspects of this field. The main advantages of such an association would be (1) continuing support of the mutual interest in the S/A approach, (2) an effective continuing education opportunity, and (3) a mutually supporting and efficient method for identifying individuals in the Jakarta area having specialized knowledge on specific aspects of systems analysis. By initiating this activity, BPPT could make a significant contribution to government operations.

APPENDIXES

APPENDIX A

Opening Remarks

Suleman Wiriadidjaja
Chairman, Workshop Organizing Committee
Deputy Chairman for Systems Analyses,
Agency for the Assessment and Application of Technology (BPPT)

On behalf of the organizing committee, I would like to welcome you to the Workshop on Systems Analysis.

Cooperation in the field of science and technology between the Republic of Indonesia and the United States has been a long time in existence, and this workshop represents one more step in this cooperation with the American scientific community through the National Research Council.

Today we are very happy that this workshop takes place in Jakarta and will be opened shortly by His Excellency Minister Habibie [Minister of State for Research and Technology]. We are thankful to His Excellency for his sponsorship and full support, as well as to the American government for the assistance provided by the U.S. Agency for International Development and to the National Research Council which played an important role in making this meeting possible.

This workshop specifically concerns the application of systems analysis as an aid in problem solving and decision making, resulting in an optimum development process. Special attention will be given to the subjects of solid waste management, urban transportation, and food systems because these subjects have been studied by the BPPT staff with the assistance of various national and local agencies, who have been particularly helpful in obtaining data and information.

More than 60 participants from various government agencies and universities have been invited to this seminar, which, it is hoped, will establish a forum for the exchange of ideas and experiences on systems analysis between Indonesian and American scientists. It is also hoped that these discussions will present us with feasible and practical results concerning our future duties and will become the starting point for the application of systems analysis to support development in Indonesia.

Opening Remarks

B. J. Habibie
Minister of State for Research and Technology
Chairman, Agency for the Assessment
and Application of Technology (BPPT)

It is a pleasure to join you on this important occasion and share with you several ideas on systems analysis.

As you may already know, the Agency for the Assessment and Application of Technology, under my direction, has the following responsibilities:

- To assist in formulating and implementing policies and programs for the application of technology relevant to national development
- To implement and guide technology transfer programs
- To evaluate worldwide technological developments and train manpower in requisite fields
- To strategize Indonesian cooperation with foreign and international technology agencies
- To provide technology evaluation services to government agencies, enterprises, and private industries as well as support their technology development and application.

Let me emphasize the significance of the last item. We are now in the fifth and final year of our third development plan, REPELITA III. A key aspect of national development planning is the optimal allocation of limited resources to achieve national goals. Less than optimal allocation leads to waste and possible slippage in achieving goals, and decision makers often have difficulty allocating resources optimally. Problem complexity and the limited time available for decision analysis are the major causes of faulty decisions.

In this context, a systems approach appears to be a very promising aid for decision making. Initially, one must formulate the problem succinctly. A concise, accurate model that describes the problem then makes possible an array of alternative solutions. Each solution is evaluated for its advantages and disadvantages, its short- and long-term impacts, and its costs and benefits. With this approach, decision makers can select the best alternative and verify its effectiveness analytically. The intuition and experience of decision makers are not excluded, but are guided by the results of the system study. Care must be taken that the system model is complete; history has shown that overlooking a subtle but critical relationship in the model can lead to unanticipated and erroneous results.

As I have previously indicated, to develop our nation we must choose well-proven technologies. A so-called "appropriate technology" for a developing nation does not mean a backward technology. A systematic approach to technology selection evaluates both the positive and negative consequences. At BPPT, the systems approach is guided by such criteria as maximization of added value, of jobs created, and of income produced.

SYSTEMS ANALYSIS

The science of this systems approach is formalized in a discipline called systems analysis, a fast-growing science. Because in this limited time I cannot describe our work in this area adequately, I will instead summarize some studies that have been or are being done by my staff.

Solid Waste Management

Management of solid waste disposal contributes to a better urban environment. A preliminary study was performed on solid waste collection and transportation in Central Jakarta, followed by the preliminary design of a solid waste incineration plant. Included was an economic evaluation based on the costs of investment, operations, and maintenance, as well as on revenue generated from electrical power output. This study also included a comparison for Central Jakarta of benefits from solid waste incineration and sanitary landfill. Further in-depth studies will be conducted.

Food System

The BPPT analysis of Indonesia's food system has concentrated on rice--the flow of this commodity from production, collection, processing, wholesale/retail sales, to consumption. The objective is to provide an analytical framework that economists can use to evaluate the impact on the food system of government programs and new technologies. The study consists of:

- A description of the system, subsystem, and linkages
- A description of each subsystem by major components
- Measurement of the major components of each subsystem in terms of performance criteria from REPELITA III.

From this, we expect to gain an improved understanding of the added-value process in the flow of food commodities, the effect of sales agents, institutional aspects, and the structure of the decision-making network. Because the analytical framework will not address allocation problems, a model will be developed to consider "what if" questions. The model will simulate policy impacts on the entire rice system.

Urban Transportation

In cooperation with the Jakarta government, BPPT has conducted several studies, the first of which was a demand forecast for urban transportation services up to the year 2000. Several recommendations for policy formulation resulted. These successful results led to a similar study on urban transportation in Medan, Surabaya, and Ujung Pandang, which focused on the growth in demand for transportation services in those cities. With additional experience, we will be able to perform more specialized studies.

Present efforts are concentrating on the Eastern Corridor of Jakarta and are expected to result in recommendations for improvements in bus service, including numbers of buses and schedule rearrangements.

Indonesia is developing its capability to apply the principles and methodologies of systems analysis to specific problems and produce concrete answers. We in Indonesia are eager to extend these scientific and technological capabilities so necessary for continued progress in developing countries. We are ready to discuss our problems and needs and to benefit from a critical evaluation of our programs.

I urge the participants in this workshop to produce concrete recommendations for the application of systems analysis in Indonesia. We would particularly welcome specific contributions from our colleagues from the United States. These contributions will serve to improve the skills of the BPPT staff engaged in the studies that are being addressed by this workshop. This transfer of skill is, as you all know, extremely critical to the process of enhancing the capability of developing nations to solve their own problems. It is with this hope that I look forward to your results and herewith declare the workshop officially open.

Opening Remarks

David B. Hertz
Director, Intelligent Computer Systems Research Institute,
University of Miami
Chairman, NRC Panel

You have honored the members of the National Research Council panel by inviting us to participate in this workshop concerned with forwarding the methods and philosophies of modern systems analysis in Indonesia. Our two countries have worked closely for many years through the U.S. Agency for International Development and the National Research Council, among others, to improve the quality of life and the economic strength of your many islands and their peoples. We look forward to being able in our short stay with you to add to your already remarkable accomplishments.

The NRC participants in this workshop will do their best to state clearly their views of what systems analysis is, what it can do, and how Indonesia can make the most use of it. Because in the short time that we have together it is not possible to be comprehensive, the activities have been chosen with you to reflect a variety of viewpoints and some differences in style as to both our approaches and the problems themselves. We will try to point out possible pitfalls and the potential opportunities and suggest ways you can avoid the former and capitalize on the latter.

This workshop is concentrating on work that your teams have already undertaken on waste disposal and sanitation, transportation, and food production. It is hoped that our visit with you will not end with simply an evaluation on our part of what you are doing in these particular fields along with suggestions for continuation and improvement of that work.

We look forward to learning that the Agency for the Assessment and Application of Technology is making increasing use of systems analysis approaches in many other areas that are important to Indonesia's newest economic plan, REPELITA IV. Although there will be a shortage of skilled personnel, each person who gains in skill through a practical and successful effort will be able to multiply that skill by training and leading others.

Finally, we thank the government of the Republic of Indonesia and BPPT for this opportunity to join in the Workshop on Systems Analysis, and we look forward to achieving significant results.

APPENDIX B

Workshop Agenda

February 7 (Monday)

10:30 a.m.	Informal meeting of NRC panel, Sari Pacific Hotel
2:00 p.m.	Informal discussion among NRC panel, Indonesian steering committee, and Indonesian lecturers

February 8 (Tuesday)

9:00 a.m.	Opening Ceremony Ir. Suleman Wiriadidjaja Deputy Chairman for Systems Analyses Agency for the Assessment and Application of Technology (BPPT) Opening Remarks Dr. B. J. Habibie Minister of State for Research and Technology Chairman, BPPT Opening Remarks Dr. David B. Hertz Chairman, NRC Panel
10:15 a.m.	A Systems Approach to Development Planning Processes Prof. M. T. Zen
11:30 a.m.	Systems Analysis, Companion to Economic Development Dr. David B. Hertz
2:00 p.m.	Specific presentations in working groups: Waste Disposal Urban Transportation Food Systems
3:35 p.m. to 4:30 p.m.	Discussion

February 9 (Wednesday)

6:00 a.m.	Food system group departs for Yogyakarta
8:00 a.m.	Food system group visits Bappeda agricultural area, Yogyakarta
	Waste disposal group visits composting plant, solid waste improvement program pilot project, open dumping and sanitary landfill in Jakarta
	Urban transportation group visits Jakarta area
5:30 p.m.	Waste disposal and urban transportation groups leave Jakarta for Surabaya

February 10 (Thursday)

	Food system group visits Gunung Kidul and food-producing region
	Waste disposal group visits composting plant and waste disposal equipment center in Surabaya
	Urban transportation group visits Tool Road and Sidoarjo Corridor, Surabaya

February 11 (Friday)

7:00 a.m.	Food system group visits food production area, Yogyakarta
8:00 a.m.	Waste disposal and urban transportation groups leave Surabaya for Jakarta
10:00 a.m.	Lecture on Systems Analysis Dr. David B. Hertz
11:00 a.m.	Food system group leaves for Jakarta
Afternoon	Discussions at BPPT

February 12 (Saturday)

9:00 a.m.	Discussions and conclusions at BPPT
11:30 a.m.	Closing ceremony

APPENDIX C

Workshop Participants

INDONESIAN PARTICIPANTS

Ir. Suleman Wiriadidjaja, Deputy Chairman for Systems Analyses, BPPT, Chairman, Workshop Organizing Committee
Ir. Wardiman Djojonegoro, Deputy Chairman for Administration, BPPT, Cochairman, Workshop Organizing Committee
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Executive Committee

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Prof. M. T. Zen, Assistant Minister II, Ministry of State for Research and Technology
Dr. Sabana Kartasasmita, Assistant Minister III, Ministry of State for Research and Technology
Dr. S. Parlin Napitupulu, Assistant Minister IV, Ministry of State for Research and Technology
Prof. Dr. Sukadji Ranuwihardjo, Assistant Minister (Policy Coordinator), Ministry of State for Research and Technology
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Prof. Dr. Amiruddin, Deputy Chairman for Basic and Applied Sciences, BPPT
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Ir. Rahardi Ramelan, Deputy Chairman for Industrial Analyses, BPPT
Dr. Ibrahim Hasan, Moderator, BPPT
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APPENDIX D

Lecture on Systems Analysis

David B. Hertz
Director, Intelligent Computer Systems Research Institute,
University of Miami
Chairman, NRC Panel

As we have discussed in this workshop, the process of analyzing systems to provide decision makers with an adequate understanding of the consequences of alternative courses of action can be a significant step in moving toward the goals of economic development in Indonesia. Systems analysis deals with both the patterns of the physical world, including the technological operational aspects of natural phenomena and man-made artifacts, as well as patterns of the social world including people and their governments.

The systems we are concerned with are generally oriented toward man-chosen goals, and are often affected to a greater or lesser degree by outside factors such as climate, or resources such as soil and minerals. The interactions of the physical and social factors present decision makers with the opportunity to choose from among alternative courses of action in pursuit of specific goals. One course of action may, in given circumstances, be significantly better than another. It is the task of the systems analyst to help the decision maker determine which courses of action would indeed be best in the circumstances.

SOME TOOLS

Over the past several decades, systems analysts have developed and used various kinds of methodologies to improve the quantitative structures on which they base their recommendations. For example, operations research (which was developed during World War II to assist the military) comprises a set of mathematical approaches to probabilistic and complex combinations of variables that permit the pinpointing of optimum solutions to carefully defined problems. Management science, carrying on from the somewhat circumscribed mathematical methods of operations research, has attempted to widen the horizon of the systems analyst by including methods of managing sets of variables, including not only the physical but people as well. Finally, systems analysis itself has broadened the horizon by including both these approaches, as well as physical and social technologies to meet overall complex objectives of systems managers.

THE OVERALL PROCESS

The process itself is simple. Perhaps an easy way to visualize the overall process is to consider the problem of choosing an airline trip to a chosen destination. Assume that one wishes to go from Jakarta to Washington, D.C. The airlines publish sets of schedules, along with sets of segmented costs. If one chooses the ultimate destination and desired objectives in terms of time, money, and other factors, such as stopovers, vacation possibilities, etc., one can, by going into the schedules, taking the overall objectives into account, arrive at specific alternatives. If the process is confined to air travel, the airline schedules will suffice. If one were to add sea travel to the potential technological process, then the boundaries of the system will be significantly widened and more alternatives will present themselves. In such a case, the time constraints would, of course, become very important, or even binding. In any case, this one-time decision could be analyzed and a set of alternatives presented that would outline the various consequences of making specific choices.

Clearly the elements we must take into account are the problem objectives, the problem structure, the organizational processes or mechanisms for decision making, the time scale of the decision, whether it is one time or continuous, and the kinds of risks that one might be taking by making a given decision. If we were to add a continuous time process and make decisions over a period of time, we would have a dynamic system in which both the processes and the constraints are apt to change. All of these types of inputs and objectives must be considered as the system analyst proceeds with his task. He should provide the decision maker with the possibilities of trade-offs and the costs of those trade-offs. Ultimately the decision maker will have to come to a decision, taking into account as much information as the systems analyst can provide. How should the systems analyst go about his job? The next section outlines a general procedure that can be used satisfactorily to undertake analyses of virtually any decision problem.

THE STEP-BY-STEP SYSTEMS ANALYSIS PROCESS

Take the following steps in roughly the order they are presented:

1. Understand the problem statement as presented to or as given by the decision makers. This understanding very often requires a preliminary drafting of the patterns of technical and social processes involved and a statement as to what kinds of alternatives the analysis is likely to lead.
2. The first step should provide sufficient understanding to yield a carefully structured statement of the objective of the analysis.
3. The variables involved are enumerated, including both the social and technical elements of the problem.
4. The constraints (what is not available, possible, or permitted) on both the solution and on the variables must be considered and defined.

5. At this point, we can begin to sketch out the structure or patterns of behavior in which (1) the static structure is described, and (2) the dynamic interactions between and among the variables, both within the system and outside the system, are included.

6. It is now possible to examine the measures to be used to evaluate the variables and develop means to measure variable changes in terms of performance of the system or parts of the system that we permit, like, or dislike.

7. Given these performance measures we can then establish the evaluation or decision criteria whereby we will measure and evaluate not simply the output of the variables, but the combination of those variables that lead to a good, bad, best, or worst decision.

8. Trade-offs between and among the alternative decisions can be considered means of adjusting the evaluation criteria to yield more sensitive methods for the decision maker to make his choices.

9. Throughout this process the analyst will have been making assumptions about each of the previous items. These assumptions should be continuously recorded for the decision maker to review, and for possible changes in future iterations of the analysis.

10. The boundaries and scope of the system as analyzed should be presented to the decison maker, along with the constraints and assumptions, so that they may be altered in future analyses.

11. Hypotheses about the action of the system will have been generated throughout the analysis, and they too should be recorded as the work of the systems analyst proceeds. Each of the previous elements will have had an influence on these hypotheses, and as the work goes forward the hypotheses themselves may change and thereby change the various parts as the analyses proceed.

12. Alternatives presented should be tested for (1) stability--that is, how the end results react over time as either physical or social conditions change; (2) their resilience or robustness--that is, how they stand up under a shock or major change in any of the input variables; and (3) their flexibility under changes of objectives by decision makers.

13. The time scale or time span under which these alternatives can be effectively used should emerge from the testing and the hypotheses.

14. At this point, decision making may be in order and the plans for implementation of decisions may be worked out. These plans should include the means by which the decision will be controlled over time, and changed if the need arises.

SUMMARY

We summarize this process by saying it must emphasize the decomposition of the problem into its parts; the testing and experimentation both by physical and by simulational methods; the generation of alternatives; the development of implementation plans; and finally, the development of means of controlling the decision process. Systems analysis methods are scientific methods applied to the unruly and disordered world of economic and social behavior. What we have tried to demonstrate is that a careful, step-by-step, interactive, systematic application of the human thought process to a problem can provide decision makers with useful tools to carry out their tasks.