ASSESSMENT OF DAMAGE AND ENVIRONMENTAL IMPACTS OF FLOOD - A CASE STUDY

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree
of
MASTER OF TECHNOLOGY
in
WATER RESOURCES DEVELOPMENT
(CIVIL)

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which is presented in this Dissertation entitled **"ASSESSMENT OF DAMAGE AND ENVIRONMENTAL IMPACTS OF FLOOD - A CASE STUDY "**, submitted in partial fulfillment of requirement for award of the degree of MASTER OF TECHNOLOGY IN WATER RESOURCES DEVELOPMENT of India Institute of Technology Roorkee is an authentic record of my own work carried out during the period from July 2003 to June 2004, under supervision of Professor Dr. U.C. Chaube.

The matter embodied in this Dissertation has not been submitted for the award at any other Degree.

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Roorkee

Date :..10..:....June , 2004 **(AGUNG PRIHANTONO)**

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SYNOPSIS

Flood damages arise basically due to flood plain occupancy but the effects of flood may be felt far beyond. Urban areas situated on riverbanks face the dilemma of flood plain occupancy. The main objective of this study is to critically review prevalent procedures for flood damage assessment and to study improvement in damage assessment procedures with emphasis on urban flood damage. Report of the National Flood Commission of Govt. of India has been studied. Through illustrative examples, prevalent procedures are explained. Improvements in data collection procedures and in economic analysis of flood control project are suggested.

Procedures for estimation of benefits and costs and for economic appraisal of flood control project differ from country to country. The methodology for economic appraisal of flood control projects and existing deficiencies in the procedure are explained.

Stage – damage functions for residential area, agricultural crops, fisheries, traffic etc are graphically depicted. Stage –damage, stage – discharge and discharge – frequency relations with and without a flood control project provide a scientific basis for assessment of expected annual damage. Type of damage, assessment procedure and data required are summarized in the tables based on study of literature.

A historical perspective of flood problem in Jakarta the capital city of Indonesia and structural measures adopted at different points of time to control flood damages is critically reviewed. Problem in implementation of flood control plan are discussed.

The flood damages assessment in Jakarta city is carried out into 4 categories:

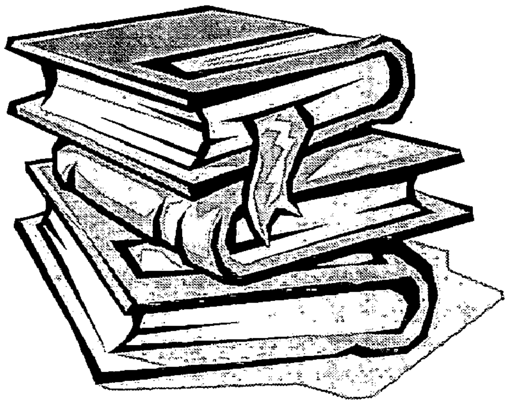
1. Flood damages due to habitual flood in the urban development condition of 1988 and 2010
2. Flood damages due to potential flood in the urban development condition of 1988 and 2010
3. Flood damages to traffic and income loss due to closure of shops and factories
4. Annual flood damages

Impacts of flood or flood control measures cannot be assessed strictly on the basis of economic benefits and costs. Often indirect and intangibles benefits are more significant though not quantified in monetary terms due to paucity of data and non available of analytical procedures. Today's intangibles may be become tomorrow's indirect or even direct benefits as advances in measuring techniques such as remote sensing, geographic information system, mathematical modeling etc are taking place. Theoretical basis for EIA of floods has been provided. Baseline information and initial environmental examination for flood control on Cisadane River in the study area have been discussed.

It would have been useful to analyze and compare the practice followed in India and other countries for assessment of urban flood damage. However such literature for urban damages in India is not available. National Flood Commission Report (1980) of Government of India does not elaborate on assessment procedures for indirect damages, which are more important in urban areas.

It is hoped that this study would serve as an useful reference material for estimation of various type of urban flood damages.

A comprehensive list of references on the available literature has been compiled for further research on this important subject.



CHAPTER I

INTRODUCTION

INTRODUCTION

1.1. GENERAL

Flood damage may be defined as the destruction or impairment, partial or complete of the value of goods and services or of lives resulting from the action of floodwater and the silt and debris that they carry. These flood damage arise basically due to flood plain occupancy but the effects of flood may be felt far beyond. Assessment of flood damages is necessary to find magnitude of flood problem in a specific area and to plan the measures (Dam embankments, diversion schemes etc), which would help in mitigation of such damages. Mitigation of flood damages is the benefit of flood control project.

1.2. DILEMMA OF FLOOD PLAIN OCCUPANCY

Before the population in river basins grew up and economic activities developed, floodwater spread over the flood plains, flowed back to the river and emptied into the sea without causing much of the damages. However, as size of human settlements started growing close to the river banks and with increased economic development activities, more and more of the flood plains got occupied leading to adverse effects of floods being felt in a significant manner by the people. *(Chaube, U.C. 2001)*

On the one hand, flood plains provide attractive location for various human activities, notably agriculture and transportation. The flat lands in river valleys consist of fertile alluvial soils. Some of the world's great civilizations have developed along the bank of rivers such as of the Tigris, the Euphrates, the Nile, and the Indus the Ganga and the Yangtze. The flat lands in the river valleys also provide transportation corridors and building sites for home and factories. For certain activities, a riverine location is essential such as those, which are dependent on river for transportation or for water for processing or cooling purpose. Not surprisingly, therefore flood plains have become the focus of a considerable portion of the world's settlements and economic activities.

Flood plain occupancy on the other hand, can be costly and in some cases may be lead to disaster. Once in a while the river may over flow its banks and exact a heavy tool of property damages, income loss, and perhaps loss of life as well. In developing countries, since means of sustenance are already limited, the toll exacted by flood disasters is especially heavy. *(Chaube, U.C. 2001)*

1.3. TYPE OF FLOOD DAMAGE

Flood cause damages to property and crops, contamination of flood and water, disruption of transportation and communication, loss of human and cattle lives and there is a continuous fear, anxiety, distress in the minds of people residing in flood plains. These flood damages may be classified – into direct, indirect and intangible damages.

1.3.1. Direct Damage:

Direct damages arise through direct physical contact and action of floodwater. These include damages such as:

- Growing and pre – harvest crops
- Houses and household property
- Private property
- Public buildings
- Public utilities (railways, roads, telegraph network, electricity)
- Loss of human life and livestock
- Damage to soil due to water logging

Silt debris and contaminants deposited by floodwater render some goods and services unusable temporarily. Such damages are close to direct damage but are more general and involve the services of labour and equipment for repair.

The transfer payment (expenditure on compensation paid to flood victims, remission of land revenues etc) should not be considered as direct damages due to floods. These do not represent losses to society but only financial transfer from government to flood victims. *(National Flood Commission 1980)*

1.3.2. Indirect Damage:

Indirect damages do not arise from floods as such but from the disruptive effects of flood on normal social and economic activities both within and beyond the flooded area. Society may be viewed as highly interconnected system. The effects of disruption to any one element can ripple through the rest of system.

The value in aggregate of the goods and services loss because of interruption to normal activities forms the indirect non-recoverable loss to the society as a whole. The indirect damages may include the following:

- Those, which arise in continuation and because of the direct damage to crops. These will include loss of earning in agro-based industry and trade.
- Loss of revenue to the road transport and railways due to interruption of services as a result of submersion or washing a way of roads, railway lines and bridges.
- Relief expenditure on medical measures, building temporary habitation facilities and rescue operations.
- Loss of earning to petty shop – keepers who just keep up their living with small daily earnings.
- Loss of employment to on farm wage earners.

Services for which annual aggregate demand will not decline due to floods (weavers, carpenters, goldsmith etc) may not be considered. Similarly there may be no loss of earnings for the shopkeeper dealing in textile and other consumer goods required occasionally. *(National Flood Commission, 1980)*

1.3.3. Intangible damages:

These intangibles are being defined merely by antithesis to the tangible damages susceptible to approximate monetary evaluation. The intangibles remaining unquantified or unevaluated thus need have no other common property than that they have been excluded from the analysis either because they could not or ought not to be included.

Being defined this way, today's intangibles may become tomorrow 's indirect or even direct damages as satisfactory methods of quantification are evolved or when there is consensus that quantification is desirable.

Intangible damages may include the following:

- Loss of human lives
- Damage to temples, monuments of historical, cultural importance

- Fear, anxiety and ill health
- Public inconvenience

Wherever feasible, information on intangibles should be collected, as it is useful in clarifying the issues involved in planning of flood safety measures. When intangible damages are significant, socio political considerations assume overriding importance and some flood control projects may be sanctioned even without any significant economic benefits. (Akhyar, 1997)

1.3.4. Environmental Impact:

As mentioned above, there are a variety of damages due to flooding of an area. Depending on availability of data some of the damages can be evaluated in monetary terms and thus may form part of economic analysis. For some of the damages (mainly in direct and intangible) either sufficient data may not be available or there may not be satisfactory methods of quantification in monetary terms. Such damages are usually grouped in the category of environmental impact. The environmental impacts also include those related to physical - chemical, biological, socio - economic and socio - cultural environment. Department of Environment and Forestry (Govt. of India) has included flood damages / flood control benefit in the list of environmental impact of a water resources project.

1.4. LITERATURE REVIEW

There are two basic approaches for estimating flood impacts: the first approach employs unit loss models and the second employs models, which estimate the linkage effects, or inter-sectoral relationships, of floods within economy *(Parker, 1992; Islam, 2000)*. The unit loss model was originally developed by American researchers *(White, 1964; Kates, 1965)* and later adopted by British and then Australian researchers *(Parker and Penning-Rowsell, 1972; Smith and Greenaway, 1988)*. Although the general concept of unit model approach, which is based on a property-by-property assessment of potential damage, is the basis for loss estimation in many countries, there are wide variations in the existing methodologies for flood loss estimation around the world and only a handful of countries have adopted standardized methodologies for flood loss estimation *(Penning- Rowsell et al., 1987; Tang et al., 1992)*. Some countries like UK, Australia have established detailed methodologies for estimation of tangible losses *(Penning-Rowsell and Chatterton, 1979; Smith, 1981; UNSW, 1981)*. However, in case of USA, Japan, etc. detailed damage estimation methodology is limited to urban damage only *(USACE, 1988a; MOC, 1996a)*. It can be noted that these countries have adopted similar approach in damage estimation i.e. unit loss approach *(Parker et al., 1987; Smith, 1994; NTIS, 1996; Parker, 2000)*. From the various available reports, it is found that countrywide standard methodologies of flood damage assessment are available in Japan and UK, i.e. for assessment of damage caused by floods in any part of the country same standard methodologies are used *(Parker et al., 1987; Penning-Rowsell, 1992; MOC, 1996b)*. USA is in the process of developing a standardized methodology for the whole country. However, in Australia and many other countries, damage assessment methodologies vary in different regions within the country according to individual studies *(Thompson and Handmer, 1996)*.

Establishment of an adequate flood loss estimation model involves many issues due to the nature of damage caused by floods. Some of the most important issues in flood loss estimation are obtaining detailed flood parameters such as flow velocity, depth and duration at any given location; proper classification of damage categories considering nature of damage; and establishment of relationships between flood parameters and damage for different damage categories. Stage-damage functions define the relationship between flood parameters and possible damage, which are derived based on historical flood damage information, questionnaire survey, laboratory experiences, etc. *(Krzysztofowicz and Davis, 1983; Smith, 1994)*. This is the conventional way of damage estimation in different countries around the world. Only a handful of models are available for flood damage assessment at present. Out of that, three well-known models are FDAP (Flood Damage Analysis Package), ANUFLOOD and ESTDAM. FDAP was developed at the Hydrologic Engineering Center(HEC) of the US Army Corps of Engineers at Davis, California to compute flood losses *(USACE, 1988b, 1994)*. Series of HEC programsincludingHEC-1, HEC-2 and HEC-3, which are a comprehensive set of computerized programs for hydrologic analysis, are included in FDAP *(USACE, 1973, 1977, 1979)*. FDAP utilizes the 'frequency method' for calculation of the expected annual damage *(Carl and Davis, 1989)*. The model calculates damage potential for specific flood magnitudes and then weighs the damage values with the probability of exceedence. ANUFLOOD is an

Australian model developed by the Center for Resource and Environmental Studies (CRES) of the Australian National University for flood damage assessment based on synthetic stage damage curves for residential and commercial property *(Greenaway and Smith, 1981; Taylor et al., 1983; Smith et al., 1983; Smith and Greenaway, 1988)*. It is available as an interactive computer package and aimed for the users involved with planning and management of flood-prone urban areas for estimation of potential flood damage in residential and commercial sectors. ESTDAM is a standardized flood loss estimation model developed at the Middlesex Polytechnic for UK *(Chatterton and Penning-Rowsell, 1981)*. All these models are useful as a tool for flood plain management as they can estimate potential damage for different scenarios based on historical data of flood parameters. However, none of these models can be used for real-time flood loss estimation or forecasting as there is no well established mechanism available in these models for simulating flood parameters of an actual flood event based on the physical characteristics of the flooded area. FDAP is principally designed for floodplain management, which can provide annual damage values.

A few research works have been conducted on real time loss estimation modeling so far. One of such modeling approaches was based on GIS and remote sensing technology. In this approach, GIS and remote sensing technology were used for delineation of flood inundated areas for loss estimation *(Yamagata and Akiyama, 1988; Shaw, 1994; Consuegra et al., 1995; Lanza and Siccardi, 1995; Tinkeke and Matthijs, 1996)*. However, the limitation of GIS and remote sensing technology in adequate estimation of flood inundation parameters severely restricts the practical application of these techniques. In 1996, the Delft Hydraulic Institute developed a flood hazard assessment model integrating GIS and hydraulic model in an attempt of real-time damage estimation modeling *(Jonge et al., 1996)*. For a series of discharges, the model calculates the flooding depth in the flood plains and the damage is estimated based on the calculated flood depths. The model focuses on the socioeconomic impacts of flooding. The flood model considered in this methodology is a 1D hydraulic model. For a given discharge curve at the upstream boundary, the flood model calculates water levels at discrete points in the river for each defined time step. The maximum simulated water level in each river node is used as input for flood inundation simulation. However, it does not have a physically based model for the flood inundation simulation, instead GIS is used for spreading of floodwater based on river model simulation.

Dutta D. et al (2003) Proposed an integrated model, which has two major components: a physically based distributed hydrologic model and a grid-based distributed loss estimation model. The loss estimation model consists of three kinds of primary tangible flood damage: urban, rural and infrastructure damage. The loss estimation model is based on the unit loss approach. It is formulated as a grid based model with a similar grid network to that used in the distributed hydrological model. In the application process, the distributed hydrologic model simulates flood inundation parameters for each grid and these are used in the loss estimation model to simulate flood damage for each grid cell. Fig. 1 shows a schematic diagram of the integrated model.

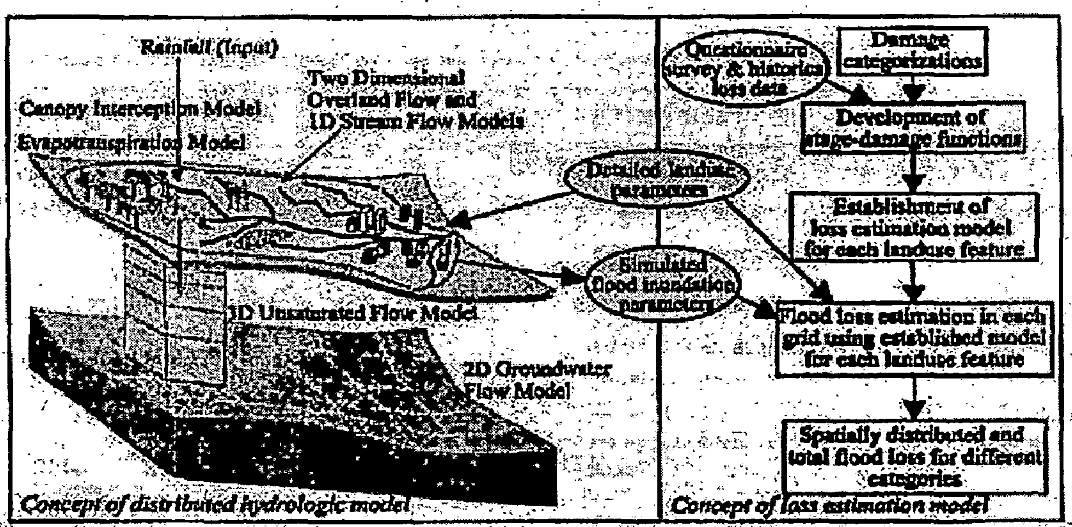


Fig. 1. A schematic diagram of the integrated flood loss estimation model.

(Source: Dutta D. et al, 2003)

Management of flood-prone areas is the result of a complex decision-making process aimed to define and implement, in the analyses zones, all those measure that can determine the compatibility between land - use related activities and the risk to which human, natural and economic resources are subjected *(Castelli & Becchi, 1988)*. Structural mitigation measures modify the characteristics of a flood (i.e., the volume and timing of flood waters, their extent and location, their velocity and depth) or the susceptibility of people and properties to flood damage. Non - structural measures (e.g. real-time forecasting and alert system, information and training campaigns, tax adjustments, flood insurance program) are capable of modifying the consequences of unavoidable damages; particularly, flood insurance provides a way for pre-paying economic losses, reducing the social impact of the event *(Thomas, 1994)*. The net premium, defined as the annual equivalent of the occasional reimbursement to be covered by the insurance company, depends on the flooding risk of the area that is on the probability distribution of damage. The overall premium also includes taxes, insurances administration costs and company gain coverage. The need for reliable estimates of insurance premium has motivated, at least in the USA, the efforts of research in the field of flood damage assessment. On the basis of the US approach, technical legislation for flood damage coverage through specific insurance programs has been proposed in Italy. It envisages the draft of a study *(**SAI** : Studio per l' Assicurazione controle Inondazioni)*, similar to the USA Flood Insurance Study (FIS), gathering technical information such as hydrologic-hydraulic analyses, detailed delimitation of flood-prone areas and flooding risk assessment. The economic evaluation of flood insurance programs encourages the extensive use of this tool, requiring a reduced financial effort and a softer environmental impact compared with structural flood protection measures *(Reitano, 1944)*.

The growing interest of public administrations in non-structural measures makes the evaluation and selection of flood control measures more problematic than ever. Nevertheless, traditional cost-benefit analysis still plays a fundamental role in justifying the implementation of any kind of intervention for a sustainable land-use planning of flood-prone areas. Economic analysis, albeit complex and approximate, is quantitative criterion that can be systematically and objectively applied also to very complex cases and therefore represents a primary decision tool *(Wubs, 1983; Beard, 1983)*. Estimation of flood damages represents a fundamental step for the economic analysis of a flood control project. In particular, frequency-damage functions, derived combining hydrological and hydraulic data with physical and socio-economic information, are one of the fundamental pieces of information upon which expenditure decisions should be based.

Many studies exist concerning flood damage estimation in urbanized catchments *(Debo, 1982; Chatterton & Penning Rowsell, 1981; Mc Bean, Gorrie, Fortin, Ding, & Moulton, 1988)*. Most of the hydrologic – hydraulic - economic models implemented to determine the economic outcomes of an inundation, however, examine very large catchments, and case studies look at rural or agricultural areas. In many cases, moreover, the analyses have concentrated on damage incurred on the natural floodplains of major rivers, lake, streams, or lying near the sea. A significant portion of damage, however, arises because of flooding of urban properties located on small drainage areas *(Lee & Esses, 1983)*. This may occur due to scarce or lacking maintenance of the natural drainage network, or because no measure is taken to drain the additional stromflow due to urban expansion upstream from the studied area. Structures adjacent to ephemeral or small, perennial streams can experience huge damage because of very high peak flows occurring once a time. Therefore it is worthwhile to analyses also the small-urbanized catchments, quantifying expected damages and identifying possible control and protection measures.

1.5. OBJECTIVE AND SCOPE OF STUDY

1.5.1. Objective:

The main objective of this Dissertation work is to critically review prevalent procedure for flood damage assessment and to study improvement in damage assessment methodology with emphasis on urban flood damages through a case study. In order to achieve the stated objective, available data for Jakarta city in Indonesia has been utilized for the case study.

1.5.2. Scope:

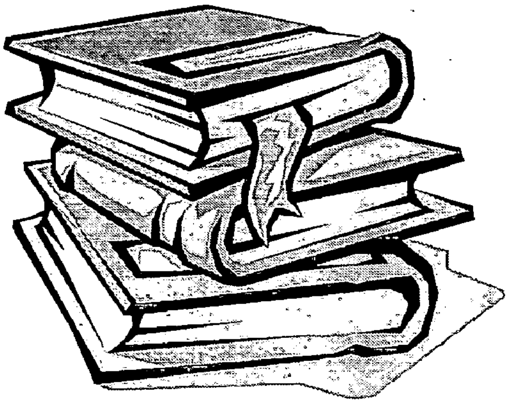
Dilemma of flood plain occupancy and types of damages that usually occur in flood plains are discussed followed by review of literature on flood damage modeling. This forms the background for the present study.

Prevalent methodology for flood damage assessment is critically reviewed and several illustrative examples are provided. Based on review of report of the National Flood Commission (1980) by Govt. of India and other literature from Indonesia, improvements in methodology are suggested.

A historical perspective of flood problem in Jakarta, the capital city of Indonesia and structural measures adopted at different points of time to control flood damages is critically reviewed. Problems in implementation of flood control plans and problems during operation and maintenance are analyzed.

Spatially distributed data for the flood damages in Jakarta city are analyzed. Regression relationships between depth, duration and damage ratios for property, income loss, and traffic damage are applied to evaluate direct and indirect damages during moderate flood and potential flood conditions.

Theoretical basis for EIA of floods / flood control measures is discussed followed by base line information and initial environmental examination of flood control measure in Cisadane river in the study area.



CHAPTER II

FLOOD DAMAGE ASSESSMENT METHOD

FLOOD DAMAGE ASSESSMENT METHOD

2.1. GENERAL

Procedure for flood damages assessment widely differs in developed and developing countries. This difference is mainly due to differing perception of flood impact and inadequacy in database. In India, emphasis at present is on assessment of direct damages. Method of assessment is based on complete enumeration. The responsibility for the collection of flood damage information rests with the state, as flood control is a state subject. The Central Water Commission is responsible for compilation and consolidation of flood damage data at the national level.

A critical review of damage assessment procedures and possible improvements are discussed below with illustrative examples.

2.2. DAMAGE ASSESSMENT PRACTICE IN INDIA

2.2.1. Crop Damages

Government of India has recommended two proformae for reporting flood damage at village, block / tehsil level as show Table 2 - 1 and 2 - 2. However, these proformoe have not yet been adopted in some cases. Damage to crops constitutes more than 60 percent of the assessed annual direct damages in India. The current practice is to consider the crop damage to be the total loss of out put. Crop damage is affected by the particular stage of growth of the crop at the time of the flood, the period of inundation and the possibility of revival of the crop after the flood.

The more correct assessment of the crop damage would be in terms of the in fructuous expenditure incurred an inputs, labour, seeds and loss of yields (Table 2 - 1 and 2 - 2).

While converting the crop damage in monetary terms, the crop yields, should be based on crop cutting experiments carried out on scientific basis in the flood affected and the neighboring areas. With respect to the prices, the prices that farmer would have obtained if their produce were not lost due to floods, should be used in finding monetary value of loss.

Table 2-1: Proforma for Reporting Flood Damage at the Village Level

Village... Tehsil/Block .... Sub-Division ..... Distt... State .... Year....

Total area affected hets.	Population affected	Crop stage at the time of flooding (crop wise)	Total crop area	Crop area completely damaged	Area resown replanted	Area partially affected	Partially crop	Replanted crop	Normally expected yield*	Total value of crop damage Rs.
1	2	3	4	4	5	6	7	8	9	10
House Damaged			Live Lost		Cattle Loss					
Number	Value (000 Rs)		Number		Number	Value (000 Rs)		(000 Rs)		
12	13		14		15	16		17		

*Specify in terms of tillering stage or pre-flowering stage and average yield for the Preceding five years

Table 2-2 : Proforma I for Reporting Flood Damage at the Block / Tehsil

Village .... Tehsil/Block .... Sub-Division ..... Distt... State .... Year ....

Block Distt.	Total area affected (000 ha)	Population effective (000)	Damage area (000 ha)	Crops value (000 Rs.)	Damage Number	To house value (000 Rs.)	Human lives lost	Cattle number	Loss value (000 Rs.)	Damage public utilities (000 Rs.)	Total damage (000 Rs.)
1	2	3	4	5	6	7	8	9	10	11	12

Source: National Flood Commission (1980)

2.2.2. Damage to Private Houses

A systematic procedure is followed in India for collecting figures relating to house damages. House is classified according to physical characteristic such as hut, kutcha, pucca houses etc.

However, no data is collected on damage to household goods. House damages need to be checked and verified. For the purpose of converting the physical damage into monetary terms, the cost of repair of replacement of the damaged property has to be realistically estimated.

2.2.3. Loss of Life

Only numerical loss of human lives and livestock is reported. Accidental deaths such as those resulting from capsizing of boats, house collapse due to rains, snake, bites etc. should not be attributed to flood damage. It is practically impossible to assign monetary value to loss of human life. Theoreticians have suggested some ways of expressing loss of human lives in monetary terms for example the sum of discounted streams of income / expenditure of the dead over his expected life span may be taken as monetary value of human life.

2.2.4. Damage to Public Property

In developing countries such as India, Government sponsored development works have been increasing and therefore proportion of damages to government properties to total damages has also been increasing.

Damage to public property is assessed by the respective departments on the basis of estimated cost of repairs. Since damage data is collected by various agencies, sometimes there is lack of coordination leading to data gap. Often due to paucity of funds, repairs are not necessarily carried out in the same financial year. The method of assessment leaves scope for double and multiple counting of the same damage in case of subsequent flooding.

Regular operation and maintenance cost of the public property do not form part of flood damage as such cost would have been incurred other wise also if no flood damage occurs.

2.2.5. Indirect Damage

Damage caused by cessation of normal economic activities of floods such as disruptions of transport network are completely ignored in the existing flood damage assessment procedure. The report of National Flood Commission (March 1980) states that such losses are likely to be more important in an industrial economy such as in USA rather than in an agricultural economy like India's. This statement may be debatable.

Since agricultural damage in India constitute nearly 60 % of the total of flood damages, it is necessary that indirect damages that depend on agricultural activities or its out put should at least be assessed on priority basis. These would include agro – based industries, which depend on local supplies of raw material, laborers and other input; both farm and non-farm wage incomes, of petty shopkeepers etc.*(Source: National Flood Commission, 1980)*

2.3. POSSIBLE IMPROVEMENT IN BENEFIT COST ANALYSIS

Benefit cost analysis (B - C analysis) of flood control project helps to select optimum combination of measures for the purpose. This chapter is based on the Report of National Flood Commission of India (1980). It explains procedure for B - C analysis of flood control project in India and possible improvement in the procedure.

2.3.1. The Methodology

2.3.1.1. Costs: The capital cost of a project is compiled by adding costs on various items such as investigation and planning, land, building, works, tools and plants, works charged staff etc. as per prevailing standards in the Irrigation and Flood Control Department of State Governments. From this, an estimate of annual average cost is obtained by adding annual interest, depreciation and maintenance costs each calculated as some prescribed percent age of total capital cost. These rates have changed from time to time. The annual rates of interest, depreciation, maintenance followed at present are shown in B - C ratio computation below.

2.3.1.2. Benefit: Estimate of annual benefit of flood control work is made by finding out the average monetary value of annual flood damages based on at least 10 years data before construction of the project. From this, an estimate of the average annual damage after the construction of the project is deducted.

There is provision for adjustment for the beneficiary value of silt deposition, if any the benefit takes into account expenditure on relief and rehabilitation, revenue remission agricultural loans etc.

2.3.1.3. Benefit Cost Ratio: The steps to be followed are as below

1. Frequency of the moderated flood.
2. Allocated cost of the dam for flood control as dams usually serve more than one purpose.
3. Cost of the flood embankment.
4. Annual cost of flood control component
   - i. 12 % of allocated cost of dam

     [10 % interest + 1 % depreciation (100 years life) + 1 % maintenance]
   - ii. 16 % of allocated cost of embankment

     [10 % interest + 2 % depreciation (50 years life) + 4 % maintenance]
   - iii. Total annual cost (i + ii)

5. Average annual damage computed on the basis of at least last 10 years data.
6. Average annual damage anticipated after the execution of the project
7. Saving in annual damage (item 5 – item 6)
8. B / C Ratio = item 7 / item 4 (iii)

Improvements in methodology for estimated of benefits, cost and for comparison of benefits, with costs are explained in subsequent paragraphs with illustrative examples.

2.3.2. Improvement in Cost Estimation

Quantum of each work item including labour should be estimated in a realistic manner. National level guidelines (Central Water Commission, Planning Commission) should be followed in preparation of cost estimate. Table 2 - 3 shows CWC guidelines, for estimating certain costs. Additional capital works such as anti – erosion measures (spurs, revetments) are often undertaken for stabilizing the benefit of embankments. Cost of these additional capital works could easily account for a significant proportion of the original capital cost (example Puthimari embankment in Assam, Kosi river embankment in Bihar) Provision for such works (if necessary due to meandering nature of river) should be made in original cost estimates.

Information on construction schedule and time phasing of estimates should be provided so that proper time value of money is taken in consideration. Rate of interest during construction should be taken into account as it affects cost if project is delayed.

The annuity method (simple interest at 10 percent) and simple straight-line depreciation at 2 percent) result in higher than economically justified figure. Compound interest rate is more appropriate than simple interest. Sinking fund method of depreciation is better than straight-line depreciation.

Instead of working out annual cost and annual benefit, the process of determining present worth of cost and benefit through discounting would taken care of annual interest and depreciation.

Maintenance cost should be computed at certain percentage of cost of works and not of whole capital cost.

Table 2 - 3: Norms for Estimating Certain Cost Items

Sl. No.	Items	Norms
1.	Preliminary expenses	1% or more of cost of 1-works. In case of big projects costing more than Rs.30 crores it could be up to5%(1to2% for diversion scheme and 2 to 4% for a storage scheme)
2	Cost of buildings	3%to 5% of 1-work. 15% of cost of temporary and semi-permanent buildings shall be taken under V-receipts and recoveries.
3	Miscellaneous (electrification), water supply security etc.	4%of the cost of I-works. Resale value to be taken under receipts and recoveries
4	Maintenance during construction	1% of the cost of I-works less A- preliminary, B-Land and Q-special T&P.
5.	Losses on stock	0.25% of the cost of I-works less A- Preliminary, P-land and Q-special T&P.
6	Establishment (for works let out on contract)	8 to 10% for concentrated works and 10 to 12% for scattered works (say canals).
7.	Establishment (for works done departmentally)	15%
8.	T and P	1%of the cost of I-works.
9.	Audit and account charges	1%of the cost of I-works
10.	Abatement of land revenue	Either at 5% of land cost or 20 times of annual revenue lost.

Source: Central Water Commission (1980)" Guidelines for preparation of Detailed Project Reports of Irrigation and Multipurpose Projects", Government of India, Ministry of Irrigation 1980.

Cost allocation of multipurpose should be done following method of separable cost remaining benefit. The method is illustrated in Table 2 - 4.

2.3.3. Improvements in Benefit Estimation

Flood control benefits are complex in nature. A better system of reporting and evaluation can be useful in removing part of difficulty in quantification of benefits. Deficiencies exit in procedure in assessment of flood damages.

Keeping in view the complexity in assessment of various flood control benefits, procedure followed in India is to include flood control benefit in environmental impact assessment procedure. Thus, descriptive explanation of direct, indirect and intangible flood control benefits of a river valley project is necessary part

Table 2 - 4: Illustrative Example Cost Allocation Using Separable Costs-Remaining Benefits Method

Sl. No.	Item / year	Flood control	Irrigation	Power	Total
	Part 1-Basic Information		-	-	-
1	Life of the project	100 year	-	-	-
2	Discount rate	10 percent	-	-	-
3	Period of construction	3 years	5 years	4 years	-
4	Total cost				
	Ist year				160
	2nd year				260
	3rd year				320
	4th year				210
	5th year				150
	Total				1100
	Present worth	-	-	-	(837.33)
5	Separable costs				
	1st year	15	45	25	85
	2nd year	50	80	60	190
	3rd year	35	115	80	230
	4th year	-	90	35	145
	5th year	-	70	-	70
	Total	100	400	220	720
	Present worth	(81.26)	(298.36)	(170.00)	(549.62)
6	Alternative costs				
	1st year	120	75	50	250
	2nd year	200	170	130	500
	3rd year	50	200	150	400
	4th year	-	120	80	200
	5th year	-	150	-	150
	Total	375	715	410	1500
	Present worth	(316.50)	(534.24)	(320.24)	(1170.78)
7	Benefits-annual average Flood control (4th to 100 yrs)	50.30	-	-	-
	Irrigation (6th to 100 yrs)	-	75.10	-	-
	Power (5th to 100 yrs)	-	-	6090	-
	Total	4879.1	7209.6	5785.5	17874.2
	Present worth	(377.87)	(466.26)	(415.91)	(1260.04)
	Part 11 joint cost allocation (all values in present worth)				
	1. Cost to be allocated				837.33
	2. Benefits (up to 100th year)	377.87	466.26	415.91	1260.04
	3. Alternative cost	316.50	534.04	320.24	1170.78
	4. Justifiable expenditure (lesser of 2&3)	316.50	466.26	320.24	1103.00
	5. Separable costs	81.26	298.36	170.00	549.62
	6. Remaining justifiable expenditure (4-5)	235.24	167.90	150.24	553.38
	7. Percentage distribution of 6	42.51%	30.34%	27.15%	100%
	8. Remaining joint cost (1-5)				287.71
	9. Remaining cost distributed as per (7)	122.31	87.29	78.11	287.71
	10. Total costs allocated (5+9)	203.57	385.65	248.11	837.33

of environmental impact assessment. In brief, improvements are required in the following:

(-) Assessment of area to be benefited with help of contour maps should be made with respect to the design flood. Low-lying areas, which are always submerged, should be excluded.

(-) Longer the period of past annual damage data, more reliable is the estimate average annual damages. However, changes in prices, land use, cropping pattern, development activities occur over a long period.
Floods of similar type of magnitude can produce a different order of damages today. Damage should be evaluated in terms of current year's process. Damages data for 15 to 20 years should be used for deriving the average annual damage.

(-) Transfer payments [relief, rehabilitation, loans, remission of land revenues] should not be considered in benefits.

(-) Additional area made available by the project should be included in benefits by considering their productivity and other attributes.

(-) Benefits from protection of land should be either in term of increase in income, which is measured by damage prevented or in terms of rise in value of land, but not both.

(-) Effect of fertilizing value of silt brought by flood may be determined by comparing data on the yield of a representative sample of flood affected farms with similar farms in nearby flood-free areas.

(-) Post project damages continue to take place. Sometimes damage may be produced by both flood and drainage congestion. Problem of drainage congestion may remain even after protection is provided against flood.

2.3.4. Improvement in BC Analysis

Benefits and cost need to be expressed in comparable terms. Therefore benefits and costs should be expressed in terms of the same year's prices and time value of money should be considered.

While costs are estimated at current prices, benefits being regarded as the average of flood damage are calculated at the respective current prices of past several years. This procedure is defective.

Flood damage data of different years should be evaluated in terms of prices of the base year, which are used for cost estimation. Cost and benefit data of different years as usually given in an unprocessed form are not comparable. These should be properly discounted to represent time value of money with respect to a particular year and then the B - C ratio should be computed. Discounting should be done at the prescribed interest rate [or social discount rate].

The following formula may be used for calculating discounting factors for any interest rate.

(i) Single payment present worth factor $= \frac{1}{(1+i)^n}$

(ii) Uniform payment series present worth factor $= \frac{(1+i)^n - 1}{i(1+i)^n}$

Where; i is the rate of interest, N is the number of year.

Table 2 - 5 explains the methodology with example. It will be noticed from table below that, according to the present methodology, B - C ratio remains constant irrespective of the time schedule of construction. When calculated by the improved method, the ratio goes down progressively as the period of completion is increased. The example also shows that the BC ratio could be higher or lower depending upon period of construction.

Rate of Interest (%)	Life (Years)	Construction period Years	B/C ratio as per prevailing methodology	B/C ratio as per proposed methodology
10	55	5	1.25	1.23
10	60	10	1.25	0.995
10	65	15	1.25	0.77

There has been a tendency in past to underestimate costs and overestimate benefits so that B/C ratio becomes favorable for getting clearance for the project.

Table 2 - 5: Example 3-B/C Ratio for Embankment as per Prevailing and Proposed Methodology

Assumptions

Life of project (Flood Embankment) -60-year

Rate of Interest – 10 percent

Year s of completion – 10 years

(Amount in Rupees)

Year	Cost	Benefit	Discounting (or present worth) factor	Present worth	
				Costs (2x4)	Benefits (3x4)
1	2	3	4	5	6
1 year	10,000		0.9091	9091	
2 year	10,000		0.8265	8265	
3 year	10,000		0.7513	7513	
4 year	10,000		0.6830	6830	
5 year	10,000		0.6209	6209	
6 year	10,000		0.5645	5645	
7 year	10,000		0.5132	5132	
8 year	10,000		0.4665	4665	
9 year	10,000		0.4241	4241	
10year	10,000		0.3856	3856	
11 year	4,000	20,000	(For uniform series from 11^{th} to 60^{th} year)		
12 years	4,000	20,000			
60 years	4,000	20,000	3.8226	15290	76452
Total				76737	76452

Notes: B/C ratio as per prevailing methodology $= \frac{20,000}{16,000} = 1.25$

B/C ratio as per proposed methodology $= \frac{76452}{76737} = 0.995$

Therefore estimates of benefits and costs should be checked at least on a sample basis by an outside independent agency. UN Guidelines for Flood Loss Prevention and Prevention has also recommended for giving this task to independent agencies.

2.4. DAMAGE FREQUENCY ANALYSIS

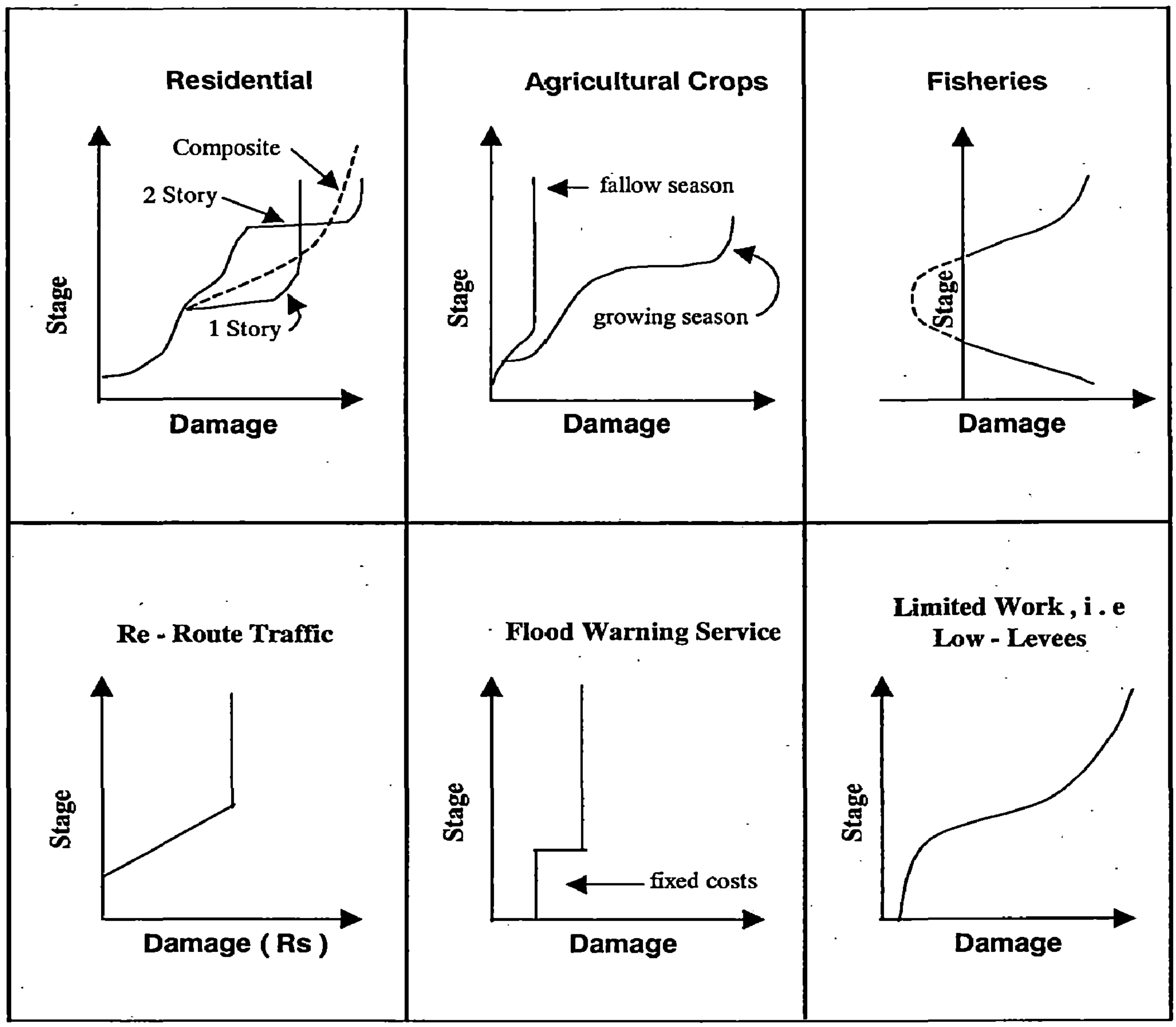
2.4.1. General

The present state-of-the-art of flood damage assessment in USA is the "frequency" technique. Considerable effort has gone into developing techniques of frequency analysis, the backbone of the procedure. The weakest part of the procedure is the damage function. Lack of data rather than concept is the major problem. Experience in the development and application of damage functions is essential. Also care should be taken to assure that the rating curve is not looped so that discharge is a unique function of stage. Otherwise more complex functions that correctly relate stage and discharge should be developed and applied. Sensitivity analysis may be useful in determining the reliability of the solution in light of the uncertainties involved.

2.4.2. Flood Damage Evaluation

Three basic functions may be used to evaluate the consequence of flood control programs. They are: (1) the stage-damage function, which defines the consequences of flood severity (magnitude) (figure 2.1), (2) the discharge-exceedence frequency function
(figure 2.2), which defines the frequency relationship of flooding and the stage-discharge relationship (figure 2.2). These three functions completely describe the flood damage potential at a specific location.

Flood control programs are designed to alter any one or all of these functions in beneficial ways (figure 2.2.). Some programmes alter only one function in a manner that is beneficial, whereas others alter one or two beneficially and another adversely. If a program results in any one of the following, it will result in lowering annual damages: (1) moves any part of the stage-damage function to the left (see Figure 2.2); i.e., reduce damage potential for a given stage, (2) lowers the stage discharge relation; i.e., reduce stage (severity) of a given flood event, or (3) lowers the



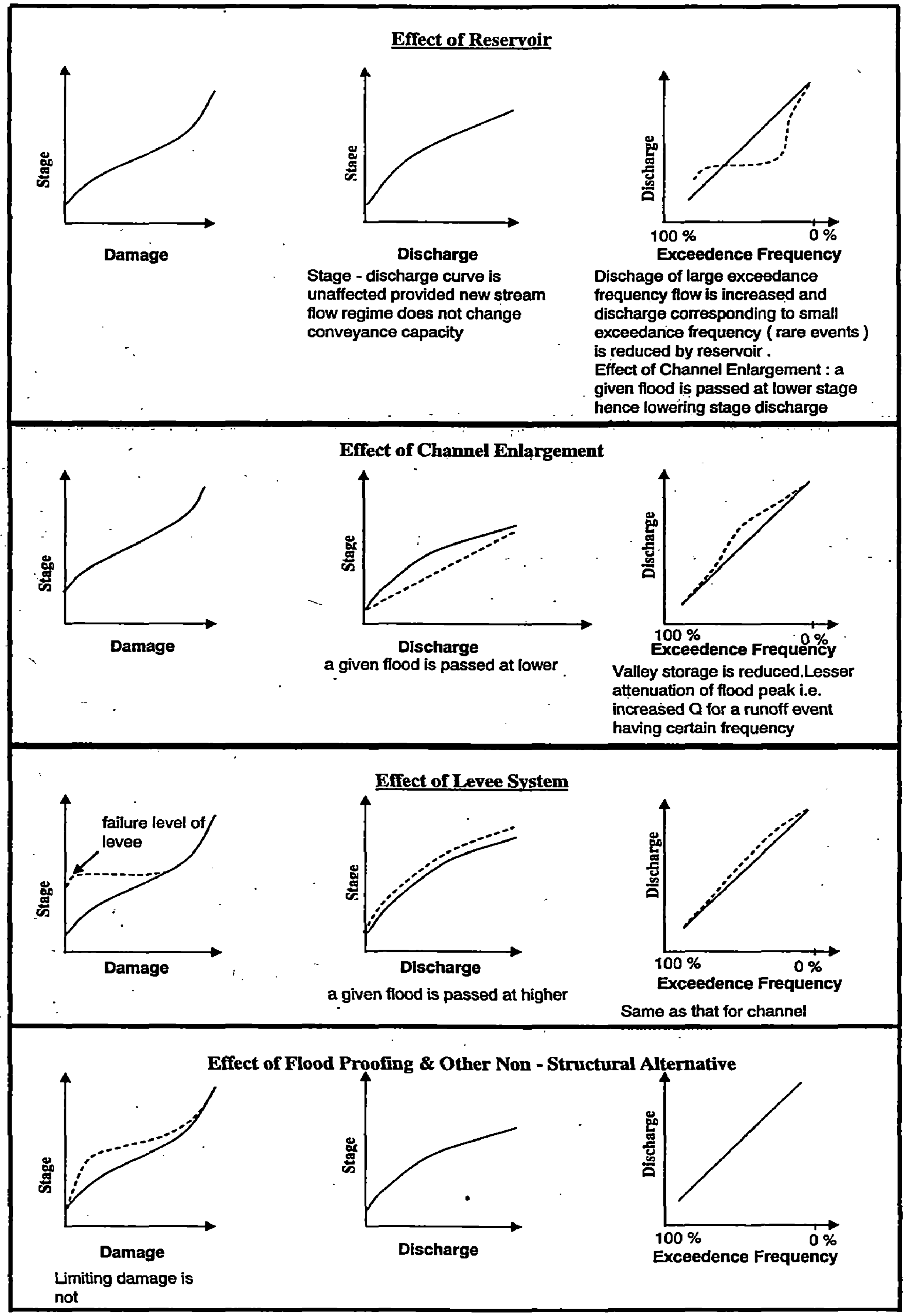
Legend :

———— Pre - Program or Pre - Program & Post Program
--------- Post - Program

Note : 1. There is a threshold stage below which damages are negligible . The above curves apply for confined damage centres. For extensive areas, continuous increase in stage would cause increase in flooded area and increase in damage without upper limit.

2 . In case of fisheries , large floods destroy spawning beds ; small floods deposit debris on spawning beds thus causing damages ; moderate floods keep debris flushed from spawning area and are therefore beneficial

FIGURE 2.1 : DIFFERENT TYPES OF STAGE DAMAGE FUNCTION



Legend :

——————— Pre - Program or Pre - Program & Post Program

- - - - - - - - - Post - Program

FIGURE 2.2 : DAMAGE EVALUATION FUNCTION

exceedence frequency discharge curve; i.e., reduce discharge for a given exceedence frequency. Notice that physical works generally alter more than one function and in general have some consequences that are adverse to the overall objective of damage reduction.

2.4.3. Optimal Storage Capacity of Flood Control Reservoir

Area under a damage - frequency curve provide estimate of expected annual damage. Thus damage - frequency curves form the basis for estimating annual damage under " with project " and " without project " conditions. Example given below illustrates the procedure for finding capacity of reservoir using stage - frequency and stage - damage data. Given the information in following tables compute reservoir capacity that maximizes the net expected flood damage reduction benefit less the annual cost of reservoir. Table 2 - 6 shows resulting stages in area downstream of a reservoir due to floods of various return period moderated by the reservoir of different capacities. Table 2 - 7 shows amount of damage due to different flood stages in the damage area.

Table 2 - 6: Stage – Frequency Data

Reservoir	flood stage for flood of Return Period of T years					Annual cost
capacity	T = 1	T = 2	T = 5	T = 10	T = 100	
0	30	105	150	165	180	10*
5	30	80	110	120	130	25
10	30	55	70	75	85	30
15	30	40	45	48	50	40
20	30	35	38	39	40	70

*: Fixed cost if capacity > 0 otherwise = 0

Table 2 - 7: Stage – Damage Data

Flood stage	30	50	70	90	110	130	150	180
cost of damage	0	10	20	30	40	50	90	150

Solution: Return period T = 1 / frequency of exceedance. Frequency = 1/T

Convert flood stage in flood damage. Draw damage - frequency curve for each alternative. Compute expected annual damage for each alternative as shown in table 2 - 8.

G/16/6

Table 2 - 8: Expected Annual Flood Damage with Different Reservoir Capacities

Alt	Frequency				
	1	0.5	0.2	0.1	0.01
I No.Dam					
Stage	30	105	150	165	180
Damage Cost	0	37.5	90	120	150
Area	$(1-0.5)\frac{(0+37}{2}$	$(0.5-0.2)\frac{(37.5+90)}{2}$	$(0.2-0.1)\frac{(90+120)}{2}$	$(0.1-0.01)\frac{(120+150)}{2}$	$(0.01-0)\times 150$
	9.375	19.125	10.5	12.15	1.5
				Total =	52.65
II capacity 5					
Stage	30	80	110	120	130
Damage Cost	0	25	40	45	50
Area	6.25	9.25	4.25	4.275	0.5
				Total =	25.025
III capacity 10					
Stage	30	55	70	75	85
Damage Cost	0	12.5	20	22.5	27.5
Area	3.175	4.875	2.125	2.25	0.275
				Total =	12.7
IV capacity 15					
Stage	30	40	45	48	50
Damage Cost	0	5	7.5	9	10
Area	1.25	1.875	0.825	0.855	0.1
				Total =	4.905
V capacity 20					
Stage	30	35	38	39	40
Damage Cost	0	2.5	4.0	4.5	5.0
Area	0.625	0.975	0.425	0.4275	0.05
				Total =	2.5

Alt	Res capa city	Annual cost	Annual damage	Annual benefit w.r.t.I	B/C Ratio	Incr cost C	Incr benefit B	$\frac{B}{C}$	Remark
I	0	0	52.65						
II	5	25	25.025	27.625	1.105	25	27.625	1.105	II better than I
III	10	30	12.7	39.950	1.332	5	12.325	2.465	III better than II
IV	15	40	4.905	47.745	1.194	10	7.795	0.779	IV not better than III
V	20	70	2.5	50.575	0.723	30	2.830	0.250	V not better than III

$$\frac{\Delta B}{\Delta C} = \frac{25.025 - 12.7}{30 - 25} = \frac{12.325}{5} = 2.465$$ (Alternative III has highest incremental B / C ratio)

Alternative III (Reservoir with capacity of 10 Unit is optimal on the basis of incremental benefit cost ratio).

2.5. URBAN FLOOD DAMAGE

The flood damage assessment in urban area is carried out in following categories due to habitual flood and due to potential flood and based on existing as well as future economic condition. Habitual flood is defined as the flood occurring more than once in a year. Potential flood is defined as the severe most historical flood, which occurred in the area.

(i) Flood damages to property (houses, shops, factory, others).

Methodology for estimation of average annual damage is explained in chapter IV

(ii) Indirect damage due to closure of shops, factories etc.

In arriving at average annual income losses due to shop closure, the same procedures as in for direct damage (Chapter V) are followed. Only a few equations and data employed are different, as the dependent variable of inundation depth / duration, the number of non- – working days is used instead of damages ratio. Also, average daily gross profit per establishment is used in place of unit value of property.

(iii) Traffic damages (time cost, vehicle-operating costs.

Methodology for estimation of traffic damage is explained in chapter V

Flood damage ratio is defined as

$$\text{Flood damage ratio} = \frac{\text{Flood damage to a property type}}{\text{Property value}} x100$$

Table 2 - 9 shows by type of urban flood damage, procedure of damage assessment and required data. Figure 2.3 depicts flows chart for estimation of average annual direct damage in property.

Table 2 - 9: Damage Type, Procedure and Data Requirement

Type of damage		Procedure		Data required
Damage to property	1)	Find relationships between inundation depths and durations by inundation area and flood damage ratio for each type of property by regression equations	-	Inundation depths and inundation durations for each flood year.
	2)	Find average flood damage per-unit property by multiplying average flood damage ratio to average property value per unit.	- -	Number of properties samples Average properties value per unit
	3)	Find the total flood damage to property by multiplying average flood damage to number of properties on reach.	-	Number of each property on reach in each inundation area.
Income losses due to shop closure	1)	Find relationships between inundation depths / durations by inundation area and non working days	-	Inundation depths and inundation ratios for each year
	2)	Find average income loss per unit by multiplying average non - working days to average daily gross profit.	-	Average daily gross profit per properties
	3)	Find the total income losses per unit property by multiplying average income loss to number of properties on reach.	-	Number of properties on reach in each inundation area.
Damage to traffic	1)	Find time cost per unit vehicle classified	-	Operating km/day normal time and during inundation per vehicle
	2)	Find incremental vehicle operating cost		
	3)	Combine (1) and (2) to get traffic damage per vehicle	-	Operating speed/hour in normal time and during inundation per vehicle
	4)	Find the total traffic damages by multiplying traffic damages to number of vehicles on reach	- - - - - -	No. Of inundated traffic impediment. Average nos. of passengers Vehicle operating cost / km in normal time and during inundation Labour participation rate Average hourly salaries Nos of vehicles on reach.
Average annual flood damage	1)	Find relationships between return period and inundation depths /durations	-	Inundation depths and inundation durations for both flood years
	2)	Find flood damages ratio and or non- working for each property.	-	Average property value per unit and or average daily gross profit.
	3)	Find value of property in each inundation area by multiplying unit value of each property to number of each property.	-	Number of each property on reach in each inundation.
	4)	Find flood damage to property by multiplying flood damage ratio and or non-working days to value of property then total the all flood damages of properties.		
	5)	Find average annual flood damages to property		

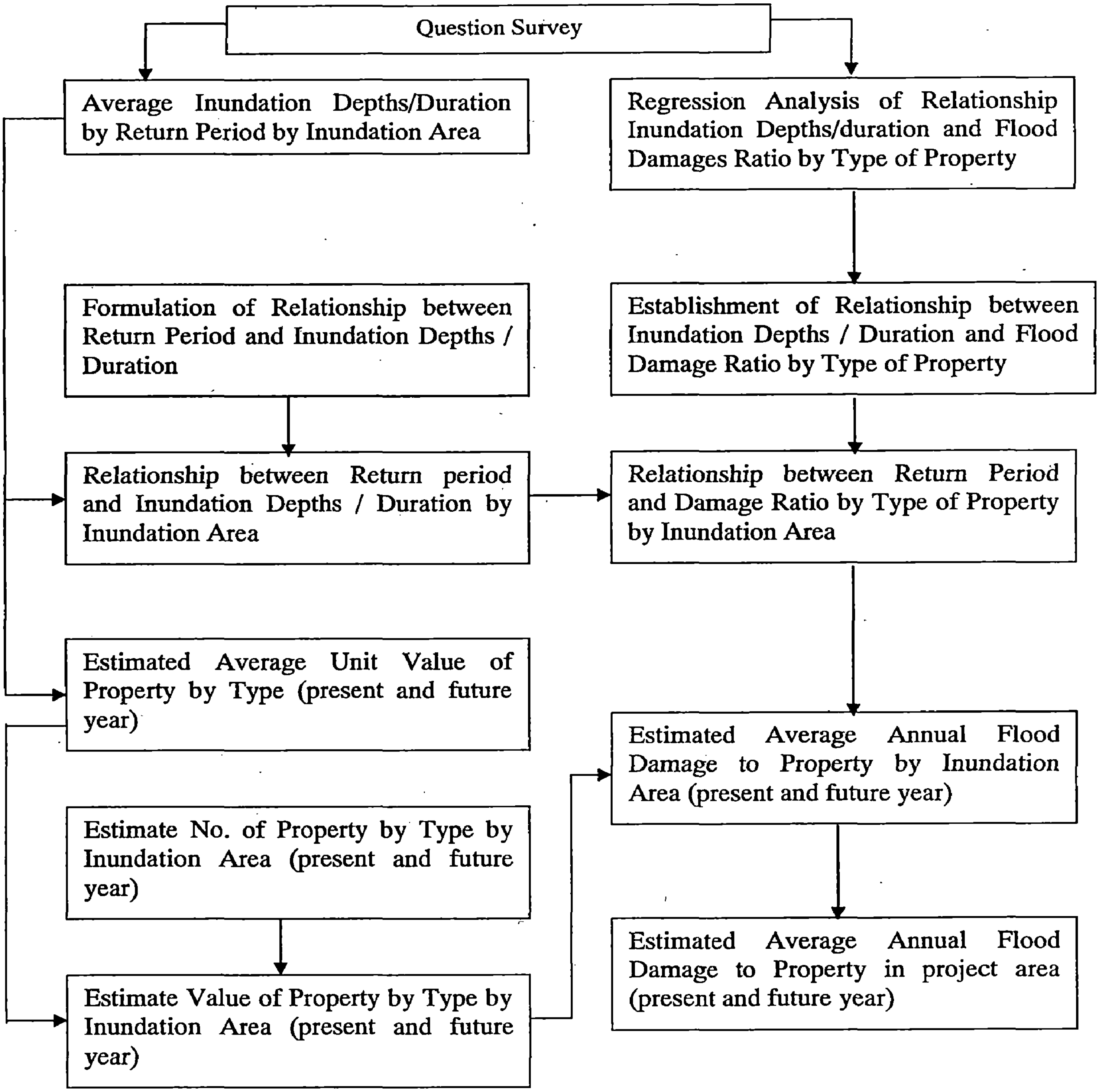
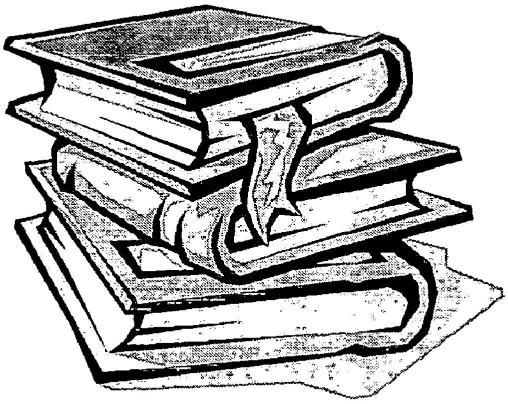


Fig. 2.3: Flow Chart for Estimation of Average Annual Flood Damage (Direct Damages to Property (present and in future year)



CHAPTER III

ANALYSIS OF FLOOD PROBLEM IN THE CITY OF DJAKARTA

ANALYSIS OF FLOOD PROBLEM IN THE CITY OF DJAKARTA

3.1. GENERAL

The City of Jakarta was originally located on the banks of the Ciliwung River estuary. In the last sixty years the city has expanded explosively. The total population has grown from only 800 000 just before the second world war to 1.2 million in 1948, 5 million in 1973, 6.4 million in 1980, 8.2 million in 1990 and about 10 million now. The city has developed more or less 25 km upstream. It has expanded eastward and westward as well, over some 15 km on either side (figure 3.1). The administrative area, which is named DKI Jakarta, is now 662 km^2 and, besides the Ciliwung, has another ten smaller rivers running through. Present river system in JABOTABEK area is shown in figure 3.2.

Until the middle of the last century, the Ciliwung River, which is 128 km long and has a 385 km^2 basin area, was the sole cause of floods in Jakarta. All flood control works constructed before then were aimed to cope with floods from that river. In the early 1960s new problems of flooding quickly arose, for two reasons: many of the newly developed areas were located beyond the Ciliwung flood control system and extended over flood-prone areas along the smaller, unregulated rivers; and inundation due to insufficient drainage was worsened by urbanization. As vast swathes of green areas had been concreted or asphalted over, most rainfall directly became runoff and little water seeped into the ground. In 1965 the government set up a special project to overcome flood and drainage problems. Initial urgent work was carried out and four detention basins were constructed by the Jakarta Flood Control Project, but this was felt to be far from sufficient, and a master plan study was carried out to formulate long-term solutions.

3.2. DRAINAGE MASTER PLAN - 1973

The Master Plan for Drainage and Flood Control of Jakarta was completed in 1973. It concerned DKI Jakarta only and the 11 rivers running through it (figure 3.2). The programme was to be implemented within ten years. Some significant works

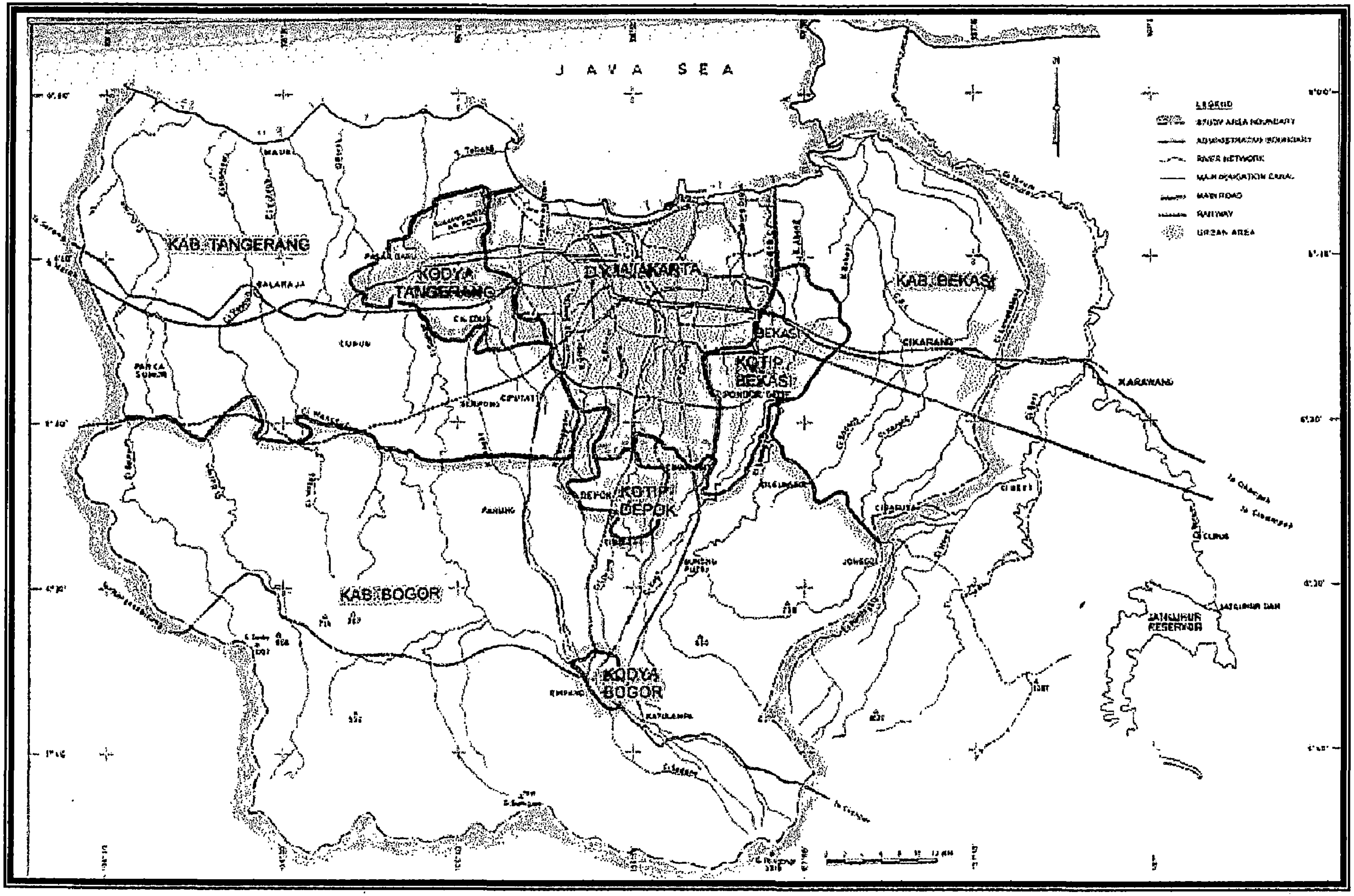


FIGURE 3.1: DKI DJAKARTA AND JABOTABEK AREA

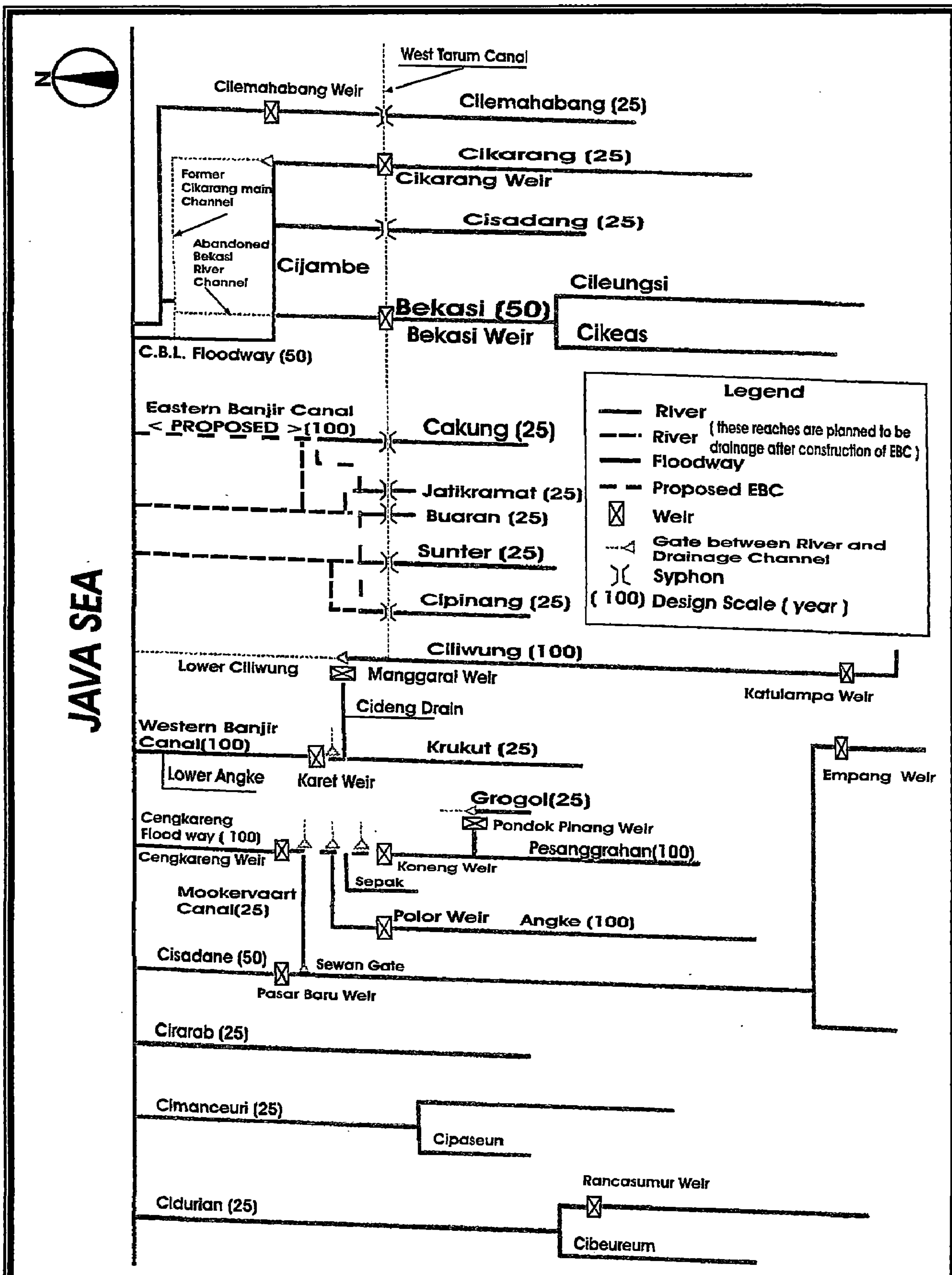


Figure 3.2.RIVER SYSTEMS AND DESIGN SCALE IN JABOTABEK AREA

were carried out as part of the programme, but many others have yet to be implemented. Most of the completed works went through substantial plan and design modifications, with significant time loss and cost overrun.

The outline of the` master plan is as follows:

a. Interception of flood flows from all rivers before entering lowland areas (i.e. the proper city area at the time) by two flood ways. The Western Floodway was meant to be an extension of a floodway constructed in 1924, which intercepts the Ciliwung, Cideng and Krukut rivers (figure 3.2). The extension was intended to cope with the Grogol, Sekretaris and Angke rivers as well. The Eastern Floodway was aimed to intercept all other remaining rivers (Cipinang, Sunter, Buaran, Jatikramat and Cakung). The floodways were planned to contain 100-year floods, i.e. 290 - 525 m^3/sec for the Western Floodway and 101 - 340 m^3/sec for the Eastern Floodway.

b. Areas located downstream of the two flood ways were divided into six drainage zones covering about 240 km^2. Most of the land (about 150 km^2) with elevation of less than 2 metres was considered as polders, and the rest treated as gravity drainage areas. Pumps and reservoirs would release floodwater from the polders. The existing old river channels were considered as primary drainage, and designed to contain 25-year floods.

When a heavy flood occurred in 1979, both the floodways had yet to be built. Losses were such in the western part of DKI Jakarta that the construction of a floodway was considered an absolute necessity. Since development along the planned Western Floodway extension route was already in progress and the cost of land had become very high, the plan had to be modified. The concept of extending the floodway was abandoned and a completely new floodway, the Cengkareng Floodway (figure 3.2), designed to withstand 100-year floods, was constructed in 1981-1982 to discharge floods from the Grogol, Sekretaris and Angke rivers.

Construction of the Eastern Floodway was postponed due to land acquisition problems. Progress since then has been quite slow. A modification of plans for the eastern Jakarta was mooted in 1987 to provide a partial solution. Most of the works formulated and executed were for channel improvement.

The implementation of the drainage components of the 1973 master plan, mostly construction of canals, reservoirs and pumping stations, has shown faster progress.

However, many things still have to be done to complete the plan, and many pumps constructed in the early period already require rehabilitation.

3.3. DRAINAGE MASTER PLAN - 1991

By 1990, as urban growth had swallowed much of the area covered by the 1973 drainage master plan, it was considered necessary to review the plan. The new drainage master plan study, which was combined with a master plan study for waste water disposal, formulated for major drainage system only, was designed to meet requirements up to the year 2010.

In 1991 a new master plan for drainage of DKI Jakarta was established to cover the upper parts of the city not included in the 1973 master plan and to review existing plans for the downstream areas. The city was divided into new six drainage zones. Detailed plans were drawn for each zone. One priority zone was selected, and further studies were done for the feasibility of construction works. But again, land acquisition problems seem to have been a major constraint in implementation. So far, most of the works that have been completed are those that were the components of the 1973 drainage master plan.

3.4. FLOOD CONTROL PLAN FOR JABOTABEK

By 1990 urbanization had extended beyond the city's administrative boundaries. Satellite towns had emerged, and completely different environmental conditions prevailed. The unfinished flood control master plan of 1973 was felt to have become obsolete. Land use over upper watersheds had changed with less and less vegetative cover. Riverbanks and flood plains had become more crowded and land value was escalating. This led to a review study in 1995-1996. In this study Jakarta was treated as a part of a larger ecosystem.

The resulting flood control master plan was not only for the City of Jakarta but for the whole Jabotabek, i.e. Jakarta and its satellite areas which include the towns of Bogor, Tangerang and Bekasi (figure 3.1). This was required for two reasons: firstly, considering actual and anticipated patterns of development (e.g. the impact of reclamation projects along Jakarta Bay upon river hydraulics, which must be judged properly), it was necessary to review existing plans and to find out more practical solutions in controlling floods in DKI Jakarta; secondly, it was necessary to build

flood control facilities for the satellite towns, especially because the development of real estate and industrial complexes was not sufficiently controlled and their impact on hydrology and river conditions has been beyond anticipation.
The results of the study can be summarized as follows:

a. Dikes and river improvement works are required for all rivers flowing along newly urbanized areas outside DKI Jakarta. Only this type of works can be suggested for both eastern rivers (Cikarang and Bekasi) and western rivers (Cidurian, Cimanceuri, Cirarab, Cisadane) (figure 3.2), because other alternatives such as flood control reservoir are considered to be more expensive and to create greater social problems.
b. Rivers flowing through DKI Jakarta (figure 3.2) are grouped into three systems, namely the Eastern Floodway System, the Western Floodway System and the Cengkareng Floodway System. Some alternatives are proposed to modify the plan of the Eastern Floodway with the intention to reduce land acquisition amount. The proposal is to construct the floodway channels with revetment (sheet piles or concrete walls) so that the same discharge capacity can be obtained with less channel width. This will increase construction costs, but decrease social problems related to land acquisition. A large floodway is planned to divert floods from Ciliwung into Cisadane at an upstream point (about 60 km from the estuary) (figure 3.3 and figure 3.4). This is aimed to further reduce the load of Ciliwung, which flows through the central part of DKI Jakarta. As for the Cengkareng Floodway System, the proposed plan is only river improvement, including dyke construction.

3.5. DELAYS IN IMPLEMENTATION OF MASTER PLANS

Implementation of the master plans has been slow. One of the main reasons is funding. While master-plan implementation was scheduled over a number of years, no budget was available immediately. Instead, the master plans were used as tools to make budget available. When the cost of all works set up in the 1973 master plan amounted to Rp 492 million, the annual budget for the project in the mid 1970s was only approximately Rp1.5 million.

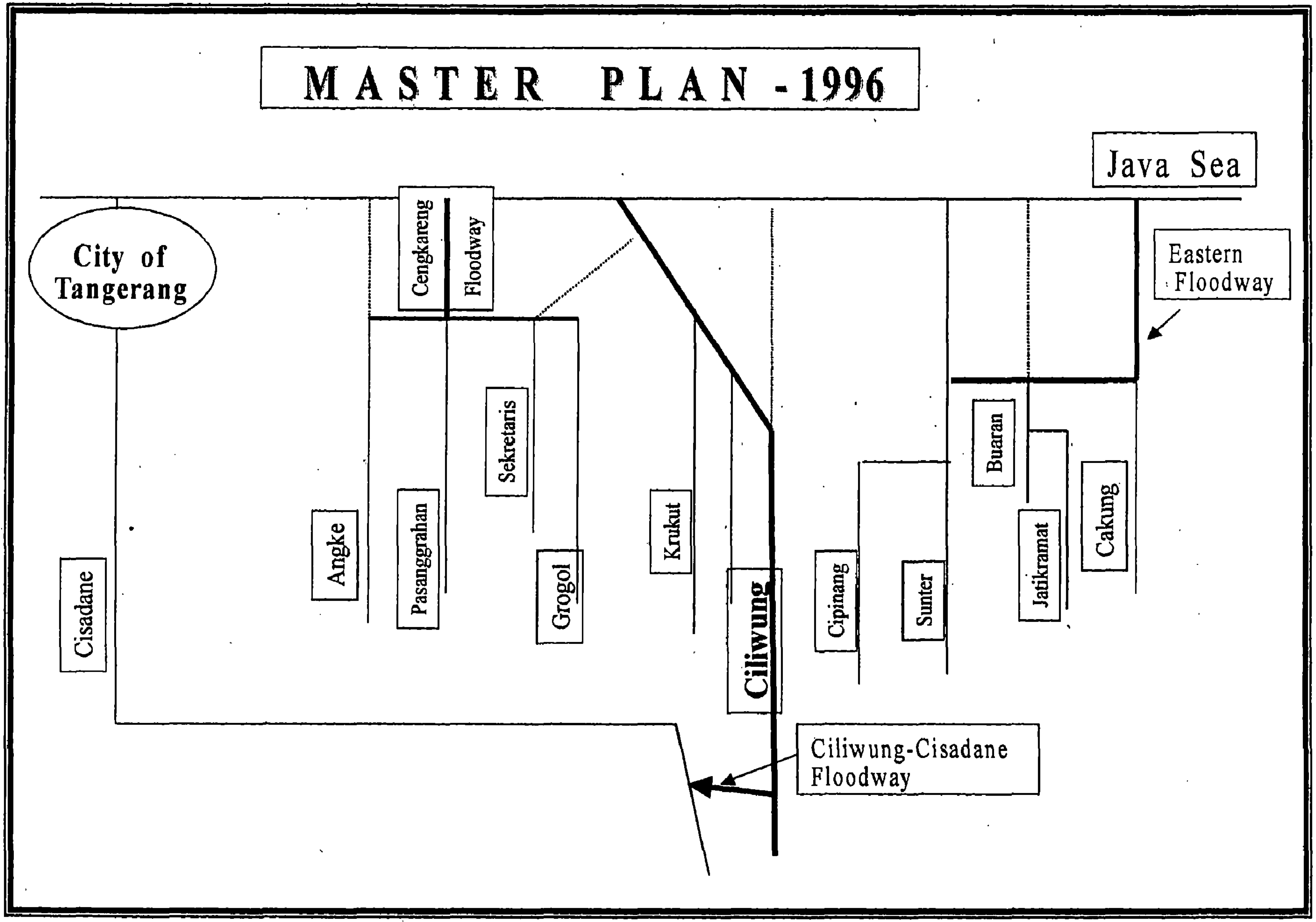


FIGURE 3.3 : MASTER PLAN - 1996

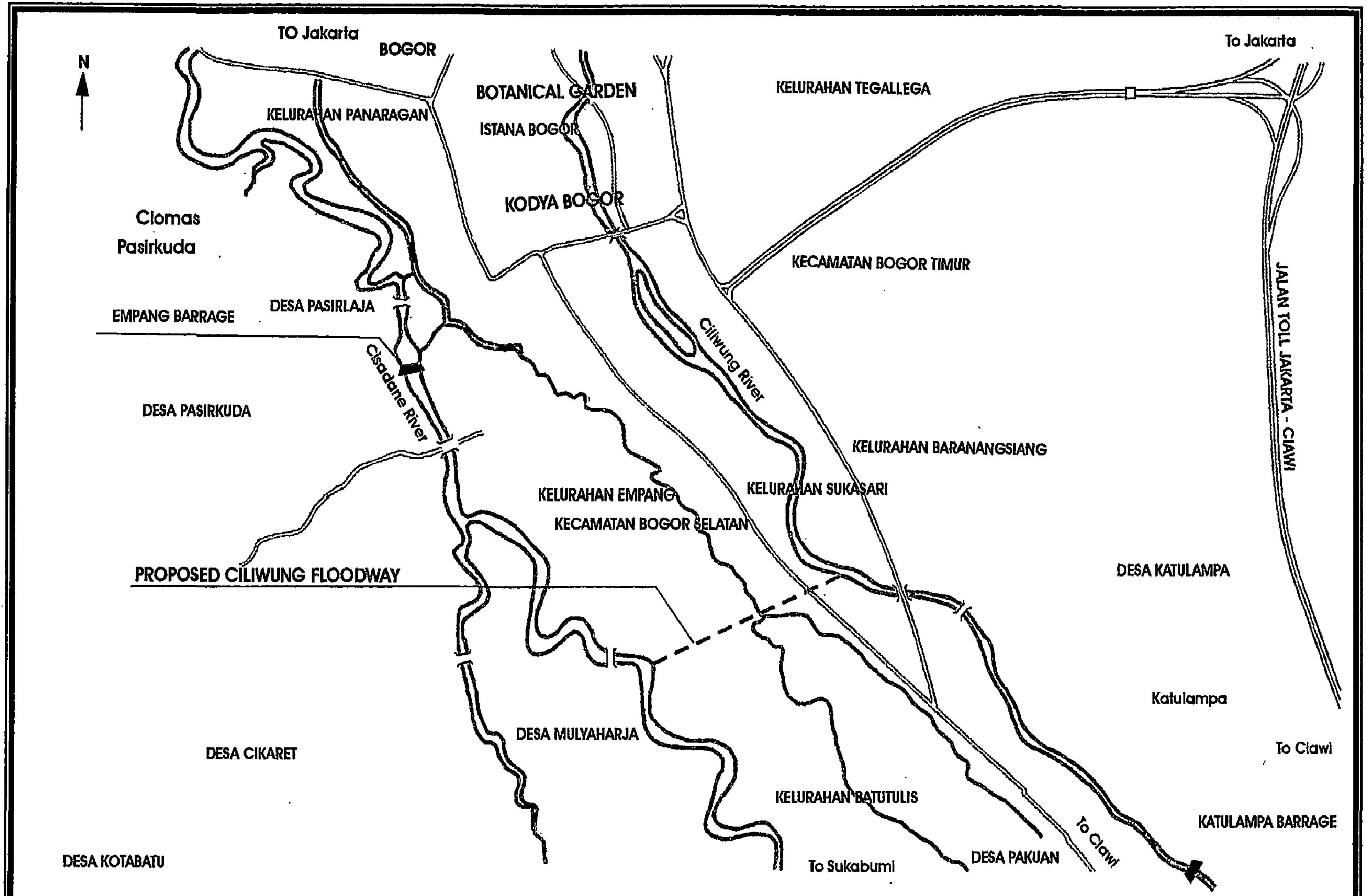


Figure 3.4 : LOCATION OF CILIWUNG FLOODWAY

Given the centralized model of development practiced at the time, the progress of a project would entirely depend on the central government's intentions and capacity to provide funds from the national budget.

Delays in master plan implementation increased budgetary requirements, not only because of inflation but also because land costs were skyrocketing. Disclosure of a master plan or parts of it would amplify physical development along construction routes and trigger land speculation in the surrounding areas. Landowners would hold on to their lands and refuse to sell or accept fair, market-price compensation. When people knew that an area would be protected from floods, they would buy land and build houses on it before other people did the same. In many cases, the situation worsened because people built anything just before the project started, so that they could claim higher compensation.

Community participation in overcoming this problem has been minimal. Flood mitigation works, dykes and channel construction, riverbank improvement, dredging, pumping stations, polder reservoirs – all require land acquisition. But most people along construction routes are not willing to sacrifice their land: they will lose it to no apparent personal benefit; instead, the benefit will be enjoyed by people upstream or downstream. They will only help enable smooth project implementation of government projects if they are sure that they can gain the best price for their land. When they deal with public officers, they are suspicious about business motives, and will not move away until hard cold cash is handed over, even when contractor bulldozers are already at their door. This is quite often a reason for construction backlog.

There are some other reasons for construction time overrun. They are mostly related to social and environmental problems not addressed in detail during the master plan studies, such as having an access road to a construction site going through a crowded slum (a problem that involves the project manager, the contractor and the leaders of the local community), or construction noise in a crowded area, which may restrict operations to daily working hours, or police may forbid the operation of hauling trucks in heavy city traffic during the day and restrict it to only four or five hours at night.

A recent example of a major work construction delay is the case of the Ciliwung to Cisadane diversion floodway mentioned above. The floodway is aimed to reduce big floods from the Ciliwung River passing through central Jakarta; it will run through the Bogor Regency (60 km upstream of Jakarta) and the excess flow will be discharged into the Cisadane River, which goes through the town of Tangerang (about 70 km northwest of Bogor and 25 km west of Jakarta). When the master plan was formulated in 1996, no objections were raised. But problems arose just before construction began in 1999-2000. The community along the Cisadane at Tangerang, supported by its local parliament and some NGOs, demanded to know why it had to accept the greater threat of an additional flood discharge from the Ciliwung when it already suffered from annual flooding from the Cisadane. Attempts at compromise did not work out and the construction plan has had to be postponed indefinitely.

3.6. PROBLEM IN OPERATION AND MAINTENANCE

3.6.1. Riverbank Occupation

Bank occupation is a serious problem when it comes to reducing the flood carrying capacity of rivers and main drainage channels in Jakarta. The process is usually gradual, starting with a couple of temporary sheds or huts made of bamboo and soon turning into dozens or hundreds of permanent buildings. Encroachment will continue even over the wet area of the channels. As an example, the width of the Ciliwung River in the stretch just upstream of its diversion point to the Western Floodway had shrunk from about 80-120 m in the 1920s to only 10-60 m in 1990.

3.6.2. Solid - Waste Disposal

Most of Jakarta's rivers and drainage channels are in bad shape because they carry too much solid waste. River and drainage channel stretches along slums are the main sources of waste. To a lesser extent, markets and commercial areas contribute to the amount of waste in channels. This creates major problems during the rainy season, especially because of the reduction in discharge-carrying capacity, clogging, and mechanical failures.

Overflow and inundation caused by channel clogging are a common occurrence. The point of blockage is usually a confluence, screens, gates and siphons. Flood and drainage pump failures due to garbage load happen often, not only because of total clogging due to the accumulation of garbage during a heavy storm but also because of broken propellers hit by hard materials in the garbage.

3.6.3. Flood Forecasting and Warning System

Up until now, a flood forecasting and warning system has been established only for the Ciliwung - Western Floodway river system. The forecasting system is computerized and equipped with remote control rainfall and discharge observation. It is meant to provide the best information needed for community preparedness, evacuation and mechanical (pumps and gates) system operation.

The success of community participation in applying a flood warning system can only be tested when an extraordinary flood occurs. Fourteen people died in one night during the big flood of February 1996. There have been other deaths since then during habitual floods, though in lesser numbers, but all due not to technical failures but to ignorance and no preparedness. When a medium-size flood is coming, people are warned to leave their houses. They do so but find that the water only rises just above floor level, so on following flood alerts, they don't bother to vacate their premises but make do instead by 'camping' on tables and beds – until they find out that it's too late to escape when a big flood reaches the house roof. *(Soenarno and Djoko Sasongko : Participatory Planning and Management For Flood Mitigation and Preparedness in The City of Jakarta)*

3.7. HABITUAL FLOOD CONDITION

Habitual flood is defined as the flood that occurs more than once a year. The habitual floods are established in the following way:

1. A first draft of habitual floods map was made on the basis of available floods maps of 1978 and 1988. These two maps were prepared by DKI, containing all the flood-affected areas in each of these two years. The first draft map was made to cover all the flood areas in these two maps except the ones from flood Control Rivers. The reasons why these two maps are adopted for making the habitual flood map are:
    a. They are latest available data and represents actual phenomenon under the present conditions of the Jakarta City.
    b. It is found from annual maximum daily rainfall data that the year of 1987 or 1988 was not a year of abundant rainfall, instead a year of low rainfall. So, flood areas in these maps are considered to be the typical ones of normal scale.

2. The locations of the habitual flood areas of the first draft map are revised through interviews conducted at almost all of the Kecamatan office. The frequency of the habitual flood is defined as the flood that occurs more than once twice or three times a year, based on interviews. Especially, some places in the northern part of the Jakarta City suffered from floods almost every day due to high tide. Hence, the frequency of floods in the habitual flood map seems to be in fact more than twice a year on average.
3. The habitual flood map was finally constructed through field survey related to flood conditions such as location, duration and depth of inundation conducted based on the second draft map.

The habitual inundation areas are distributed at 78 locations as shown in figure 4.2 of Chapter IV). They sum up to 3,615.2 ha or 5.46 % of the study area (Table 4 - 5 of Chapter IV). An interview survey on the flood conditions of habitual flood; inundation depth and duration, for the above 78 habitual flood areas was conducted in December 1989.

The mean inundations depth of each flood area ranges from 0.10 m to 0.53 m (figure 3.5) and its means duration time is in the range of one hour and 48 hour (figure 3.6).

3.8. POTENTIAL FLOOD CONDITION

The study area suffered from major floods on January 19/20 in 1977, January 18/19 in 1979 and December 24/25 in 1981. The rainfall of the 1979 flood concentrated in the inside areas of the Banjir Canals with a small distribution for outside areas (Table 3 - 1). Therefore, the floods of January 18/19 in 1979 are considered mostly as the ones from the major urban drainage channels.

At the flood times of January 19/20, 1977 and December 24/25, 1981, high rainfall depths were recorded for the whole Study Area (Table 3 - 1). Those floods are considered as a combination of the floods both from the flood Control Rivers and major urban drainage channels.

Based on the above discussions, the 1979 flood map was employed as a base map in establishing the potential flood map for the whole study area. The 1977 and 1981 flood maps were utilized to supplement the 1979 flood map.

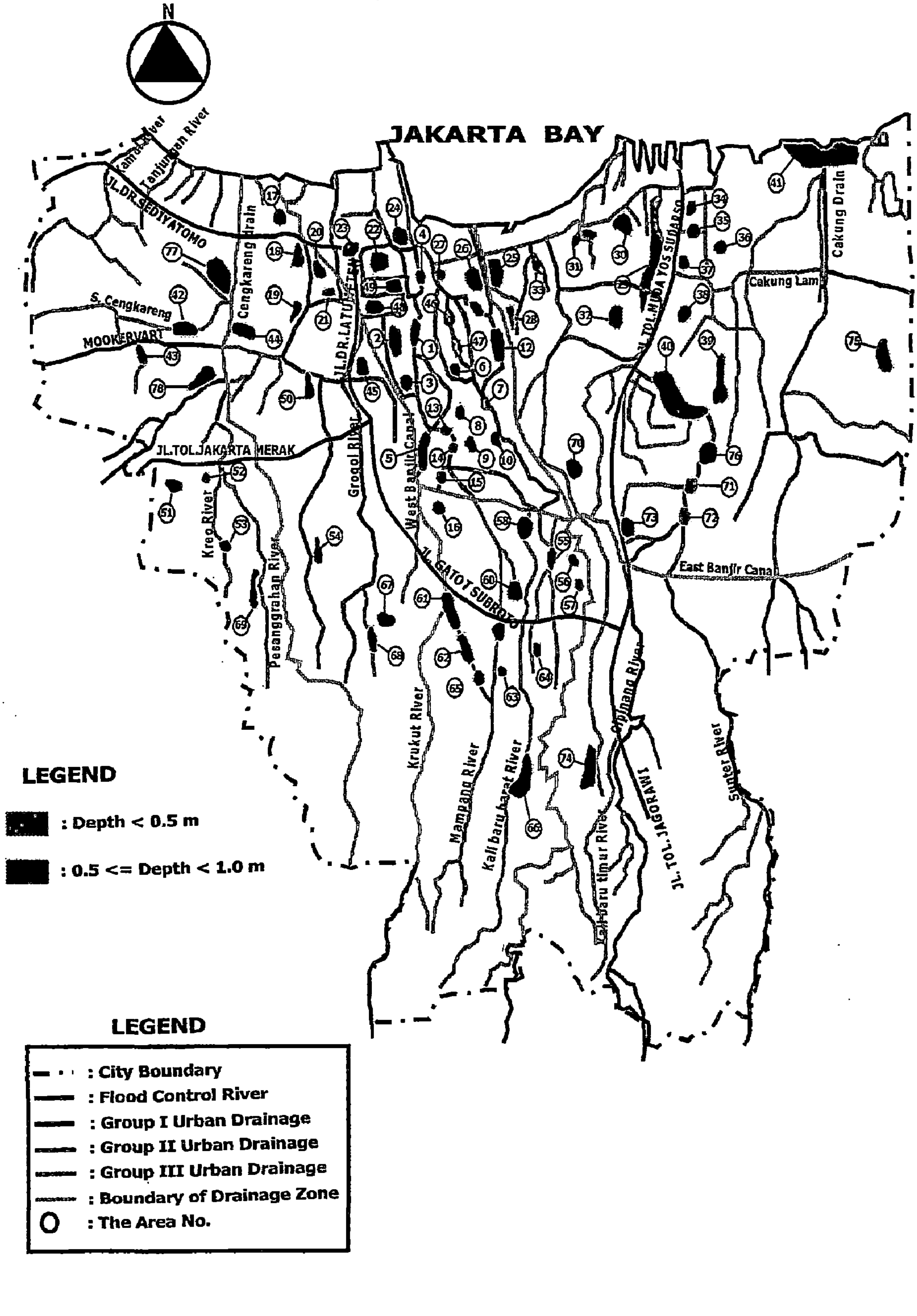


Figure.3 - 5 : DISTRIBUTION OF HABITUAL FLOOD DEPTH

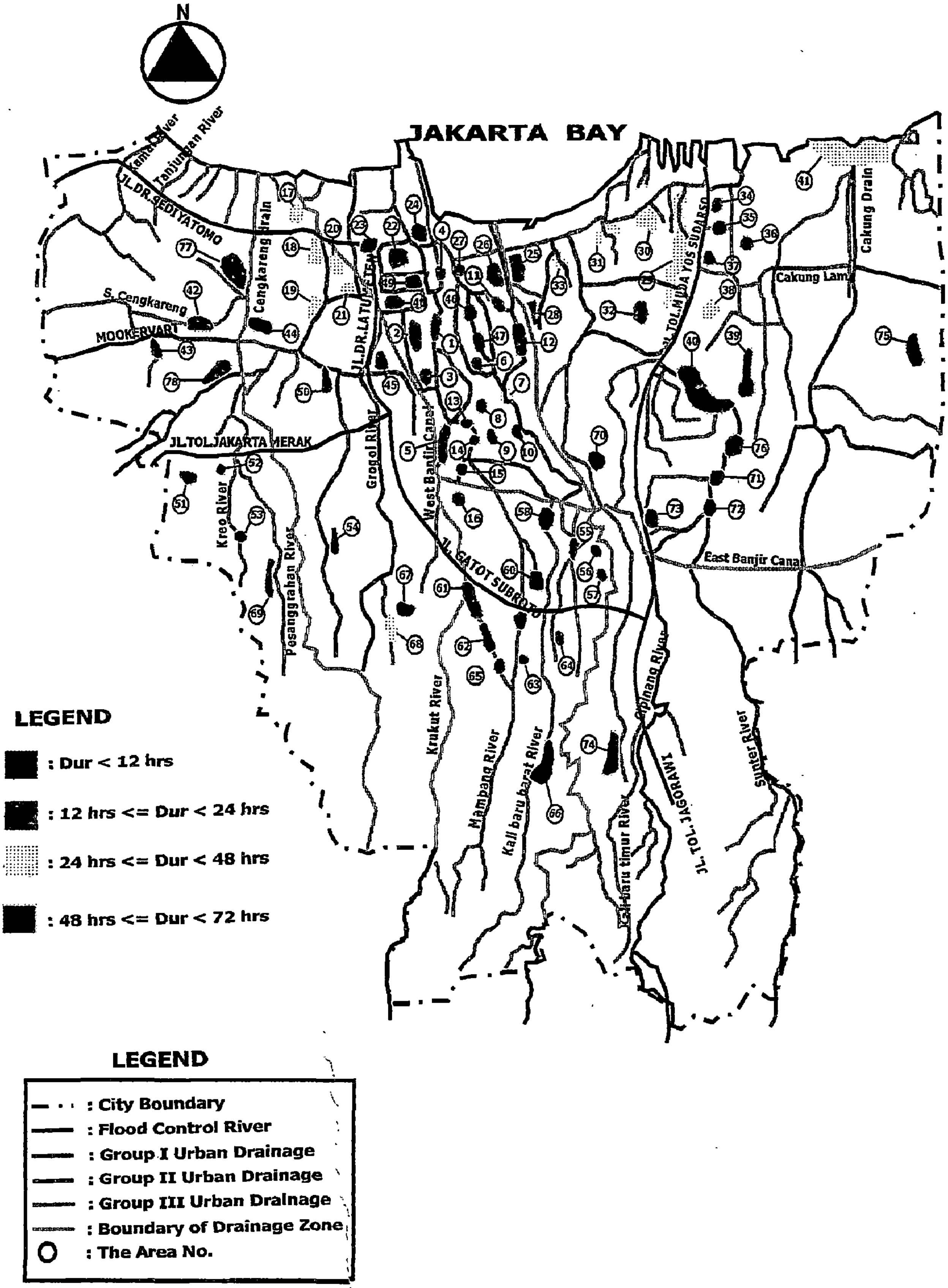


Figure.3 - 6 : DISTRIBUTION OF HABITUAL FLOOD DURATION

Table 3 - 1 : Rainfall of 1977, 1979 and 1981 Floods

(unit: mm)

Rainfall Gauging Station No.	1977			1979			1981		
	Jan 18	Jan 19	Jan 20	Jan 17	Jan 18	Jan 19	Dec. 24	Dec. 25	Dec. 26
24A	-	-	-	-	-	-	-	-	-
24B	-	-	-	-	90	-	-	-	-
26	90	247	53	19	100	35	67	2	33
26A	4	123	56	4	114	61	-	-	-
26B	-	-	-	-	-	-	-	-	-
26C	-	-	-	-	-	-	175	48	59
26D	-	-	-	-	-	-	100	42	0
26F	-	-	-	-	134	-	s	31	0
26G	-	-	-	8	135	48	75	52	18
27	62	200	3	6	207	71	125	1	29
27A	-	-	-	-	-	-	-	-	-
27B	80	330	34	3	180	60	150	47	2
28C	53	197	29	9	205	80	124	22	15
28D	32	216	43	-	223	74	107	87	3
28E	17	194	9	10	200	63	132	36	0
29B	67	215	36	7	92	39	-	-	-
29C	-	-	-	-	158	28	-	-	-
29D	-	-	-	-	110	-	-	-	-
30	2	47	23	22	170	73	80	0	91
30D	-	-	-	-	-	-	-	-	-
30E	4	64	21	60	176	118	91	78	24
30F	62	24	58	-	185	-	-	-	-
30H	-	-	-	15	105	93	123	50	11
30I	-	-	-	-	134	-	87	67	2
30J	85	10	60	19	70	60	82	32	4
31A	-	-	-	-	190	85	87	65	19
31B	-	-	-	-	-	-	-	-	-
32A	-	-	-	-	144	-	-	-	-
32B	-	-	-	-	150	80	-	-	-
32C	39	61	58	13	70	82	171	54	4
32D	954	27	10	-	-	-	-	-	-
33A	53	97	63	29	106	34	132	85	62
33B	103	157	60	-	104	54	133	74	1
33C	103	250	51	11	60	33	119	28	0
33D	-	-	-	-	-	-	-	-	-
34	-	-	-	-	-	-	-	-	-
34A	51	16	45	88	45	0	134	48	0
35	-	-	-	45	27	103	133	34	0
35A	-	-	-	-		-	-	-	-
35D	-	-	-	-	50	28	225	59	13
36	-	-	-	12	61	23	186	80	20
36B	-	-	-	-	87	-	-	-	-
78	-	-	-	-		-	-	-	-
78H	-	-	-	-		-	-	-	-

The potential flood map was prepared through the following manner:

1. The potential flood map for the area other than the inner areas of the East Banjir Canal was prepared by overlaying the 1977 and 1981 flood maps on the 1979 flood map to fill the shortage of flood area in the 1979 flood map. The shortage might have occurred mainly due to the deviation of the regional rainfall distribution. However, the potential flood map for the inside areas of the East Banjir canal was represented by the 1979 flood map due to the reason mentioned above.
2. The habitual flood areas established in the previous section, were incorporated into the potential flood map in case the habitual flood areas lie outside the potential flood areas.
3. The land use of the Study Area has undergone a considerable change since 1979, resulting in change of the flood condition in many locations. Such changes in flood condition have been checked through the interviews at each Kecamatan Office.
4. The draft potential flood map drawn through the above processes was checked through the field survey.

The potential flood areas are located at 94 places as shown in Figure 4.1 of Chapter IV. The inundation area is 10,784 ha or 16.29 % of study area as shown in (table 4 - 9 of Chapter IV).

The inundation depth and duration of the potential flood areas were estimated by JICA (1990) through the interview survey conducted along with that for habitual flood areas. The data are shown in Table 4 - 5 and Table 4 - 9 of Chapter IV.

The mean inundation depth of each flood area ranges from 0.19 m to 2.02 m (Figure.3.7) and its mean duration time is in the range of two hours and 238 hours (Figure.3.8). Frequency of the above potential flood is estimated at approximately 40 years as described below.

The potential flood is prepared based on the above three (3) major floods; 1977, 1979 and 1981 floods. Return period of the potential flood is estimated based on basin average daily rainfalls of the study area during the days of these flooding. In order or estimate the basin average daily rainfall, daily rainfall data were collected at the stations in and around the Study Area. (Table 3 - 1)

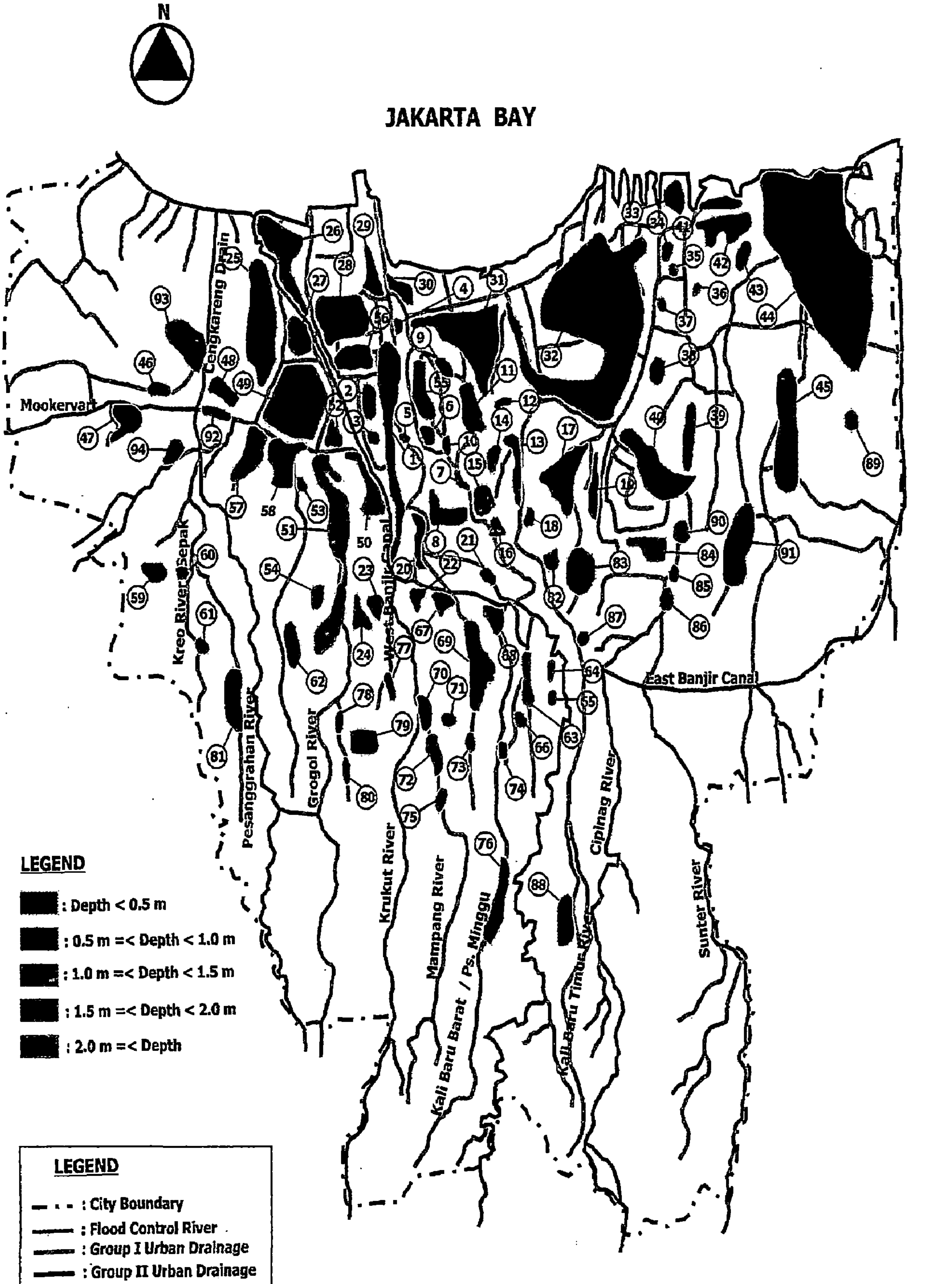


FIGURE 3.7 : DISTRIBUTION OF POTENTIAL FLOOD DEPTH

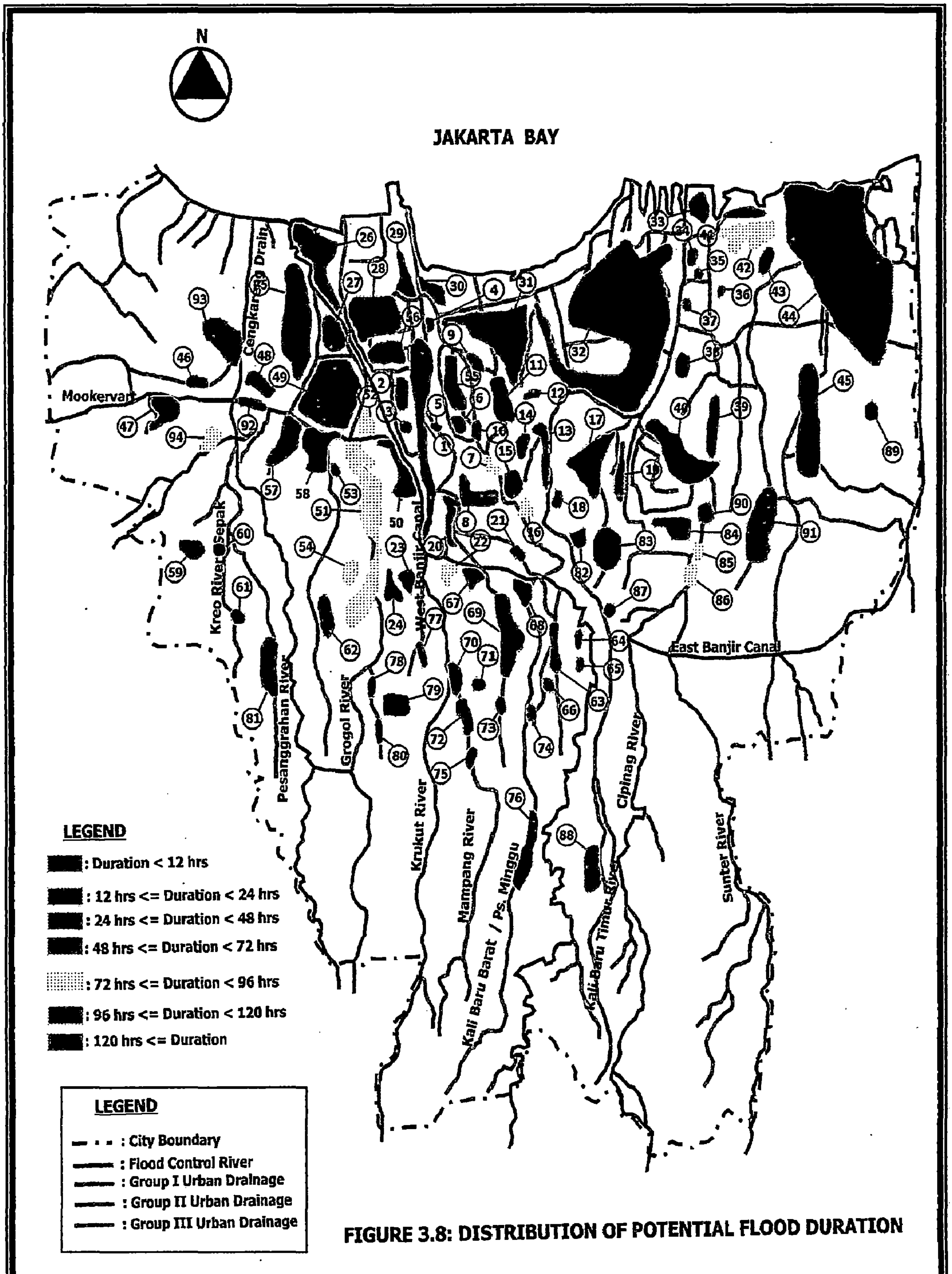
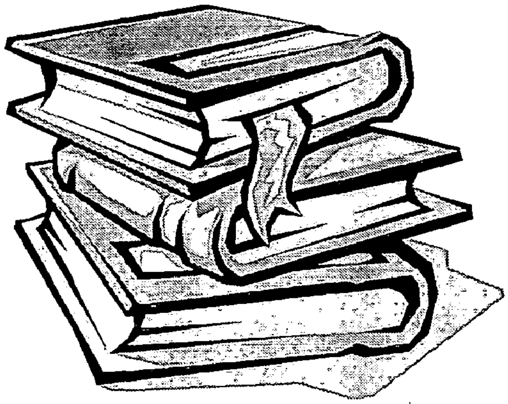


FIGURE 3.8: DISTRIBUTION OF POTENTIAL FLOOD DURATION

As seen in Table 3 - 1, there are a lot of lack portion in the daily rainfall data, hence interpolation is necessary to supplement them. The premise conditions of interpolation are as follows:

1. Estimation of correlation between rainfall stations is conducted based on the daily rainfall data with more than 30 mm / day on the same day.
2. Interpolation is applied for those selected few rainfall station where correlation of the data is relatively high, that is, correlation coefficient is more than 0.7.
3. Only primary regression is applied to interpolate the daily rainfall data.

The basin average daily rainfall data is obtained from the interpolated daily rainfall data only in case that such interpolated data are available for more than 15 rainfall stations, which is 50 % of total rainfall stations in the study Area. In fact, for certain years, such interpolated data are available for only a few stations, and the basin average rainfall calculated based on such a few data is not reliable.



CHAPTER IV

ASSESSMENT OF DIRECT FLOOD DAMAGE IN THE STUDY AREA

ASSESSMENT OF DIRECT FLOOD DAMAGE IN THE STUDY AREA

4.1. GENERAL

In urban areas flood damages are due to damage to property (direct damage), due to closure of shops, factories and due to disruption of traffic (indirect damage). It is possible to assess these damages in a more scientific manner. Depending on availability of data, part of the urban flood damages may be included in economic analysis, whereas others could be discussed as environmental impacts in qualitative manner but in a more informative and scientific manner. This chapter analyses improvement in procedures for assessment of various type of urban flood damages using the available data for Djakarta City (Indonesia).

The Djakarta City is about 662 km^2 in area, which is drained by several rivers and drainage channels connecting with the rivers. There are 11 large rivers which originate in the southern mountainous located outside the city or the study area. River floods affect the city, water logging of local rainfall and tide effect of Djakarta Bay.

This study is limited to the flood in the major urban drainage channels caused by local rainfall and high tide of the Bay of Djakarta. The total drainage of 662 km^2 of the study area is divided into 27 sub-drainage areas. There are 43 rain gauge station and 9 automatic water level gauging stations.

Habitual flood is defined as the flood that occurs more than once a year, Potential flood and inundation map are based on three major floods, which occurred in 1977, 1979, 1981.

Anticipated major flood damages in the Djakarta city are: i) Direct damages to house, shop, factory and other properties, and indirect damage to ii) Income losses due to closure of shop , factory and other enterprises, and iii) Damages to traffic and infrastructure.

The sampling questionnaire survey data obtained from report are: inundation depth and inundation duration in each of the 92 flood area and 1000 houses, 192 shops and 120 factories, distributed over the area. (Table 4 - 1)

The potential floods map for the areas other than the inner areas of the east Banjir Canal was prepared by overlaying the 1977 and 1981 flood maps on the 1979 flood map to fill the shortage of flood area in the 1979 flood map. Also the habitual flood areas were incorporated into the potential flood map in case the habitual areas lie outside the potential flood areas. Figure 4.1 shows the potential flood area and figure 4.2 shows the habitual flood area.

Since the potential flood covers the three major floods above, the return period of the potential flood is estimated at 40 approximately.

The flood damages assessment is carried out into 4 categories:

1. Flood damages for habitual flood in the year 1988 and 2010.
2. Flood damages for potential flood in the year 1988 and 2010.
3. Flood damages to traffic.
4. Annual flood damages.

The flood assessment is initiated by finding relationship between inundation depths / duration's by inundation area and flood damages based on questionnaire survey data for both flood years (habitual flood year and potential flood year).

Further, the unit values of property are assessed, and then by finding the number of property, flood damages are calculated. (Bagus Nugroho 2001).

4.2. RELATION BETWEEN INUNDATION AND FLOOD DAMAGE TO PROPERTY

The relationships between inundations depths / durations and flood damages for houses, shops, and factories were analyzed based on the answers from 1,300 samples.

On the assumptions that direct flood damages to houses, shops and factories are the functions of inundation depths/ durations, multiple regression analysis was performed. In formulating regression equations, flood damage ratio was adopted as the dependent variable instead of flood damages themselves.

For finding out the relationships between inundation depths/durations, multiple regression analysis was performed.

The equation is in general form:

$$Yi = a + bx_1 + cx_2$$

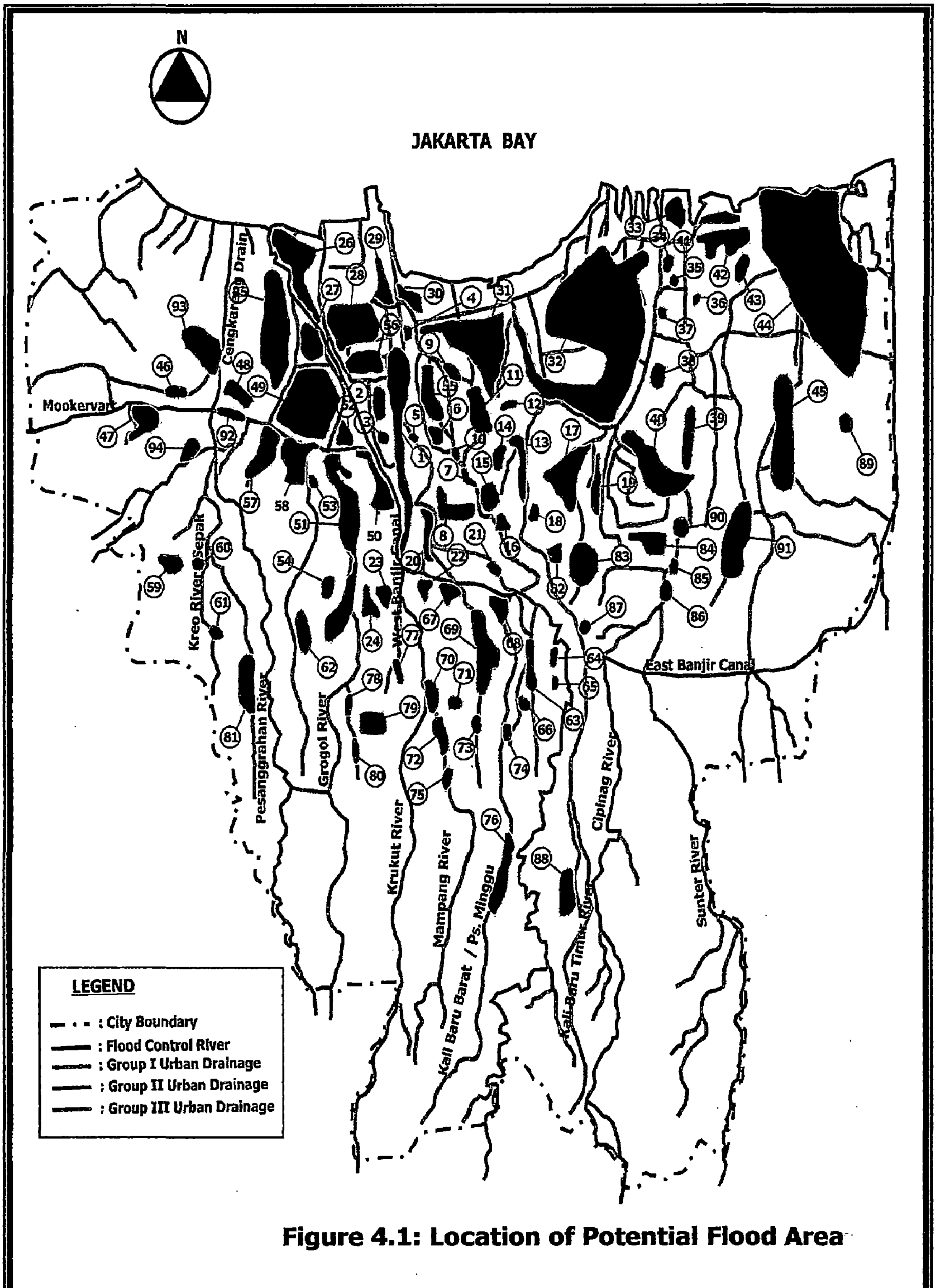


Figure 4.1: Location of Potential Flood Area

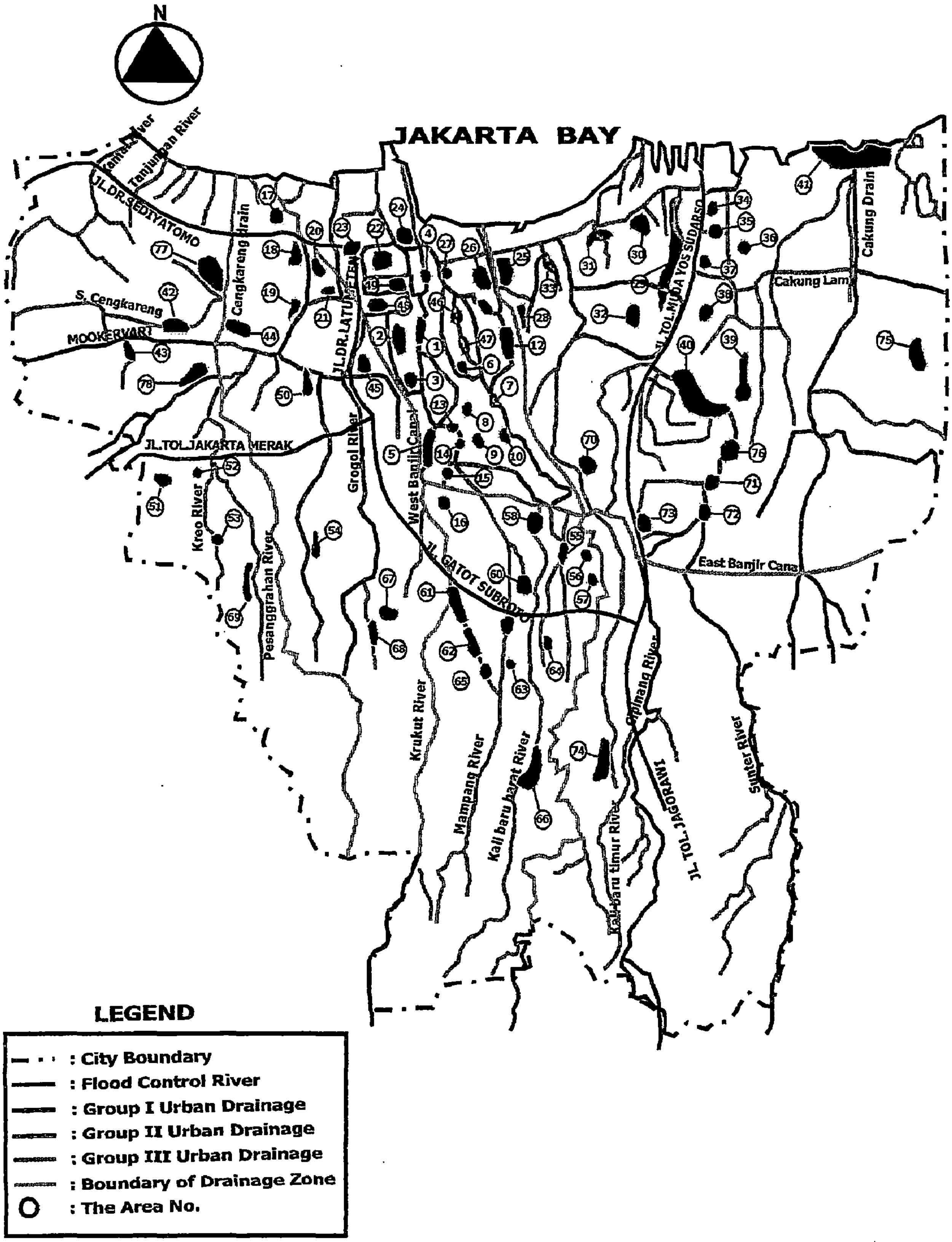


Figure.4 - 2 : LOCATION OF HABITUAL FLOOD IN THE STUDY AREA

Where,

Yi = flood damage ratio (%)

x_1 = inundation depth (cm)

x_2 = inundation duration (hour)

a , b , c, = constants

Deviation $= [yi - (a + bx_1 + cx_2)]$

$$\text{Error } \varepsilon = \sum_{i=1}^{N} [y_i - (a + bx_i + cx_2)]^2$$

$$\frac{\delta \varepsilon}{\delta a} = 0 \ , \ \frac{\delta \varepsilon}{\delta b} = 0 \ , \ \frac{\delta \varepsilon}{\delta c} = 0$$

$$\varepsilon = \sum_{i=1}^{N} \left[yi^2 - 2yi(a + bx_1 + cx_2) + (a + bx_1 + cx_2)^2 \right]$$

$$\varepsilon = \sum_{i=1}^{N} \left[\begin{array}{l} yi^2 - 2ayi - 2byi\,x_1 - 2cx_2) + a^2 + 2ab\,x_1 + 2ac\,x_2 + 2bcx_1x_2 + \\ b^2x_1^2 + c^2x_2^2 \end{array} \right]$$

$$\frac{\delta \varepsilon}{\delta a} = 0 \longrightarrow 2yi + 2a + 2byi + 2cx_2 = 0$$

$$\longrightarrow \sum_{i=1}^{N} yi = Na + b\sum^{N} x_1 + c\sum^{N} x_2$$

$$\frac{\delta \varepsilon}{\delta b} = 0 \longrightarrow 2yix_1 + 2ax_1 + 2cx_1x_2 + 2bx_1^2 = 0$$

$$\longrightarrow \sum_{i=1}^{N} yix_2 = a\sum^{N} x_1 + c\sum^{N} x_1x_2 + b\sum^{N} x_1^2$$

$$\frac{\delta \varepsilon}{\delta c} = 0 \longrightarrow 2yix_2 + 2ax_2 + 2bx_1x_2 + 2cx_2^2 = 0$$

$$\longrightarrow \sum_{i=1}^{N} yix_2 = a\sum^{N} x_2 + b\sum^{N} x_1x_2 + c\sum^{N} x_2^2$$

Then we have 3 equations:

$$Na + b\sum x_1 + c\sum x_2 = \sum yi$$

$$a\sum x_1 + c\sum x_1 x_2 + b\sum x_1^2 = \sum yix_1$$

$$a\sum x_2 + b\sum x_1 x_2 + c\sum x_2^2 = \sum yix_2$$

In matrix form:

$$\begin{pmatrix} N & +\sum x_1 & +\sum x_2 \\ \sum x_1 & +\sum x_1^2 & +\sum x_1 x_2 \\ \sum x_2 & +b\sum x_1 x_2 & +c\sum x_2^2 \end{pmatrix} \cdot \begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} \sum yi \\ \sum yix_1 \\ \sum yix_2 \end{pmatrix}$$

Then we can find the values of a, b, and c.

For example, for flood damages to house in 1988 habitual flood:

$\Sigma x_1 = 17.09$	$\Sigma x_1^2 = 4.8843$
$\Sigma x_2 = 1{,}299$	$\Sigma x_2^2 = 32{,}395$
$\Sigma yi = 131{,}879$	$\Sigma x_1 x_2 = 310.64$
$\Sigma yi\, x_1 = 0.29585$	N = 78
$\Sigma yi\, x_2 = 22.00873$	

Hence, we get:

a = 0.015709

b = 0.006304

c = - 0.000011

So, the regression equation is:

$$yi = 0.015709 + 0.006304\, x_1 - 0.000011\, x_2$$

To find the multiple correlation coefficient:

$$\text{Variance of yi : } S_i^2 = \frac{\Sigma (y_1 - \bar{y})}{N} = \frac{99.7765}{78} = 1.2792$$

$$\text{Unexplained variance } s_i^2 = \frac{\Sigma (y_1 - \hat{y})}{N} = \frac{99.777}{78} = 1.279$$

Multiple correlation coefficients:

$$R = \sqrt{\frac{\hat{S}_i^2}{s_i^2}} = \sqrt{\frac{1.279}{1.2792}} = 0.999$$

Since the value of R is more than 0.6 viz. 0.999, then the regression equation is sufficiently dependable.

The result is shown in table 4 – 2. Three (3) regression equations are formulated for each of the three (3) types of property. The first one is concerned with the habitual flood year, the second one with the potential flood year and the third one with medium flood year. Correlation coefficients are generally low because of the size of the sample. However, T – values show that all the regression equations are sufficiently dependable.

Average flood damage ratios for habitual flood year range from 0.03 % to 0.15 % depending on type of property. Likewise, average flood damage ratios for the potential flood range from 1.89 % to 4.13 %.

Regarding a given type of property, say a house, average flood damage ratio is multiplied by the average property value a house to get average flood damages per house in table 4 – 3 (1) and table 4 – 3 (2) shows average property value and flood damage per unit in the year 1988 and in the year 2010 respectively.

Damageable items for a house consist of the building and household possessions including furniture, household appliances/ equipment, clothes, kitchen utensils/ware and vehicles. Damageable items for a shop are made up of the building (s), equipment/machines including display equipment, light and heat equipment and vehicles, and inventory, i.e. commodities on display and in stock. Likewise, damageable items for a factory comprise building(s), equipment/machines including manufacturing tools, equipment and machinery, light and heat equipment and vehicles, and inventory such as product, semi – product, materials and spare parts.

Average flood damages per property for the habitual flood year range from Rp. 14,000,- to Rp.53,000,- depending on the types of property. Likewise, average flood damages per property for the potential flood year range from Rp. 296,000,- to Rp. 2,959,000,-.

The average flood damages per unit for houses in 1988 habitual flood year is estimated by the following manner:

$Y = 0.015709 + 0.006304\,X1 - 0.000011X2$

Average inundation depth X1 = 21 cm

Average inundation duration X2 = 20 hours

Average property value of house per unit p = Rp. 13,010,745,-

$y = 0.015709 + 0.006304 \times 21 - 0.000011 \times 20$

$= 0.14787$

Average flood damages per unit house:

$Z = (p \times y) / 100$

$= (13{,}010{,}745 \times 0.14787) / 100 =$ Rp. 19,239,-.

The three (3) regression equations for a given type of property are given table 4 – 2. These are used for computing damages in habitual flood and potential flood. The equations in table 4 – 2 are incorporated into a single equation as shown in table 4 – 4. Newly formulated three (3) equations in table 4 – 4 express the ultimate quantitative relationships between inundation depths/durations and flood damage ratios for houses, shops, factories. These are used for computing average annual flood damages.

4.3. ESTIMATION OF DIRECT DAMAGE DUE TO HABITUAL FLOOD

Inundation depths/durations by inundation for the habitual flood year (Table 4 - 5), equations defining the relationships between inundation depths/durations and flood damage ratios for the houses, shops and factories (table 4 – 2), average property value per house, shop and factory (Table 4 – 3) and the number of respective three (3) types of property by inundation area in 1988 and 2010 (Table 4 – 6 (2) and 4 – 7 (2)) were combined together to arrive at direct flood damages to houses, shops and factories for 1988 and 2010. Direct flood damages to other types of property were also incorporated according to the method summarized in Table 4 – 8 (1)

The procedures are as follows:

For example, habitual flood damage for 1988 habitual flood year:

No. of houses : 343,080

No. of shops : 7,438

No. of factory : 2,603

So, the habitual flood damage is:

= 343,080 x Rp. 19,432 + 7,438 x Rp. 14,457 + 2,603 x Rp. 53,304

= Rp. 6,913,012,038,-.

The habitual flood occurs twice on year, thus flood damage is:

=Rp. 6,913,012,038 x 2 = Rp. 13,826,024,070, -

With 51.85 % addition for other specified property, the habitual flood damages become:

= Rp. 13,826,024,070, - x 1.5185

= Rp. 20,994,817,560, -

4.4. ESTIMATION OF DIRECT DAMAGE DUE TO POTENTIAL FLOOD

Potential flood damages is estimated essentially in the same manner as the habitual flood damage is carried out in the above section. Therefore, explanation is simplified to avoid redundancy.

In arriving at direct flood damages to houses, shops, and factories for 1988 and 2010, inundation depths/durations by inundation area for the potential flood year (Table 4 – 9) is employed instead of the corresponding data for the habitual flood year. Otherwise, exactly the same equations and data area used. Regarding direct flood damages to other types of property in Table 4 – 8 (2), the same method as in the preceding section is employed.

4.5. AVERAGE ANNUAL DIRECT DAMAGE

4.5.1. Direct Flood Damages to Property

Relationships between return period and inundation depths/durations were established on the assumption that there exists a convex curve relation between them as shown in table 4 – 10. This assumption is based on such a relationship existing between return period and basin average rainfall.

Average relationships between inundation depths/durations and flood damages ratios for houses, shops and factories have already been analyzed (Table 4 – 4).

These two (2) sets of relationships are combined together. Furthermore, average depths/durations by inundation area for both the habitual year (Table 4 – 5) and for potential year (Table 4 – 9), unit value of house, shop and factory for 1988 and 2010 (Table 4 - 3) and the number of the three (3) types of property by inundation area for 1988 and 2010 (table 4 - 6 and 4 - 7) are brought in and combined together.

The resultant equations expressing the relationships between return period and direct damages to house, shops, and factories are converted into probability density functions. They are finally integrated by return period for the span of ½ to 43 years (table 4 - 11).

The procedures is illustrated as follows:

For inundation area no.1, taking return period = 22 years.

DEP (i , x) = 0.8444 * DEP (i , ½) + 0.1556 * DEP (i , 43) +
0.2245 * (DEP (i , 43) - DEP (i, ½)) * LOG (x)

DUR (i , x) = 0.8444 * DUR (i , ½) + 0.1556 * DEP (i , 43) +
0.2245 * (DUR (i, 43) - DUR (i, ½)) * LOG (x)

Where:

DEP (i , x) = average inundation depth (cm) in inundation area no.i for the X year return period = DEP (1,22)

DEP (i , ½) = average inundation depth (cm) in inundation area for the habitual flood year for ½ year return period

= DEP (1, ½) = 10 cm

DEP (i, 43) = average inundation depth (cm) in inundation area for the potential flood year for 43 year return period

= DEP (1, 43) = 54 cm

X = return period = 22 year

DUR (i, x) = average inundation duration (hr) in inundation area no.i for the x year return period = DUR (1, 22)

DUR (i, ½) = average inundation duration (hr) in inundation area no.i for the habitual flood year

= DUR (1, ½) = 18 hours.

DUR (i, 43) = average inundation duration (hr) in inundation area no.i for the potential flood year

= DUR (1, 43) = 33 hours.

So,

DEP (1, 22) = 0.8444 x 10 + 0.1556 x 54 + 0.2245 x (54 –10) LOG (22)

= 30.11 cm

DUR (1,22) = 0.8444 x 18 + 1.556 x 33 + 0.2245 x (33 – 18) LOG (22)

= 24.86 hours

Flood damage ratio per property:

frd (house) = -0.617707 + 0.02902333 x 30.11 + 0.0787833 x 24.87

= 0.452041

frd (shop) = -0.628531 + 0.02109201 x 30.11 + 0.01097092 x 24.86

= 0.279307

frd (factory) = - 1.345342 + 0.03343442 x 30.11 + 0.03588397 x 24.86

= 0.553444

Value of property:

VL (house) = nos. of house x unit value of property per house

= 29,223 x Rp. 13,010,745,-

= Rp. $3.802130011 \times 10^{11}$

VL (shop) = 1,251 x Rp. 42,743,254,-

= Rp. $5.347181075 \times 10^{10}$

VL (factory) = 19 x Rp. 71,583,109,-
= Rp. 1,360,079,071,-.

Flood damages per property :

FD (house) = $0.452041 \times 3.802130011 \times 10^{11} / 100$ = Rp. 1,718,718,652,-

FD (shop) = $0.279288 \times 5.347181075 \times 10^{10} / 100$ = Rp. 149,350,510,-

FD (factory) = 0.553444 x Rp. 1,360,079,071 / 100 = Rp. 7,527,276,-.

Total flood damages to properties:

TFD = . FD (property) = Rp. 1,875,596,438,-

Average annual flood damages to property:

$$AFD = \int_{1/2}^{43} TFD\,(x, y) / x^2\, dx = \left[\frac{TFD}{X} \right]_{1/2}^{43} = Rp.\ 3,623,311,300,-$$

Going through these procedures, average annual average direct damages to the three (3) types of property for 1988 and 2010 can be obtained as shown in table 4 - 12 and 4 – 13).

Taking into account the damages to other property, annual average direct flood damages to property add up to Rp. 142,674.0 million for 1988 and Rp. 275,935.5 million for 2010.(Table 5 – 17 chapter V)

Table 4 - 1 : Number of Samples by Area Number

Flood Area No.	No.of Samples by Area Number			Flood Area No.	No. of Samples by Area Number		
	House	Shop	Factory		House	Shop	Factory
1	31.0	3.0	-	47	15.0	9.0	-
2	7.0	1.0	-	48	10.0	3.0	-
3	6.0	1.0	-	49	19.0	17.0	-
4	6.0	1.0	-	50	13.0	5.0	-
5	5.0	-	-	51	26.0	9.0	-
6	5.0	-	-	52	8.0	3.0	-
7	5.0	-	-	53	8.0	-	-
8	18.0	11.0	24.0	54	5.0	1.0	-
9	9.0	1.0	-	55	25.0	10.0	-
10	4.0	3.0	-	56	24.0	2.0	-
11	10.0	-	-	57	15.0	2.0	10.0
12	5.0	-	10.0	58	10.0	-	-
13	26.0	12.0	-	59	5.0	-	-
14	15.0	-	-	60	7.0	-	10.0
15	10.0	-	-	61	6.0	-	-
16	6.0	8.0	-	62	7.0	-	-
17	24.0	-	-	63	10.0	8.0	-
18	4.0	-	-	64	5.0	-	-
19	10.0	-	-	65	5.0	-	-
20	14.0	-	-	66	5.0	1.0	-
21	9.0	-	-	67	15.0	-	-
22	6.0	-	-	68	10.0	1.0	-
23	6.0	-	-	69	20.0	1.0	-
24	4.0	-	-	70	4.0	2.0	-
25	17.0	-	36.0	71	5.0	1.0	-
26	20.0	9.0	-	72	10.0	3.0	-
27	15.0	13.0	-	73	6.0	5.0	-
28	17.0	3.0	11.0	74	4.0	-	-
29	14.0	4.0	-	75	6.0	4.0	-
30	9.0	2.0	-	76	15.0	-	-
31	41.0	1.0	-	77	5.0	1.0	-
32	33.0	1.0	-	78	13.0	-	-
33	10.0	1.0	-	79	4.0	1.0	-
34	5.0	1.0	-	80	6.0	-	-
35	5.0	1.0	-	81	20.0	-	-
36	5.0	1.0	-	82	9.0	4.0	-
37	5.0	1.0	-	83	21.0	1.0	-
38	5.0	1.0	-	84	11.0	-	10.0
39	11.0	2.0	-	85	5.0	-	-
40	14.0	3.0	-	86	4.0	-	-
41	10.0	-	-	87	5.0	-	-
42	13.0	2.0	-	88	5.0	-	-
43	10.0	4.0	-	89	6.0	-	-
44	20.0	5.0	-	90	8.0	-	-
45	13.0	1.0	-	91	10.0	1.0	-
46	5.0	-	-	92	3.0	-	9.0
Sub Total	542.0	97.0	81.0	Sub Total	458.0	95.0	39.0
				Total	**1,000.0**	**192.0**	**120.0**

Source : JICA (1990)

Table 4 - 2 : Regression Analysis of Relationship between Inundation Depths / Durations and Flood Damage Ratio

Definition :

Y_i : Flood Damage Ratio to Property Value (%) X_{i1} : Inundation Depth (cm) X_{i2} : Inundation Duration (hr)

i - 1 : in the Habitual Flood Year. i - 2 : in the Potential Flood Year i - 3 : in the Medium Flood Year (Theoritical)

$\bar{Y}_i$: Average Flood Damage Ratio to Property Value (%)

$\bar{X}_{i1}$: Average Inundation Depth (cm) ; $\bar{X}_{11} = 21$, $\bar{X}_{21} = 78$, $\bar{X}_{31} = 53$

$\bar{X}_{i2}$: Average Inundation Duration (hr.) ; $\bar{X}_{12} = 20$, $\bar{X}_{22} = 80$, $\bar{X}_{32} = 54$

P : Average Property Value per Unit (Rp,) $\bar{Z}_i$: Average Flood Damages per Unit (= PYi : 100) (Rp.)

Property	Regression Equation	$\bar{Y}_i$	$\bar{Z}_i$	Correlation Coefficient	T - Value
1. House	Y_1 = 0.01694 + 0.00794 X_{11} + 0.00091 X_{12}	$\bar{Y}_1$ = 0.14935	$\bar{Z}_1$ = 19,432	0.24770	5.75060
	Y_2 = 0.87866 + 0.01474 X_{21} + 0.00310 X_{22}	$\bar{Y}_2$ = 2.27638	$\bar{Z}_2$ = 296,174	0.15720	4.01140
	Y_3 = 0.10504 + 0.01944 X_{31} + 0.00390 X_{32}	$\bar{Y}_3$ = 1.34596	$\bar{Z}_3$ = 175,119	0.24860	8.67640
	P = 13,010,745.0				
2. Shop	Y_1 = -0.05324 + 0.00040 X_{11} + 0.00261 X_{12}	$\bar{Y}_1$ = 0.03382	$\bar{Z}_1$ = 14,457	0.22630	1.88720
	Y_2 = 0.13332 + 0.01590 X_{21} + 0.00651 X_{22}	$\bar{Y}_2$ = 1.89432	$\bar{Z}_2$ = 809,694	0.21000	2.22140
	Y_3 = -0.39743 + 0.01983 X_{31} + 0.00793 X_{32}	$\bar{Y}_3$ = 1.08178	$\bar{Z}_3$ = 462,388	0.33800	4.75170
	P = 42,743,254.0				
3. Factory	Y_1 = -0.02344 + 0.00350 X_{11} + 0.00122 X_{12}	$\bar{Y}_1$ = 0.074460	$\bar{Z}_1$ = 53,304	0.47220	1.94360
	Y_2 = 1.62334 + 0.01424 X_{21} + 0.01749 X_{22}	$\bar{Y}_2$ = 4.13326	$\bar{Z}_2$ = 2,958,716	0.55640	2.89660
	Y_3 = 0.51254 + 0.01598 X_{31} + 0.01861 X_{32}	$\bar{Y}_3$ = 2.36442	$\bar{Z}_3$ = 1,692,525	0.66340	4.61160
	P = 71,583,109.0				

Source : JICA (1990)

Table 4 - 3 (1) : Average Property Value and Flood Damage per Unit in 1988

1. **Average Property Value per Unit**

(Unit : Rp.)

	Item	House	Shop	Factory
1	Building	9,859,421	27,969,634	26,594,580
2	Household Possession	3,151,324		
3	Equipment & Machine		10,017,852	42,270,467
4	Inventory		4,755,768	2,718,062
-	**Total**	**13,010,745**	**42,743,254**	**71,583,109**

Note : Average number of household member per house worked out at 5.6 , average number of workers per shop at 2.8 , and average number of workers per factory at 8.5 .

2. **Average Flood Damages per Unit**

(Unit : Rp.)

	Property	Habitual	Potential	Medium (Theoretical)
1)	House			
	Building	14,550	198,514	118,043
	Household Possession	4,882	97,660	57,076
	Total	**19,432**	**296,174**	**175,119**
2)	Shop			
	Building	7,560	421,177	240,535
	Equipment & Machine	2,069	74,409	42,752
	Inventory	4,828	314,108	179,101
	Total	**14,457**	**809,694**	**462,388**
3)	Factory			
	Building	49,107	847,156	494,468
	Equipment & Machine	893	790,688	448,423
	Inventory	3,304	1,320,872	749,634
	Total	**53,304**	**2,958,716**	**1,692,525**

Source : JICA (1990)

Table 4 - 3 (2) : Average Property Value and Flood Damage per Unit in 2010

1. Average Property Value per Unit

(Unit : Rp.)

Item		House	Shop	Factory
1	Building	15,263,705	43,300,741	41,171,974
2	Household Possession	4,878,672		
3	Equipment & Machine		15,508,977	65,440,347
4	Inventory		7,362,566	4,207,924
	Total	**20,142,377**	**66,172,284**	**110,820,245**

Source : J I C A (1990)

Note : The a bove figure were calculated by multiplying the corresponding figure for 1988 by 1.548134 , which is the estimated growth rate of per capita GDP 1988 to 2010 . Refer to Table 5 - 10 in Chapter V

Table 4 - 4 : Relationship between Inundation Depths / Durations and Flood Damage Ratios

Definition :

Y : Flood Damage Ratio (%)

X_1 : Inundation Depth (cm)

X_2 : Inundation Duration (hr.)

Property	Equation			
1 House	$Y =$	$-0.617707 +$	$0.02902333 X_1$	$+ 0.00787833 X_2$
2 Shop	$Y =$	$-0.628531 +$	$0.02109201 X_1$	$+ 0.01097092 X_2$
3 Factory	$Y =$	$-1.345342 +$	$0.03343442 X_1$	$+ 0.03588397 X_2$

Source : JICA (1990)

Table 4 - 5: Survey Result for Habitual Flood Area

Flood Area No.	Flood Area (ha)	Depth of Inundation max. (m)	Depth of Inundation mean. (m)	Duration of Inundation max. (hour)	Duration of Inundation mean. (hour)
			X_1		X_2
1	30.6	0.25	0.10	77.0	18.0
2	49.0	0.30	0.13	70.0	18.0
3	27.0	0.25	0.10	68.0	16.0
4	24.5	0.20	0.10	65.0	15.0
5	52.7	0.30	0.14	75.0	19.0
6	40.4	0.20	0.17	48.0	18.0
7	18.4	0.50	0.41	96.0	35.0
8	24.5	0.50	0.21	24.0	8.0
9	30.6	0.40	0.20	24.0	8.0
10	24.5	0.50	0.22	24.0	8.0
11	36.8	0.25	0.11	72.0	22.0
12	102.9	0.50	0.22	24.0	13.0
13	17.2	0.25	0.14	24.0	7.0
14	16.0	0.25	0.13	24.0	7.0
15	8.6	0.30	0.15	24.0	7.0
16	24.5	0.30	0.14	48.0	17.0
17	41.6	0.50	0.27	144.0	43.0
18	53.9	0.45	0.25	72.0	36.0
19	41.7	0.55	0.29	72.0	36.0
20	44.1	0.40	0.24	96.0	39.0
21	25.7	0.45	0.25	72.0	30.0
22	47.8	0.20	0.15	48.0	20.0
23	30.6	0.25	0.18	24.0	23.0
24	36.8	0.50	0.27	24.0	19.0
25	69.8	0.50	0.16	168.0	17.0
26	56.4	0.45	0.14	48.0	18.0
27	12.3	0.55	0.18	48.0	16.0
28	25.7	0.55	0.17	72.0	19.0
29	211.9	0.50	0.18	168.0	41.0
30	85.8	0.55	0.22	72.0	36.0
31	58.8	0.55	0.25	48.0	24.0
32	36.8	0.45	0.15	36.0	18.0
33	46.6	0.50	0.20	60.0	33.0
34	29.4	0.50	0.29	24.0	18.0
35	24.5	0.45	0.25	24.0	15.0
36	18.4	0.45	0.23	24.0	19.0
37	20.8	0.50	0.31	24.0	16.0
38	41.7	0.30	0.15	168.0	40.0
39	90.7	0.25	0.11	36.0	17.0
40	153.1	0.35	0.17	48.0	18.0
41	215.6	0.25	0.11	72.0	24.0
42	29.4	0.20	0.17	36.0	22.0
43	73.5	0.30	0.18	24.0	16.0
44	61.3	0.20	0.18	2.0	2.0
45	47.8	0.75	0.27	168.0	20.0
46	22.1	0.50	0.17	36.0	13.0
47	18.4	0.50	0.20	36.0	12.0

Flood Area No.	Flood Area (ha)	Depth of Inundation max. (m)	Depth of Inundation mean. (m) X_1	Duration of Inundation max. (hour)	Duration of Inundation mean. (hour) X_2
48	39.2	0.50	0.23	48.0	13.0
49	45.3	0.50	0.22	36.0	15.0
50	45.3	0.40	0.18	24.0	13.0
51	33.1	0.50	0.45	1.0	1.0
52	14.7	0.05	0.05	1.0	1.0
53	28.2	0.20	0.11	1.0	1.0
54	74.7	0.60	0.36	5.0	3.0
55	39.2	0.70	0.41	24.0	7.0
56	20.8	0.30	0.14	5.0	3.0
57	15.9	0.80	0.80	5.0	5.0
58	34.3	0.20	0.13	2.0	2.0
59	49.0	0.35	0.25	3.0	2.0
60	39.2	0.40	0.28	3.0	2.0
61	40.4	0.10	0.10	12.0	12.0
62	56.4	1.00	0.44	72.0	26.0
63	23.3	0.40	0.23	5.0	3.0
64	17.2	0.30	0.18	24.0	13.0
65	23.3	0.30	0.15	24.0	11.0
66	104.1	0.25	0.13	1.0	1.0
67	68.6	0.30	0.23	1.0	1.0
68	22.1	0.60	0.34	48.0	31.0
69	73.5	0.50	0.27	24.0	10.0
70	41.7	0.20	0.11	6.0	2.0
71	23.3	1.50	0.53	48.0	22.0
72	19.6	1.00	0.53	72.0	48.0
73	22.1	0.15	0.10	48.0	14.0
74	89.4	0.30	0.20	24.0	7.0
75	47.8	0.15	0.09	1.0	1.0
76	49.0	1.00	0.48	72.0	45.0
77	53.3	0.20	0.18	19.0	12.0
78	60.0	0.30	0.18	24.0	16.0
Total	3,615.2	32.70	17.09	3,464.0	1,299.0

Source : JICA (1990)

Table 4 - 6 (1) :Number of Property by Type Inundation Area in 1988
(Potential Flood Area)

Inundation Area	NUMBER OF PROPERTY			Inundation Area	NUMBER OF PROPERTY		
	House	Shop	Factory		House	Shop	Factory
1	29,223.0	1,251.0	19.0	48	1,010.0	5.0	6.0
2	6,022.0	35.0	16.0	49	17,647.0	142.0	23.0
3	2,950.0	66.0	2.0	50	7,830.0	81.0	1.0
4	1,107.0	168.0	3.0	51	14,966.0	120.0	92.0
5	867.0	27.0	1.0	52	2,944.0	75.0	5.0
6	1,330.0	65.0	2.0	53	1,364.0	7.0	-
7	108.0	2.0	-	54	2,164.0	3.0	56.0
8	3,619.0	117.0	3.0	55	9,275.0	405.0	3.0
9	5,227.0	154.0	8.0	56	10,366.0	236.0	74.0
10	395.0	77.0	1.0	57	2,019.0	66.0	2.0
11	6,009.0	241.0	9.0	58	3,395.0	58.0	1.0
12	645.0	12.0	1.0	59	491.0	15.0	-
13	11,719.0	93.0	10.0	60	186.0	5.0	-
14	1,949.0	92.0	3.0	61	258.0	6.0	-
15	2,699.0	73.0	2.0	62	2,277.0	29.0	4.0
16	1,986.0	32.0	2.0	63	3,730.0	40.0	1.0
17	10,805.0	103.0	2.0	64	2,860.0	25.0	1.0
18	3,540.0	14.0	-	65	1,617.0	24.0	-
19	1,810.0	37.0	1.0	66	515.0	8.0	-
20	5,727.0	115.0	2.0	67	1,274.0	11.0	1.0
21	855.0	4.0	-	68	4,933.0	-	1,574.0
22	2,050.0	41.0	2.0	69	6,130.0	52.0	65.0
23	1,964.0	72.0	-	70	2,094.0	14.0	3.0
24	398.0	6.0	1.0	71	389.0	3.0	2.0
25	1,783.0	12.0	27.0	72	3,174.0	15.0	1.0
26	3,237.0	110.0	25.0	73	1,383.0	2.0	-
27	3,334.0	51.0	179.0	74	497.0	2.0	-
28	11,893.0	187.0	198.0	75	450.0	1.0	-
29	5,425.0	987.0	6.0	76	1,699.0	94.0	-
30	711.0	22.0	5.0	77	1,145.0	11.0	-
31	19,650.0	550.0	41.0	78	579.0	28.0	-
32	38,896.0	657.0	65.0	79	1,400.0	102.0	-
33	3,823.0	8.0	16.0	80	1,889.0	7.0	-
34	1,698.0	28.0	-	81	2,265.0	19.0	1.0
35	1,423.0	23.0	-	82	4,676.0	46.0	5.0
36	661.0	25.0	-	83	8,460.0	25.0	23.0
37	1,298.0	21.0	-	84	2,984.0	58.0	-
38	316.0	-	-	85	1,040.0	24.0	3.0
39	1,370.0	27.0	1.0	86	1,323.0	23.0	2.0
40	4,251.0	97.0	1.0	87	2,395.0	64.0	1.0
41	3,393.0	-	7.0	88	2,197.0	15.0	1.0
42	10,693.0	105.0	1.0	89	243.0	2.0	1.0
43	2,188.0	26.0	-	90	1,204.0	24.0	-
44	11,749.0	-	14.0	91	1,891.0	6.0	96.0
45	2,243.0	18.0	6.0	92	579.0	5.0	4.0
46	488.0	4.0	4.0	93	2,540.0	14.0	16.0
47	892.0	-	2.0	94	631.0	2.0	3.0
Sub Total	234,419.0	5,855.0	688.0	Sub Total	144,378.0	2,019.0	2,071.0
				Total	**378,797.0**	**7,874.0**	**2,759.0**

Source : JICA (1990)

Table 4 - 6 (2) : Number of Property by Type Inundation Area in 1988
(Habitual Flood Area)

Inundation Area	NUMBER OF PROPERTY			Inundation Area	NUMBER OF PROPERTY		
	House	Shop	Factory		House	Shop	Factory
1	29,223.0	1,251.0	19.0	46	488.0	4.0	4.0
2	6,022.0	35.0	16.0	47	892.0	-	2.0
3	2,950.0	66.0	2.0	48	1,010.0	5.0	6.0
4	1,107.0	168.0	3.0	49	17,647.0	142.0	23.0
5	867.0	27.0	1.0	50	7,830.0	81.0	1.0
6	1,330.0	65.0	2.0	51	14,966.0	120.0	92.0
7	108.0	2.0	-	52	2,944.0	75.0	5.0
8	3,619.0	117.0	3.0	53	1,364.0	7.0	-
9	5,227.0	154.0	8.0	54	2,164.0	3.0	56.0
10	395.0	77.0	1.0	55	9,275.0	405.0	3.0
11	6,009.0	241.0	9.0	56	10,366.0	236.0	74.0
12	645.0	12.0	1.0	57	2,019.0	66.0	2.0
13	11,719.0	93.0	10.0	58	3,395.0	58.0	1.0
14	1,949.0	92.0	3.0	59	491.0	15.0	-
15	2,699.0	73.0	2.0	60	186.0	5.0	-
16	1,986.0	32.0	2.0	61	258.0	6.0	-
17	10,805.0	103.0	2.0	62	2,277.0	29.0	4.0
18	3,540.0	14.0	-	63	3,730.0	40.0	1.0
19	1,810.0	37.0	1.0	64	2,860.0	25.0	1.0
20	5,727.0	115.0	2.0	65	1,617.0	24.0	-
21	855.0	4.0	-	66	515.0	8.0	-
22	2,050.0	41.0	2.0	67	1,274.0	11.0	1.0
23	1,964.0	72.0	-	68	4,933.0	-	1,574.0
24	398.0	6.0	1.0	69	6,130.0	52.0	65.0
25	1,783.0	12.0	27.0	70	2,094.0	14.0	3.0
26	3,237.0	110.0	25.0	71	389.0	3.0	2.0
27	3,334.0	51.0	179.0	72	3,174.0	15.0	1.0
28	11,893.0	187.0	198.0	73	1,383.0	2.0	-
29	5,425.0	987.0	6.0	74	497.0	2.0	-
30	711.0	22.0	5.0	75	450.0	1.0	-
31	19,650.0	550.0	41.0	76	1,699.0	94.0	-
32	38,896.0	657.0	65.0	77	1,145.0	11.0	-
33	3,823.0	8.0	16.0	78	579.0	28.0	-
34	1,698.0	28.0	-				
35	1,423.0	23.0	-				
36	661.0	25.0	-				
37	1,298.0	21.0	-				
38	316.0	-	-				
39	1,370.0	27.0	1.0				
40	4,251.0	97.0	1.0				
41	3,393.0	-	7.0				
42	10,693.0	105.0	1.0				
43	2,188.0	26.0	-				
44	11,749.0	-	14.0				
45	2,243.0	18.0	6.0				
Sub Total	233,039.0	5,851.0	682.0	Sub Total	110,041.0	1,587.0	1,921.0
				Total	**343,080.0**	**7,438.0**	**2,603.0**

Source : JICA (1990)

Table 4 - 7 (1) : Number of Property by Type Inundation Area in 2010
(Potential Flood Area)

Inundation Area	NUMBER OF PROPERTY			Inundation Area	NUMBER OF PROPERTY		
	House	Shop	Factory		House	Shop	Factory
1	31,130.0	1,823.0	30.0	48	1,461.0	7.0	9.0
2	6,362.0	51.0	25.0	49	20,123.0	207.0	36.0
3	3,095.0	97.0	2.0	50	8,426.0	118.0	1.0
4	1,268.0	245.0	5.0	51	18,880.0	175.0	145.0
5	975.0	40.0	2.0	52	3,275.0	109.0	7.0
6	1,555.0	95.0	3.0	53	1,544.0	11.0	-
7	474.0	2.0	-	54	2,415.0	5.0	89.0
8	4,775.0	170.0	4.0	55	9,858.0	590.0	5.0
9	5,535.0	225.0	13.0	56	10,914.0	344.0	118.0
10	489.0	112.0	2.0	57	5,133.0	97.0	3.0
11	6,667.0	351.0	14.0	58	6,475.0	84.0	2.0
12	1,028.0	17.0	1.0	59	1,618.0	22.0	-
13	11,961.0	135.0	16.0	60	609.0	8.0	-
14	2,089.0	134.0	5.0	61	1,086.0	9.0	-
15	2,864.0	107.0	4.0	62	4,235.0	43.0	6.0
16	2,267.0	47.0	3.0	63	4,406.0	58.0	1.0
17	11,733.0	150.0	3.0	64	3,287.0	36.0	1.0
18	3,824.0	20.0	1.0	65	1,994.0	35.0	1.0
19	2,170.0	54.0	1.0	66	680.0	12.0	-
20	6,537.0	167.0	3.0	67	1,809.0	16.0	1.0
21	1,085.0	6.0	-	68	5,777.0	-	2,490.0
22	2,436.0	59.0	3.0	69	7,692.0	76.0	103.0
23	2,382.0	104.0	-	70	2,607.0	20.0	4.0
24	689.0	9.0	2.0	71	554.0	5.0	3.0
25	4,143.0	18.0	43.0	72	3,909.0	21.0	2.0
26	4,666.0	160.0	39.0	73	1,693.0	3.0	-
27	3,895.0	74.0	283.0	74	684.0	3.0	1.0
28	13,442.0	273.0	314.0	75	856.0	2.0	-
29	6,214.0	1,438.0	9.0	76	2,386.0	137.0	-
30	1,063.0	32.0	8.0	77	1,444.0	17.0	-
31	21,486.0	801.0	64.0	78	891.0	41.0	-
32	53,862.0	957.0	104.0	79	2,550.0	149.0	1.0
33	4,837.0	11.0	26.0	80	2,384.0	11.0	-
34	2,147.0	41.0	1.0	81	5,384.0	28.0	1.0
35	1,800.0	34.0	1.0	82	5,470.0	67.0	8.0
36	994.0	36.0	-	83	10,493.0	36.0	36.0
37	1,642.0	31.0	-	84	4,438.0	85.0	-
38	714.0	-	-	85	1,568.0	35.0	5.0
39	2,199.0	39.0	2.0	86	1,788.0	33.0	3.0
40	6,284.0	141.0	2.0	87	2,977.0	94.0	2.0
41	4,548.0	-	11.0	88	2,818.0	22.0	2.0
42	12,672.0	153.0	2.0	89	677.0	2.0	2.0
43	2,752.0	38.0	1.0	90	1,842.0	34.0	1.0
44	23,376.0	-	22.0	91	4,576.0	9.0	153.0
45	4,389.0	26.0	9.0	92	902.0	7.0	6.0
46	742.0	5.0	6.0	93	3,734.0	21.0	25.0
47	1,713.0	-	3.0	94	1,123.0	3.0	4.0
Sub Total	292,970.0	8,528.0	1,092.0	Sub Total	189,445.0	2,947.0	3,277.0
				Total	482,415.0	11,475.0	4,369.0

Source : JICA (1990)

Table 4 - 7 (2): Number of Property by Type Inundation Area in 2010
(Habitual Flood Area)

Inundation Area	NUMBER OF PROPERTY			Inundation Area	NUMBER OF PROPERTY		
	House	Shop	Factory		House	Shop	Factory
1	31,130.0	1,823.0	30.0	46	742.0	5.0	6.0
2	6,362.0	51.0	25.0	47	1,713.0	-	3.0
3	3,095.0	97.0	2.0	48	1,461.0	7.0	9.0
4	1,268.0	245.0	5.0	49	20,123.0	207.0	36.0
5	975.0	40.0	2.0	50	8,426.0	118.0	1.0
6	1,555.0	95.0	3.0	51	18,880.0	175.0	145.0
7	474.0	2.0	-	52	3,275.0	109.0	7.0
8	4,775.0	170.0	4.0	53	1,544.0	11.0	-
9	5,535.0	225.0	13.0	54	2,415.0	5.0	89.0
10	489.0	112.0	2.0	55	9,858.0	590.0	5.0
11	6,667.0	351.0	14.0	56	10,914.0	344.0	118.0
12	1,028.0	17.0	1.0	57	5,133.0	97.0	3.0
13	11,961.0	135.0	16.0	58	6,475.0	84.0	2.0
14	2,089.0	134.0	5.0	59	1,618.0	22.0	-
15	2,864.0	107.0	4.0	60	609.0	8.0	-
16	2,267.0	47.0	3.0	61	1,086.0	9.0	-
17	11,733.0	150.0	3.0	62	4,235.0	43.0	6.0
18	3,824.0	20.0	1.0	63	4,406.0	58.0	1.0
19	2,170.0	54.0	1.0	64	3,287.0	36.0	1.0
20	6,537.0	167.0	3.0	65	1,994.0	35.0	1.0
21	1,085.0	6.0	-	66	680.0	12.0	-
22	2,436.0	59.0	3.0	67	1,809.0	16.0	1.0
23	2,382.0	104.0	-	68	5,777.0	-	2,490.0
24	689.0	9.0	2.0	69	7,692.0	76.0	103.0
25	4,143.0	18.0	43.0	70	2,607.0	20.0	4.0
26	4,666.0	160.0	39.0	71	554.0	5.0	3.0
27	3,895.0	74.0	283.0	72	3,909.0	21.0	2.0
28	13,442.0	273.0	314.0	73	1,693.0	3.0	-
29	6,214.0	1,438.0	9.0	74	684.0	3.0	1.0
30	1,063.0	32.0	8.0	75	856.0	2.0	-
31	21,486.0	801.0	64.0	76	2,386.0	137.0	-
32	53,862.0	957.0	104.0	77	1,444.0	17.0	-
33	4,837.0	11.0	26.0	78	891.0	41.0	-
34	2,147.0	41.0	1.0				
35	1,800.0	34.0	1.0				
36	994.0	36.0	-				
37	1,642.0	31.0	-				
38	714.0	-	-				
39	2,199.0	39.0	2.0				
40	6,284.0	141.0	2.0				
41	4,548.0	-	11.0				
42	12,672.0	153.0	2.0				
43	2,752.0	38.0	1.0				
44	23,376.0	-	22.0				
45	4,389.0	26.0	9.0				
Sub Total	290,515.0	8,523.0	1,083.0	Sub Total	139,176.0	2,316.0	3,037.0
				Total	429,691.0	10,839.0	4,120.0

Source : JICA (1990)

Table 4 - 8 (1) : Estimation of the Number and Ratio of Other Specified Property in the Habitual Inundation Area

I. The Year 1988

1. Total Number of Other Specified Property

Hotel	Restaurant	Hospital	Office	School	Religious Facilities	Total
180.0	1,256.0	1,533.0	5,178.0	5,355.0	8,244.0	21,746.0

2. Estimation of the Number of Other Specified Property in the Inundation Areas
   21,746 x 23.942 (population ratio) = 5,206 ... ...(1)

3. Estimation of the Number of Hostels, Restaurants and Hospitals in the Inundation Areas
   (180 + 1,256 + 1,533) x 23.942 = 711 ... ...(2)

4. Ratios of (1) and (2) to 10,041 (Number of Shops , Factories in the Inundation Areas)

   5,206 : 10.041 = 51,85 % **(for direct damage)**
   711 : 10.041 = 7.08 % **(for indirect damage)**

II. The Year 2010

1. Total Number of Other Specified Property

   21,746 x 1,456861 (estimated growth rate of population 1988 to 2010)
   = 31,681

2. Estimation of the Number of Other Specified Property in the Inundation Areas
   31,681 x 20,89 % (population ratio) = 6,618 ... ...(1)

3. Estimation of the Number of Hostels, Restaurants and Hospitals in the Inundation Areas
   (180 + 1,256 + 1,533) x 1.456861 x 20,89 % = 904 ... ...(2)

4. Ratios of (1) and (2) to 14,959 (Number of Shops , Factories in the Inundation Areas)

   6.618 : 14.959 = 44,24 % **(for direct damage)**
   904 : 14.959 = 6,04 % **(for indirect damage)**

Note : School = Primary , Junior General High & High School
Religious Facilities = Church , Temple and Mosque

Table 4 - 8 (2) : Estimation of the Number and Ratio of Other Specified Property in the Potential Inundation Area

I. The Year 1988

1. Total Number of Other Specified Property

Hotel	Restaurant	Hospital	Office	School	Religious Facilities	Total
180.0	1,256.0	1,533.0	5,178.0	5,355.0	8,244.0	21,746.0

2. Estimation of the Number of Other Specified Property in the Inundation Areas
   21,746 x 23.942 (population ratio) = 5,206 ... ...(1)

3. Estimation of the Number of Hostels, Restaurants and Hospitals in the Inundation Area:
   (180 + 1,256 + 1,533) x 23.942 = 711 ... ...(2)

4. Ratios of (1) and (2) to 10,633 (Number of Shops , Factories in the Inundation Areas)

   5,206 : 10,633 = 48,96 % **(for direct damage)**
   711 : 10,633 = 6,69 % **(for indirect damage)**

II. The Year 2010

1. Total Number of Other Specified Property

   21,746 x 1,456861 (estimated growth rate of population 1988 to 2010)
   = 31,681

2. Estimation of the Number of Other Specified Property in the Inundation Areas
   31,681 x 20,89 % (population ratio) = 6,618 ... ...(1)

3. Estimation of the Number of Hostels, Restaurants and Hospitals in the Inundation Areas
   (180 + 1,256 + 1,533) x 1.456861 x 20,89 % = 904 ... ...(2)

4. Ratios of (1) and (2) to 15,844 (Number of Shops , Factories in the Inundation Areas)

   6.618 : 15,844 = 41,77 % **(for direct damage)**
   904 : 15,844 = 5,71 % **(for indirect damage)**

Note : School = Primary , Junior General High & High School
Religious Facilities = Church , Temple and Mosque

Table 4 - 9 : Survey Result for Potential Flood Area

Survey Result for Potential Flood Area					
Flood Area No.	Flood Area (ha)	Depth of Inundation		Duration of Inundation	
		max. (m)	mean (m) X_1	max. (hour)	mean (hour) X_2
1	307.50	1.00	0.54	120.00	33.00
2	58.80	1.20	0.60	120.00	32.00
3	30.60	0.90	0.52	120.00	35.00
4	25.70	1.10	0.55	96.00	30.00
5	18.40	3.00	1.52	96.00	46.00
6	31.90	0.70	0.51	48.00	31.00
7	27.00	1.50	1.13	96.00	72.00
8	90.70	1.00	0.62	168.00	37.00
9	55.10	0.50	0.35	168.00	62.00
10	15.90	1.00	0.48	72.00	54.00
11	105.40	1.25	0.38	48.00	23.00
12	15.90	0.50	0.34	48.00	25.00
13	109.00	1.50	0.64	96.00	45.00
14	38.00	1.50	0.57	120.00	36.00
15	51.50	2.00	1.45	74.00	56.00
16	29.40	1.50	1.27	168.00	76.00
17	171.50	2.00	0.42	84.00	18.00
18	49.00	1.00	0.65	24.00	24.00
19	62.50	1.00	0.59	96.00	32.00
20	61.30	1.00	0.38	120.00	33.00
21	23.30	1.00	0.80	72.00	49.00
22	30.60	1.20	0.67	168.00	80.00
23	40.40	2.00	0.92	120.00	46.00
24	52.70	0.50	0.33	24.00	19.00
25	303.80	1.50	0.70	168.00	97.00
26	248.70	1.20	0.76	336.00	142.00
27	94.30	1.50	0.81	336.00	170.00
28	270.70	1.00	0.41	360.00	111.00
29	139.70	1.00	0.55	168.00	58.00
30	72.30	1.00	0.73	96.00	56.00
31	368.70	1.60	0.73	168.00	84.00
32	1,379.40	1.00	0.60	176.00	100.00
33	69.80	2.50	0.70	216.00	97.00
34	30.60	3.00	1.25	360.00	175.00
35	25.70	3.00	1.25	360.00	170.00
36	24.50	2.50	1.13	336.00	155.00
37	23.30	2.50	1.10	336.00	163.00
38	47.80	2.00	0.57	360.00	102.00
39	94.30	2.00	0.64	360.00	105.00
40	182.50	2.00	0.51	336.00	97.00
41	79.60	1.50	0.47	168.00	116.00
42	138.40	1.00	0.45	240.00	83.00
43	41.70	1.25	0.55	336.00	216.00
44	1,585.20	1.50	0.49	360.00	107.00
45	281.80	0.70	0.41	120.00	57.00

46	31.90	0.80	0.63	168.00	82.00
47	100.50	1.00	0.62	336.00	50.00
48	62.50	1.50	0.84	216.00	130.00
49	425.10	1.50	0.66	240.00	129.00
50	102.90	2.00	1.17	168.00	67.00
51	360.20	2.00	1.30	168.00	83.00
52	56.40	2.20	1.11	168.00	72.00
53	30.60	1.70	0.96	336.00	171.00
54	42.90	0.60	0.43	168.00	94.00
55	105.40	2.50	0.60	72.00	50.00
56	94.30	1.30	0.49	168.00	57.00
57	122.50	3.00	1.55	360.00	194.00
58	140.90	1.10	0.69	96.00	51.00
59	52.70	0.80	0.47	36.00	30.00
60	18.40	1.20	0.49	49.00	22.00
61	33.10	0.50	0.19	26.00	13.00
62	77.20	1.50	0.82	72.00	28.00
63	50.20	2.00	1.55	168.00	60.00
64	31.90	3.00	2.02	288.00	70.00
65	28.20	2.00	1.20	72.00	40.00
66	12.30	1.50	1.24	168.00	106.00
67	44.10	1.70	0.70	336.00	130.00
68	63.70	0.50	0.38	24.00	8.00
69	164.20	1.50	0.68	168.00	40.00
70	49.00	1.00	0.61	52.00	34.00
71	14.70	0.30	0.24	24.00	12.00
72	57.60	2.00	1.31	168.00	71.00
73	23.30	1.20	0.60	48.00	24.00
74	14.70	0.50	0.34	36.00	27.00
75	30.60	2.00	1.30	168.00	70.00
76	91.90	1.00	0.34	24.00	10.00
77	23.30	1.00	0.67	168.00	48.00
78	23.30	1.40	0.75	72.00	13.00
79	85.80	0.60	0.40	2.00	2.00
80	38.00	1.50	0.23	72.00	52.00
81	123.70	1.60	0.77	120.00	47.00
82	50.20	0.30	0.21	48.00	9.00
83	115.20	1.50	0.62	48.00	20.00
84	77.20	2.50	1.79	336.00	238.00
85	28.20	1.60	0.94	96.00	72.00
86	24.50	2.00	1.25	120.00	79.00
87	30.60	0.70	0.43	168.00	54.00
88	94.30	1.50	0.86	96.00	58.00
89	49.00	0.45	0.23	36.00	19.00
90	34.30	2.00	1.25	168.00	112.00
91	188.70	1.00	0.72	360.00	143.00
92	39.20	1.50	0.84	216.00	130.00
93	160.00	1.20	0.47	300.00	95.00
94	60.00	1.25	0.54	276.00	90.00
Total	10,784.30	134.10	69.54	15,355.00	6,761.00

Source : JICA (1990)

Table 4 - 10 : Relationships between Return Period and Inundation Depths / Durations

DEP (i , x) = 0.8444 * DEP (i , 1/2) + 0.1556 * DEP (i , 43)
+ 0.2245 * (DEP (i , 43) - DEP (i , 1/2)) * LOG (x)

DUR (i , x) = 0.8444 * DUR (i , 1/2) + 0.1556 * DUR (i , 43)
+ 0.2245 * (DUR (i , 43) - DUR (i , 1/2)) * LOG (x)

where

DEP (i , x) : Average Inundation Depth (cm) in Inundation Area No. i for the x Year Return Period

DEP (i , 1/2) : Average Inundation Depth (cm) in Inundation Area No. i for the Habitual Flood Year (= 1/2 Year Return Period)

DEP (i , 43) : Average Inundation Depth (cm) in Inundation Area No. i for the Potential Flood Year (= 43 Year Return Period)

x : x Year Return Period

DUR (i , x) : Average Inundation Duration (hr) in Inundation Area No. i for the x Year Return Period

DUR (i , 1/2) : Average Inundation Duration (hr) in Inundation Area No. i for the Habitual Flood Year (= 1/2 Year Return Perod)

DUR (i , 43) : Average Inundation Duration (hr) in Inundation Area No. i for the Potential Flood Year (= 43 Year Return Perod)

Note : DEP (i , 1/2 , DEP (i , 43) , DUR (i , 1/2) , DUR (i , 43) in the " without " case are calculated based on the questionnaire survey

Table 4 - 11 : **Methodology for Estimation of Average Annual Flood Damages (Direct Damages to Property)**

1. frd (p , i , x)	=	$a_0(p) + b_1(p) * DEP(i, x) + b_2(p) * DUR(i, x)$	**.....Formula 1**
Where			
frd (p , i , x)	=	Flood Damage Ratio for Property Type P (p = House, Shop or Factory) in Inundation Area No. i for x Year Return Period	
$a_0(p), b_1(p), b_2(p)$	:	Constants for Property Type p	
DEP (i , x),DUR (i , x)	:	Refer to table 3 - 20	
2. VL (p , i , y)	:	vl (p , y) * NO (p , i , y)	**..... Formula 2**
Where			
VL (p , i , y)	:	Value of Property Type p in Inundation Area No. i in the year y	
vl (p , y)	:	Unit Value of Property Type p in the Year y	
NO (p , i , y)	:	No. of Property Type p in Inundation Area No. i in the Year y	
3. FD (p , i , x, y)	=	frd (p , i , x) * VL (p, i, y)	**..... Formula 3**
TFD (x , y)	=	$\sum_p \sum_i FD(p, i, x, y) = A(y) + B(y) * LOG(x)$	**..... Formula 4**
Where			
FD (p , i , x, y)	:	Flood Damage to Property Type p in Inundation Area No. i for x Year Return Period in the Year y	
TFD (x , y)	:	Flood Damages to Property for x Year Return Period in the Year y	
A (y) , B (y)	:	Constants for the Year y	

4. AFD (y)

$$= \int_{1/2}^{43} TFD(x, y) / x2 \, dx$$

$$= \int_{1/2}^{43} (A(y) + B(y) * LOG(x)) / x2 \, dx$$

$$= \left[-A(y)/x - B(y) * (LOG(x) + 1)/x \right]_{1/2}^{43} \qquad \textbf{..... Formula 5}$$

Where

AFD (y) : Average Annual Flood Damages to Property in the Year y

Table 4 - 12 : Estimated Average Annual Flood Damages (Direct Damages to property) by Inundation Area in 1988

(Unit : Rp.)

Inundation Area No.	Flood Damages	Inundation Area No.	Flood Damages
1	3,622,109,291.0	48	378,541,793.0
2	896,251,289.0	49	5,220,512,277.0
3	329,882,579.0	50	3,058,427,310.0
4	160,257,267.0	51	8,485,860,003.0
5	439,727,156.0	52	950,494,125.0
6	191,096,386.0	53	504,125,575.0
7	55,032,767.0	54	596,768,468.0
8	685,312,544.0	55	2,654,231,032.0
9	596,358,703.0	56	1,353,338,991.0
10	85,862,609.0	57	1,902,498,246.0
11	382,198,907.0	58	615,433,815.0
12	54,634,704.0	59	67,089,312.0
13	1,938,519,117.0	60	27,420,707.0
14	270,465,536.0	61	(8,093,253.0)
15	1,285,229,831.0	62	819,384,136.0
16	854,896,722.0	63	1,953,791,835.0
17	1,705,755,125.0	64	1,951,979,518.0
18	789,079,825.0	65	588,662,599.0
19	426,960,086.0	66	217,669,273.0
20	833,621,954.0	67	379,973,295.0
21	248,250,288.0	68	2,002,949,028.0
22	482,460,326.0	69	1,499,841,762.0
23	617,229,699.0	70	265,550,850.0
24	41,016,773.0	71	68,501,719.0
25	521,732,556.0	72	1,955,856,683.0
26	1,169,076,551.0	73	167,976,898.0
27	2,066,966,770.0	74	34,599,988.0
28	2,602,272,877.0	75	171,071,211.0
29	1,599,982,831.0	76	393,444,311.0
30	215,454,807.0	77	228,975,021.0
31	6,215,283,241.0	78	123,580,128.0
32	8,885,370,109.0	79	(47,770,738.0)
33	1,130,312,180.0	80	403,338,610.0
34	984,491,294.0	81	332,364,631.0
35	789,058,471.0	82	(381,097,816.0)
36	346,127,218.0	83	587,326,759.0
37	677,076,667.0	84	2,069,567,355.0
38	72,516,427.0	85	250,101,210.0
39	313,637,160.0	86	464,059,759.0
40	858,879,396.0	87	91,755,089.0
41	615,173,544.0	88	411,401,040.0
42	1,769,446,203.0	89	(16,376,819.0)
43	710,369,147.0	90	459,332,644.0
44	2,125,066,272.0	91	687,570,835.0
45	378,384,686.0	92	155,232,252.0
46	113,229,594.0	93	246,014,419.0
47	171,222,539.0	94	113,009,807.0
Sub Total	51,323,340,024.0	Sub Total	44,456,285,693.0
		Total	**95,779,625,717.0**

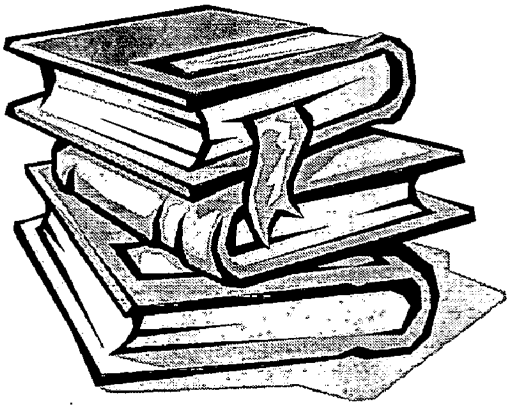
Note : **Property = Houses, Shops and Factories**

Table 4 - 13 : Estimated Average Annual Flood Damages (Direct Damages to property) by Inundation Area in 2010

(Unit : Rp.)

Inundation Area No.	Flood Damages	Inundation Area No.	Flood Damages
1	6,159,983,994.0	48	849,250,766.0
2	1,484,259,899.0	49	9,325,075,190.0
3	544,849,887.0	50	5,139,009,223.0
4	302,919,798.0	51	16,795,990,243.0
5	786,487,101.0	52	1,670,276,421.0
6	354,526,791.0	53	888,503,498.0
7	360,931,408.0	54	1,121,296,314.0
8	1,408,762,630.0	55	4,517,483,480.0
9	1,008,136,154.0	56	2,299,326,235.0
10	174,534,480.0	57	7,210,395,600.0
11	670,323,365.0	58	1,801,894,505.0
12	134,087,082.0	59	332,685,098.0
13	3,093,811,543.0	60	135,925,050.0
14	463,867,324.0	61	(48,704,652.0)
15	2,167,878,102.0	62	2,340,727,836.0
16	1,531,057,305.0	63	3,591,843,456.0
17	2,890,238,183.0	64	3,490,136,359.0
18	1,326,027,038.0	65	1,133,967,297.0
19	799,878,127.0	66	447,247,414.0
20	1,493,328,924.0	67	833,674,493.0
21	488,718,140.0	68	4,445,156,323.0
22	899,077,251.0	69	2,969,293,335.0
23	1,176,662,191.0	70	512,920,967.0
24	109,750,473.0	71	151,603,173.0
25	1,784,660,147.0	72	3,741,300,621.0
26	2,628,313,121.0	73	318,530,262.0
27	4,287,319,256.0	74	74,002,302.0
28	4,946,899,704.0	75	503,922,291.0
29	3,097,023,312.0	76	859,017,618.0
30	499,759,593.0	77	449,193,413.0
31	10,842,201,672.0	78	293,182,014.0
32	19,147,533,610.0	79	(125,251,103.0)
33	2,243,682,172.0	80	789,591,237.0
34	1,949,918,345.0	81	1,213,657,944.0
35	1,565,292,630.0	82	(700,634,627.0)
36	802,513,111.0	83	1,127,083,088.0
37	1,335,636,760.0	84	4,761,457,809.0
38	253,662,390.0	85	584,095,074.0
39	776,843,850.0	86	974,499,356.0
40	1,965,449,436.0	87	177,933,566.0
41	1,283,288,931.0	88	820,075,361.0
42	3,268,813,190.0	89	(68,064,035.0)
43	1,399,805,836.0	90	1,089,112,761.0
44	6,526,515,813.0	91	2,213,842,491.0
45	1,134,151,282.0	92	372,519,238.0
46	265,351,047.0	93	563,005,943.0
47	507,218,000.0	94	307,420,867.0
Sub Total	102,341,950,398.0	Sub Total	92,294,471,115.0
		Total	194,636,421,513.0

Note : Property = Houses, Shops and Factories



CHAPTER V

INDIRECT AND TOTAL FLOOD DAMAGE IN THE STUDY AREA

INDIRECT AND TOTAL FLOOD DAMAGE IN THE STUDY AREA

5.1. GENERAL

Indirect flood damages are due to closure of shops, factories and due to disruption of traffic. In conventional procedure of benefit cost analysis of flood control projects in India such type of damages are usually not considered and these form part of EIA of river valley projects. This is mainly because of paucity of data on indirect damages.

In this chapter an attempt has been made to illustrate procedure for monetary evaluation of indirect damages using available data and information for the city of Djakarta. Total (direct and indirect) damages for habitual flood and potential flood and average annual damages are also estimated in this chapter.

5.2. RELATION BETWEEN INUNDATION AND INCOME LOSSES DUE TO CLOSURE OF SHOPS AND FACTORIES

When an area is inundated, it sometimes happens that people cannot commute and shops / factories are forced to stop their operations. On the assumption that the number of non – working (non – operating) days due to floods is the function of inundation depths / durations, multiple regression analysis was performed.

The results are shown in table 5 - 1. Three (3) regression equations are formulated for each items, the house (household), shop and factory. The first one is concerned with the habitual flood year, the second one with the potential flood year, and the third one with the medium flood year. Correlation coefficients are generally low because of the size of the samples.

The average number of non-working days for the habitual flood year ranges from 0.21 to 1.05. Likewise, the average number of non – working days for the potential flood year range from 2.5 to 4.5.

Regarding a given type of establishment, say a shop average non – working days are multiplied by the average daily gross profit of a shop to get income loss per shop (Table 5 – 2). Average income losses for the habitual flood year are Rp. 12,000,- for shop and Rp. 114,000,- for a factory. Likewise, average income losses for the potential flood year are Rp. 92,000,- for a shop and Rp. 490,000,- for a factory.

The average income losses are possessed by the following manner:

Say for a shop, the regression equation for 1988 habitual flood year is :

Y = 0.00864 + 0.003703 X1 + 0.01630 X2 (table 5 – 1)

Average inundation depth X1 = 21 cm

Average inundation duration X2 = 20 hours

Y = 0.00864 + 0.003703 x 21 + 0.01630 x 20 = 0.4124

Average income per day per unit p p = Rp. 27,976,- (table 5 – 2)

Average income loss per unit (shop) :

Z = 27,976 x 0.4124 = **Rp.11,537,-**

The same procedure for computing income losses for a factory, the regression equation for 1988 habitual flood year is :

Y = -0.04070 + 0.050050 X1 + 0.002160 X2 (table 5 – 1)

Average inundation depth X1 = 21 cm

Average inundation duration X2 = 20 hours

Y = -0.04070 + 0.050050 x 21 + 0.002160 x 20 = 1.0536

Average income per day per unit p p = Rp. 108,489,- (table 5 – 2)

Average income loss per unit (factory) :

Z = 108,489 x 1.0536 = **Rp.114,304,-**

The three (3) regression equations for a given type of property are given in table 5 – 1. These are used for computing indirect damages in habitual flood and potential flood condition. The equations in table 5 – 1 are incorporated into a single equation as shown in table 5 – 3. Newly formulated three (3) equations in table 5 – 3 express the ultimate quantitative relationships between inundation depths / durations and non – working days due to flooding of houses, households, shops and factories. These are used for computing average annual indirect flood damages.

5.3. RELATION BETWEEN INUNDATION AND TRAFFIC DAMAGES

Once inundation hits the study area, vehicular traffic will be affected in various ways. Especially the driver may sometimes be forced to slow down vehicle operating speed and also it may be take longer hours for him to reach destination due to slower vehicle operating speed and / a roundabout route.

As a general rule, vehicle-operating cost (VOC) per km will rise as vehicle-operating speed is slowed down. That is to say, incremental VOC may rise during inundation due to higher VOC per km. At the same time, time cost will be incurred because additional hours required can be expressed in monetary terms.

Mathematically speaking, time cost per vehicle is the function of additional hours necessitated per vehicle per day, the number of inundated days in which traffic impediment is prevalent, the average number of passengers per vehicle and economic value per hour. Also, incremental VOC per vehicle is expressed as the function of additional VOC necessitated per vehicle per day and the number of inundated days in which traffic impediment is prevalent (Table 5 - 4).

A sampling questionnaire survey was carried out to obtain actual figures to use in the formulae in table 5 - 4. The number of samples was 100 each for households and companies. Those households and companies, which own and utilize vehicles, were selected. Vehicles were classified into four types: passenger car, bus, truck, and motorcycle.

Basic figures for estimation of traffic damages were worked out as a result of the questionnaire survey (table 5 - 5).

Mathematical formulae in the table 5 - 4 and the figures in table 5 – 5 were combined to arrive at traffic damages per vehicle as presented in table 5 – 6.

Estimation of Time Cost

TC (i, v) : (KM f (v) / SP f (v) - KMn (v) / SPn (v))
* TI * NP (v) * LP * HW * NV (i, v)

where

TC (i, v)	: Time cost by inundation area by vehicle
KMf (v)	: Operating kilo – meters per day during inundation by vehicle
SPf (v)	: Operating speed per hour during inundation by vehicle
KMn (v)	: Operating kilo – meters per day in normal time vehicle
SPn (v)	: Operating speed per hour in normal time by vehicle
TI	: No. of inundated days in flood season in which traffic impediment is prevalent
NP (v)	: Average No. of passengers by vehicle
LP	: Labor participation rate

HW : Hourly wages / salaries

NV (i, v) : No. of vehicles on road by inundation area by vehicle

Estimation of Incremental Vehicle Operating Cost

IVOC (i, v) = (KM f (v) * VOCf (v) - KMn (v) * VOCn (v))

Where

IVOC (i, v) : Incremental vehicle operating cost by inundation area by vehicle

VOCf (v) : Vehicle operating cost per km during inundation by vehicle

VOCn (v) : Vehicle operating cost per km in normal time by vehicle

The procedures are as follow (for example, for passenger car):

Time cost TC (i , v) = (KMf (v) / SPf (v) – KMn (v) / SPn (v))
* TI * NP (v) * LP * HW * NV (i , v)

where :

KMf (v) = Operating kilometers per day during inundation
= 69 km

SPf (v) = Operating speed per hour during inundation
= 21 km/hr

Kmn (v) = Operating kilometers per day in normal time
= 77 km

SPn (v) = Operating speed per hour in normal time
= 51 km/hr

TI = No. of inundated days in flood season in which traffic impediment is prevalent = 1 day

NP (v) = Average nos. of passengers = 3 persons

LP = Labour participation rate = 0.4117

HW = Hourly wages / salaries = Rp. 471,-

NV (i , v) = Nos. of vehicles on read by inundation area = 2,328,-

TC = (69/21 – 77/51) x 1 x 3 x 0.4117 x 471 x 1
= Rp. 1,033,-

Incremental vehicle operating cost :

IVOC (i, v) = (KMf (v) x VOC f (v) – KMn (v))

Where :

VOC f (o) = Vehicle operating cost per km during inundation

= Rp. 118,-

VOCn (v) = Vehicle operating cost per km in normal time

= Rp.91,-

IVOC = (69 x 118) – (77 x 91) = Rp. 1,135,-

Total flood damage to traffic per passenger cars

= TC + IVOC

= Rp. 1,033 + 1,135 = Rp. 2,168,-

According to the Table (5 - 6), traffic damages per vehicle are Rp. 2,168,- for passenger car, Rp. 8,314,- for the bus, Rp. 7,483,- for the truck and Rp.359,- the motorcycle.

Consider that number of passenger car in 1988 habitual flood year is 70,118 cars. Flood damages to traffic

= 70,118 x Rp.2, 168 = Rp. 152,015,824 ,-

Similarly, flood damages to traffic for:

Bus	= 23,817 x Rp. 8,314	= Rp. 198,014,538 ,-
Truck	= 30,232 x Rp. 7,483	= Rp. 226,226,056 ,-
Motorcycle	= 134,590 x Rp.359	= Rp. 48,317,810 ,-

So, flood damages to traffic is :

= Rp. (152,015,824 + 198,014,538 + 226,226,056 + 48,317,810)

= Rp. 624,574,228 ,-

Assuming that the flood occurs twice on year, thus total flood damages to traffic become:

2 x Rp. 624,574,228 = Rp.1, 249,148,456,-

It was found that traffic damages for the potential flood year are not discernibly different from those the habitual flood year.

5.4. ESTIMATION OF INDIRECT DAMAGE DUE TO HABITUAL FLOOD

Inundation depths/durations by inundation area for the habitual flood year, equations defining the relationships between inundation depths/durations and the number of non – working days due to flooding of shops and factories (Table 5 – 1), the average daily gross profit per shop and factory (Table 5 – 2) and the number of the respective two (2) types of establishments by inundation area in 1988 and 2010 were combined together to arrive at income losses due to shop closure for shops and factories for 1988 and 2010.

The procedures are as follows:

Average income loss per shop in 1988 habitual flood year

= Rp. 11,537 ,-

Average income loss per factory in 1988 habitual flood year

= Rp. 114,304 ,-

So, income losses in 1988 habitual flood year:

= 7,438 x Rp. 11,537 + 2,603 x Rp. 114,304

= Rp. 383,345,518, -

Assuming that the flood occurs twice on year , thus income losses :

= Rp. 383,345,518,- x 2 = Rp. 766,691,036 ,-

With 7.08 % additional for other specified property ((Table 4 – 8 (1)), total income losses become:

= Rp.766,691,036, - x 1.0708

= Rp. 820,972,761, -

Traffic damages per passenger car, bus, truck and motor cycle (Table 5 – 6) and the estimated number of vehicles by inundation area in 1988 and 2010 (Table 5 – 7 and 5 – 8) were combined together to arrive at traffic damages for 1988 and 2010.

The number of vehicles by type for 2010 was estimated on the assumptions that it is a function of per capita GDP in DKI Jakarta (Table 5 – 9 and 5 – 10). The number of vehicles was distributed to each Kelurahan based on the existing road lengths in each Kelurahan.Then the number of vehicles in a Kelurahan was assigned to an inundation area in proportion to the extent the inundation area occupies the Kelurahan.

5.5. TOTAL DAMAGE DUE TO HABITUAL FLOOD

The Study area is divided into six (6) drainage areas (Figure 5 – 1). It is estimated that population will grow more rapidly in drainage zone no.1 in the West Fringe and no. 6 in the East Fringe as development accelerates in the future. In proportion to the rising population density, flood prone areas will newly appear in the two (2) areas. Along with it, new flood damage will emerge and be increasingly felt. These have not been considered in the present analysis.

The three (3) kinds of flood damages described in chapter 4 and this chapter are added together and the result is multiplied by 120 % to reach the final total amount of flood damages. Twenty (20) percent addition is to incorporate all unspecified / unqualified flood damages including damages to roads and bridges.

Total habitual flood damages work out to Rp. 35,631.7 million for 1988 and Rp. 66,705.6 million for 2010 (Table 5 – 11).

5.6. ESTIMATION OF INDIRECT DAMAGE DUE TO POTENTIAL FLOOD

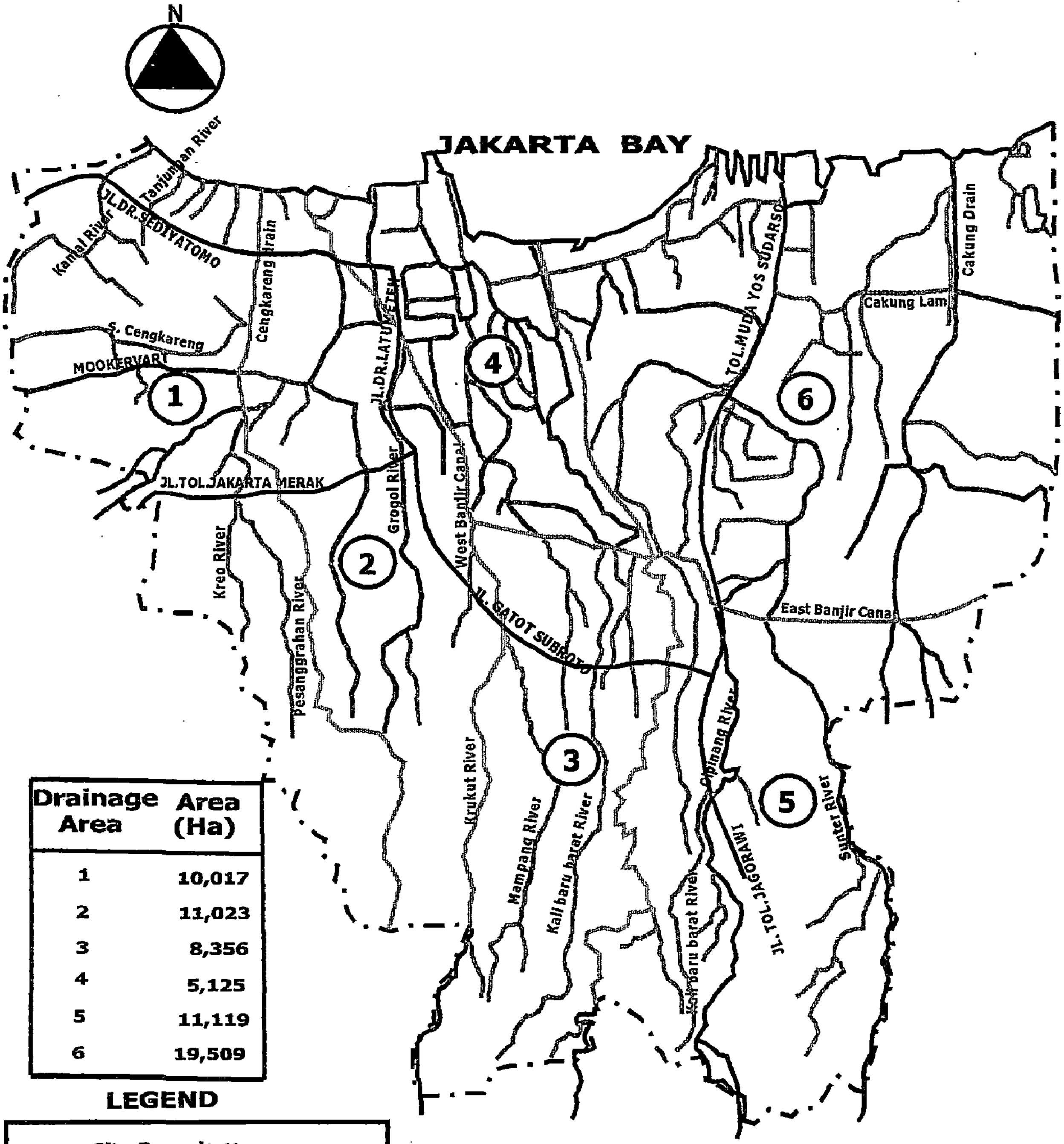
In arriving at income losses due to shop closure for shops and factories for 1988 and 2010. Inundation depths/durations by inundation area for the potential flood year (Table 4 – 9) is employed. Otherwise, exactly the same equations and data as in the preceding section are used. Also, regarding income losses due to shops closure for other types of property table 4 – 8 (2), the same method as in the preceding section is employed.

Potential flood damages to traffic for 1988 and 2010 are assumed to be same as habitual flood damages to traffic for 1988 and 2010.

5.7. TOTAL DAMAGE DUE TO POTENTIAL FLOOD

The three (3) types of flood damages described above are added together, and the result is multiplied by 120 % to arrive at the final amount of flood damage. 20 % addition is to incorporate all unspecified / unquantified flood damages including damages to roads and bridges.

Total potential flood damages work out to Rp. 209,918.2 million for 1988 and Rp. 403,386.6 million for 2010 (Table 5 – 12).



Drainage Area	Area (Ha)
1	10,017
2	11,023
3	8,356
4	5,125
5	11,119
6	19,509

LEGEND

- : City Boundary
- : Flood Control River
- : Group I Urban Drainage
- : Group II Urban Drainage
- : Group III Urban Drainage
- : Boundary of Drainage Zone
- O : Drainage Area No.

FIG.5.1.DIVIDED DRAINAGE ZONE IN THE STUDY AREA

5.8. AVERAGE ANNUAL INDIRECT DAMAGE

5.8.1. Average Annual Income Losses Due to Shop Closure

When inundation hits, shops, factories and others establishments are sometimes forced to stop their operations for hours or days. During that period they cannot engage in economic activities, resulting in income losses.

In arriving at average annual income losses due to shop closure, the same procedures as in the preceding section are followed. Only a few equations and data employed are different, as the dependent variable of inundation depths/durations, the number of non – working days is used instead of flood damage ratio. Also, average daily gross profit per establishment is used in place of unit value of property.

Average annual income losses due to shop closure by inundation area for 1988 and 2010 are shown in table 5 – 13 and 5 – 14. Taking into account the income losses for other establishments, average annual income losses due to shop closure sum up to 1,831.0 million for 1988 and Rp. 2,797.6 million for 2010.

5.8.2. Average Annual Traffic Damage

As mentioned already, it was found out as result of the sampling questionnaire survey that there is no discernible difference in the traffic damages for the habitual flood year and those for the potential flood year. It means that average annual traffic damages are equal to traffic damages for the habitual or the potential flood year.

Table 5 – 15 and 5 – 16 shown average annual traffic damages by inundation area for both the habitual and potential flood years. The damages sum up to Rp. 1,249.1 million for 1988 and Rp. 2,463.8 million for 2010.

Making 20% allowances for the flood damages unaccounted for including damages to roads and bridges, average annual flood damages for the year 1988 and 2010 finally work out at Rp. 174,905.1 million and Rp. 337,436.3 million respectively (Table 5 – 17).

5.9. SUMMARY OF ESTIMATED AVERAGE ANNUAL DAMAGES

Direct damages have been computed in chapter 4. Indirect damages have been computed in this chapter. Combining various table, summary of the average annual damages for various damage categories are shown in table 5 – 17.

Table 5 - 1 : Regression Analysis of Relationship between Inundation Depths / Durations and Non - working (Non - Operation) days

Definition :

Y_i : Non - Working Days due to Floods (days) X_{i1} : Inundation Depth (cm) X_{i2} : Inundation Duration (hr)

i - 1 : in the Habitual Flood Year i - 2 : in the Potential Flood Year i - 3 : in the Medium Flood Year (Theoritical)

$\bar{Y}_i$: Average Non - Working Days due to Floods (days)

$\bar{X}_{i1}$: Average Inundation Depth (cm) ; $\bar{X}_{11} = 21$, $\bar{X}_{21} = 78$, $\bar{X}_{31} = 53$

$\bar{X}_{i2}$: Average Inundafion Duration (hr.) ; $\bar{X}_{12} = 20$, $\bar{X}_{22} = 80$, $\bar{X}_{32} = 54$

P : Average Income per day per unit (Rp,) $\bar{Z}_i$: Average Income Losses per Unit ($= P\bar{Y}i$) (Rp.)

Property	Regression Equation	$\bar{Y}i$	$\bar{Z}i$	Correlation Coefficient	T - Value
1. House	$Y_1 = 0.018300 + 0.003100 X_{11} + 0.006220 X_{12}$	$\bar{Y}_1 =$ 0.20780		0.28060	8.11270
	$Y_2 = 1.176600 + 0.002050 X_{21} + 0.014840 X_{22}$	$\bar{Y}_2 =$ 2.52370		0.48620	17.52620
	$Y_3 = 0.403600 + 0.004910 X_{31} + 0.015780 X_{32}$	$\bar{Y}_3 =$ 1.51600		0.54000	26.94680
2. Shop	$Y_1 = 0.086400 + 0.003703 X_{11} + 0.016300 X_{12}$	$\bar{Y}_1 =$ 0.41240	$\bar{Z}_1 =$ 11,537	0.27920	3.22500
	$Y_2 = -0.210200 + 0.007760 X_{21} + 0.036280 X_{22}$	$\bar{Y}_2 =$ 3.29750	$\bar{Z}_2 =$ 92,251	0.75920	16.45460
	$Y_3 = -0.289500 + 0.007730 X_{31} + 0.035650 X_{32}$ P = 27,976.00	$\bar{Y}_3 =$ 2.04530	$\bar{Z}_3 =$ 57,219	0.75930	20.77380
3. Factory	$Y_1 = -0.040700 + 0.050050 X_{11} + 0.002160 X_{12}$	$\bar{Y}_1 =$ 1.05360	$\bar{Z}_1 =$ 114,304	0.22520	1.95740
	$Y_2 = -0.570900 + 0.038590 X_{21} + 0.026040 X_{22}$	$\bar{Y}_2 =$ 4.52230	$\bar{Z}_2 =$ 490,620	0.66470	9.28790
	$Y_3 = -0.149400 + 0.029130 X_{31} + 0.029920 X_{32}$ P = 108,489.00	$\bar{Y}_3 =$ 3.01020	$\bar{Z}_3 =$ 326,574	0.69970	11.16790

Source : JICA (1990)

Table 5 - 2 : Average Daily Gross Profit per Shop and Factory in 1988

(Unit : Rp.)

	Item	Shop	Factory
1	Average Monthly Sales per Establishment	2,571,306.0	9,765,000.0
2	Average Gross Profit Ratio	32.64%	33.33%
3	Average Monthly Gross Profit per Establishment (No.1 x No. 2)	839,274	3,254,675
4	Average Daily Gross Profit per Establishment (No.3 / 30)	27,976	108,489

Note : Average number of workers per shop and factory are 2.8 and 8.5 respectively
Source : JICA (1990)

Table 5 - 3 : Regression Analysis of Relationship between Inundation Depths / Durations and Non - Working (Non - Operation) days

Definition :

Y : Non - Working Days due to Floods (days)
X_1 : Inundation Depth (cm)
X_2 : Inundation Duration (hr.)

Property		Equation					
1. House	Y	=	-0.591789 +	$0.01381111 X_1$	+	$0.02547778 X_2$
2. Shop	Y	=	-0.562888 +	$0.00679400 X_1$	+	$0.04163070 X_2$
3. Factory	Y	=	-0.162458 +	$0.02991222 X_1$	+	$0.02939506 X_2$

Source : JICA (1990)

Table 5 - 4 : Formula for Estimation of Flood Damages to Traffic

1. Estimation of Time Cost

= (Kmf (v) / SP(v) - KMn (v) / SPn (v))
* TI * NP (v) * LP * HW * NV (i , v)

where

TC (i , v)	:	Time cost by inundation area by vehicle
KMf (f)	:	Operating kilo - meters per day during inundation by vehicles
SPf (v)	:	Operating speed per hour during inundation by vehicle
KMn (v)	:	Operating kilo - meters per day in normal time by vehicle
SPn (v)	:	Operating speed per hour in normal time by vehicle
TI	:	No. of inundated days in flood season in which traffic impedimei is prevalent
NP (v)	:	Average No. of passanger by vehicle
LP	:	Labor participation rate
HW	:	Hourly wages / salaries
NV (i , v)	:	No. of vehicles on road by inundation area by vehicle

2. Estimation of Incremental Vehicle Operating Cost

IVOC (i , v) = (KMf (v) * VOCf (v) - KMn (v) * VOCn (v))

where

IVOC (i , v)	:	Incremental vehicle operating cost by inundation area by vehicle
VOCf (v)	:	Vehicle operating cost per km during inundation by vehicle
VOCn (v)	:	Vehicle operating cost per km in normal time by vehicle

Table 5 - 5 :Basic Figures for Estimation of Flood Damages to Traffic

	Item	Unit	Passenger Car	Bus	Truck	Motor Cycle
1	Operating km per day in normal time	km	77.0	125.0	153.0	46.0
2	Operating speed km per hr in normal time	km/hr	51.0	55.0	57.0	48.0
3	Operating km per day during inundation	km	69.0	113.0	138.0	41.0
4	Operating speed km per hr during inundation	km/hr	21.0	28.0	29.0	24.0
5	No. of inundated days which impediment is prevalent	days	1.0	1.0	1.0	1.0
6	Average No. of passengers	persons	3.0	10.0	2.0	1.0
7	vehicle operating cost km in normal time	Rp.	91.0	223.0	254.0	31.0
8	vehicle operating cost km during inundation	Rp.	118.0	290.0	330.0	40.0

Labor Participation : 0.4117
Average hourly wages / salaries : Rp.113.000/(30 days x 8 hrs) = Rp 471.00

Source : JICA (1990)

Table 5 - 6 : Flood Damage to Traffic per Vehicle

Item		Unit	Passenger Car	Bus	Truck	Motor Cycle
1	Time Cost	Rp	1,033.0	3,419.0	805.0	145.0
2	Incremental Vehicle Operating Cost	Rp	1,135.0	4,895.0	6,678.0	214.0
3	Total	Rp	2,168.0	8,314.0	7,483.0	359.0

Table 5 - 7 :Estimated No. of Vehicles on Read by Inundation Area in 1988

Inundation Area No.	Passanger Car	Bus	Truck	Motor Cycle	Total
1	2,328.0	791.0	1,004.0	4,469.0	8,592.0
2	436.0	148.0	188.0	836.0	1,608.0
3	142.0	48.0	61.0	272.0	523.0
4	127.0	43.0	55.0	245.0	470.0
5	119.0	40.0	51.0	228.0	438.0
6	212.0	72.0	92.0	407.0	783.0
7	115.0	39.0	49.0	220.0	423.0
8	380.0	129.0	164.0	729.0	1,402.0
9	1,941.0	659.0	837.0	3,726.0	7,163.0
10	64.0	22.0	28.0	123.0	237.0
11	417.0	142.0	180.0	801.0	1,540.0
12	62.0	21.0	27.0	118.0	228.0
13	1,777.0	604.0	766.0	3,410.0	6,557.0
14	321.0	109.0	138.0	616.0	1,184.0
15	293.0	100.0	126.0	563.0	1,082.0
16	395.0	134.0	170.0	758.0	1,457.0
17	3,266.0	1,110.0	1,408.0	6,269.0	12,053.0
18	652.0	221.0	281.0	1,251.0	2,405.0
19	1,627.0	553.0	702.0	3,124.0	6,006.0
20	279.0	95.0	120.0	536.0	1,030.0
21	185.0	63.0	80.0	356.0	684.0
22	563.0	191.0	243.0	1,081.0	2,078.0
23	335.0	114.0	145.0	644.0	1,238.0
24	56.0	19.0	24.0	107.0	206.0
25	188.0	64.0	81.0	360.0	693.0
26	212.0	72.0	92.0	408.0	784.0
27	162.0	55.0	70.0	311.0	598.0
28	541.0	184.0	233.0	1,038.0	1,996.0
29	210.0	71.0	91.0	404.0	776.0
30	84.0	28.0	36.0	161.0	309.0
31	3,405.0	1,157.0	1,468.0	6,535.0	12,565.0
32	3,196.0	1,086.0	1,378.0	6,134.0	11,794.0
33	257.0	87.0	111.0	493.0	948.0
34	107.0	36.0	46.0	205.0	394.0
35	90.0	30.0	39.0	172.0	331.0
36	47.0	16.0	20.0	90.0	173.0
37	82.0	28.0	35.0	157.0	302.0
38	106.0	36.0	46.0	204.0	392.0
39	175.0	59.0	75.0	336.0	645.0
40	13,325.0	4,527.0	5,745.0	25,577.0	49,174.0
41	179.0	61.0	77.0	343.0	660.0
42	485.0	165.0	209.0	932.0	1,791.0
43	111.0	38.0	48.0	213.0	410.0
44	1,348.0	458.0	581.0	2,588.0	4,975.0
45	292.0	99.0	126.0	560.0	1,077.0

46	24.0	8.0	10.0	46.0	88.0
47	99.0	34.0	43.0	190.0	366.0
48	95.0	32.0	41.0	183.0	351.0
49	3,333.0	1,132.0	1,437.0	6,397.0	12,299.0
50	1,708.0	580.0	737.0	3,279.0	6,304.0
51	1,658.0	563.0	715.0	3,183.0	6,119.0
52	507.0	172.0	219.0	973.0	1,871.0
53	199.0	68.0	86.0	382.0	735.0
54	62.0	21.0	27.0	118.0	228.0
55	1,235.0	419.0	532.0	2,370.0	4,556.0
56	633.0	215.0	273.0	1,215.0	2,336.0
57	379.0	129.0	163.0	727.0	1,398.0
58	341.0	116.0	147.0	654.0	1,258.0
59	70.0	24.0	30.0	135.0	259.0
60	98.0	33.0	42.0	187.0	360.0
61	199.0	68.0	86.0	382.0	735.0
62	154.0	52.0	66.0	295.0	567.0
63	425.0	144.0	183.0	816.0	1,568.0
64	322.0	109.0	139.0	618.0	1,188.0
65	248.0	84.0	107.0	477.0	916.0
66	76.0	26.0	33.0	146.0	281.0
67	316.0	107.0	136.0	607.0	1,166.0
68	194.0	66.0	84.0	373.0	717.0
69	830.0	282.0	358.0	1,593.0	3,063.0
70	110.0	37.0	47.0	211.0	405.0
71	45.0	15.0	19.0	86.0	165.0
72	210.0	71.0	91.0	403.0	775.0
73	58.0	20.0	25.0	112.0	215.0
74	69.0	23.0	30.0	132.0	254.0
75	183.0	62.0	79.0	352.0	676.0
76	228.0	77.0	98.0	437.0	840.0
77	135.0	46.0	58.0	260.0	499.0
78	342.0	116.0	147.0	656.0	1,261.0
79	245.0	83.0	106.0	471.0	905.0
80	240.0	82.0	104.0	461.0	887.0
81	307.0	104.0	132.0	590.0	1,133.0
82	328.0	112.0	142.0	630.0	1,212.0
83	760.0	258.0	328.0	1,459.0	2,805.0
84	5,778.0	1,963.0	2,491.0	11,090.0	21,322.0
85	1,511.0	513.0	651.0	2,900.0	5,575.0
86	1,657.0	563.0	714.0	3,180.0	6,114.0
87	168.0	57.0	72.0	323.0	620.0
88	336.0	114.0	145.0	644.0	1,239.0
89	63.0	21.0	27.0	121.0	232.0
90	2,576.0	875.0	1,111.0	4,945.0	9,507.0
91	573.0	195.0	247.0	1,100.0	2,115.0
92	37.0	13.0	16.0	71.0	137.0
93	202.0	69.0	87.0	388.0	746.0
94	58.0	20.0	25.0	112.0	215.0
Total	70,118.0	23,817.0	30,232.0	134,590.0	258,757.0

Source : JICA (1990)

Table 5 - 8 :Estimated No. of Vehicles on Read by Inundation Area in 2010

Inundation Area No.	Passanger Car	Bus	Truck	Motor Cycle	Total
1	4,023.0	1,727.0	1,998.0	8,008.0	15,756.0
2	753.0	323.0	374.0	1,498.0	2,948.0
3	245.0	105.0	122.0	488.0	960.0
4	220.0	95.0	109.0	438.0	862.0
5	206.0	88.0	102.0	409.0	805.0
6	367.0	157.0	182.0	730.0	1,436.0
7	198.0		98.0	394.0	690.0
8	656.0	282.0	326.0	1,307.0	2,571.0
9	3,354.0	1,440.0	1,666.0	6,677.0	13,137.0
10	111.0	47.0	55.0	220.0	433.0
11	721.0	310.0	358.0	1,435.0	2,824.0
12	106.0	46.0	53.0	212.0	417.0
13	3,070.0	1,318.0	1,525.0	6,112.0	12,025.0
14	554.0	238.0	275.0	1,103.0	2,170.0
15	507.0	218.0	252.0	1,009.0	1,986.0
16	683.0	293.0	339.0	1,359.0	2,674.0
17	5,644.0	2,423.0	2,803.0	11,235.0	22,105.0
18	1,126.0	483.0	559.0	2,242.0	4,410.0
19	2,812.0	1,207.0	1,396.0	5,598.0	11,013.0
20	482.0	207.0	239.0	960.0	1,888.0
21	321.0	138.0	159.0	638.0	1,256.0
22	973.0	418.0	483.0	1,937.0	3,811.0
23	580.0	249.0	288.0	1,154.0	2,271.0
24	97.0	42.0	48.0	192.0	379.0
25	324.0	139.0	161.0	646.0	1,270.0
26	367.0	158.0	182.0	731.0	1,438.0
27	280.0	120.0	139.0	557.0	1,096.0
28	934.0	401.0	464.0	1,860.0	3,659.0
29	363.0	156.0	180.0	723.0	1,422.0
30	145.0	62.0	72.0	288.0	567.0
31	5,883.0	2,526.0	2,921.0	11,712.0	23,042.0
32	5,522.0	2,371.0	2,742.0	10,993.0	21,628.0
33	444.0	191.0	220.0	883.0	1,738.0
34	185.0	79.0	92.0	368.0	724.0
35	155.0	66.0	77.0	308.0	606.0
36	81.0	35.0	40.0	161.0	317.0
37	141.0	61.0	70.0	281.0	553.0
38	184.0	79.0	91.0	366.0	720.0
39	302.0	130.0	150.0	602.0	1,184.0
40	23,024.0	9,885.0	11,434.0	45,835.0	90,178.0
41	309.0	132.0	153.0	614.0	1,208.0
42	839.0	360.0	416.0	1,669.0	3,284.0
43	192.0	82.0	95.0	382.0	751.0
44	2,330.0	1,000.0	1,157.0	4,638.0	9,125.0
45	504.0	216.0	250.0	1,003.0	1,973.0

46	42.0	18.0	21.0	83.0	164.0
47	171.0	73.0	85.0	340.0	669.0
48	164.0	71.0	82.0	327.0	644.0
49	5,758.0	2,472.0	2,860.0	11,464.0	22,554.0
50	2,952.0	1,267.0	1,466.0	5,876.0	11,561.0
51	2,865.0	1,230.0	1,423.0	5,703.0	11,221.0
52	876.0	376.0	435.0	1,744.0	3,431.0
53	344.0	148.0	171.0	685.0	1,348.0
54	107.0	46.0	53.0	212.0	418.0
55	2,134.0	916.0	1,060.0	4,247.0	8,357.0
56	1,094.0	470.0	543.0	2,178.0	4,285.0
57	654.0	281.0	325.0	1,303.0	2,563.0
58	588.0	253.0	292.0	1,171.0	2,304.0
59	121.0	52.0	60.0	241.0	474.0
60	169.0	72.0	84.0	336.0	661.0
61	344.0	148.0	171.0	684.0	1,347.0
62	266.0	114.0	132.0	529.0	1,041.0
63	735.0	315.0	365.0	1,462.0	2,877.0
64	556.0	239.0	276.0	1,107.0	2,178.0
65	429.0	184.0	213.0	854.0	1,680.0
66	131.0	56.0	65.0	261.0	513.0
67	546.0	234.0	271.0	1,087.0	2,138.0
68	336.0	144.0	167.0	668.0	1,315.0
69	1,434.0	616.0	712.0	2,854.0	5,616.0
70	190.0	81.0	94.0	377.0	742.0
71	77.0	33.0	38.0	154.0	302.0
72	363.0	156.0	180.0	722.0	1,421.0
73	101.0	43.0	50.0	201.0	395.0
74	119.0	51.0	59.0	237.0	466.0
75	317.0	136.0	157.0	631.0	1,241.0
76	393.0	169.0	195.0	783.0	1,540.0
77	234.0	100.0	116.0	465.0	915.0
78	591.0	254.0	293.0	1,176.0	2,314.0
79	424.0	182.0	211.0	844.0	1,661.0
80	415.0	178.0	206.0	827.0	1,626.0
81	531.0	228.0	264.0	1,057.0	2,080.0
82	567.0	244.0	282.0	1,130.0	2,223.0
83	1,313.0	564.0	652.0	2,615.0	5,144.0
84	9,983.0	4,286.0	4,957.0	19,873.0	39,099.0
85	2,610.0	1,121.0	1,296.0	5,197.0	10,224.0
86	2,862.0	1,229.0	1,421.0	5,698.0	11,210.0
87	290.0	125.0	144.0	578.0	1,137.0
88	580.0	249.0	288.0	1,155.0	2,272.0
89	109.0	47.0	54.0	217.0	427.0
90	4,451.0	1,911.0	2,211.0	8,862.0	17,435.0
91	990.0	425.0	492.0	1,971.0	3,878.0
92	64.0	28.0	32.0	128.0	252.0
93	349.0	150.0	173.0	695.0	1,367.0
94	101.0	43.0	50.0	201.0	395.0
Total	121,157.0	51,931.0	60,162.0	241,185.0	474,435.0

Source : JICA (1990)

Table 5 - 9 : Regression Analysis of Relationship between per Capita GDP No. Vehicles in DKI Jakarta

Vehicles	Regression Equation	Correlation Coefficient	T - Value
Passenger Car	y = -153,987 + 0.2774162 x	0.9683	10.9638
Bus	y = - 178,368 + 0.1532583 x	0.9155	6.4366
Truck	y = - 142,216 + 0.1627227 x	0.9843	15.7684
Motor Cycle	y = - 343,573 + 0.5794560 x	0.9825	14.8991
Total	y = - 818,161 + 1.1728532 x	0.9760	12.6725
Where	x : per Capita GDP (Rp. at 1989 prices) y : No. of registered vehicles		

Source : JICA (1990)

Table 5 - 10 : **Registered Vehicles and per Capita GDP in DKI Jakarta**

Item	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	2010
Per Capita GDP (Rp.)	1,175,000.0	1,285,000.0	1,362,000.0	1,545,000.0	1,574,000.0	1,695,000.0	1,756,000.0	1,760,000.0	1,779,000.0	1,829,000.0	1,902,000.0	2,944,000.0
Passenger Car	190,566	202,781	222,345	247,066	275,139	299,164	321,837	340,177	356,188	376,907	397,159	686,226
Bus	17,132	21,655	29,350	38,478	48,603	61,285	81,047	99,078	111,147	123,740	134,928	294,623
Truck	58,449	64,713	77,781	95,858	112,498	128,859	140,562	149,781	154,498	159,344	171,223	340,780
Motor Cycle	369,428	403,668	428,144	495,312	570,972	628,414	669,906	697,572	713,063	720,024	762,324	1,366,117
Total	635,575	692,817	757,620	876,714	1,007,212	1,117,722	1,213,352	1,286,608	1,334,896	1,380,015	1,465,634	2,687,746

Note : Per Capita GDP is at 1989 prices

Table 5 - 11 : Estimated Habitual Flood Damages

(Unit: Rp.)

Damages Item	Amount of Damages	
	1988	2010
1. Direct Damages to Property		
House	17,563,028,010.00	34,574,135,505.00
Shop	40,536,086.00	91,053,263.00
Factory	402,400,639.00	985,842,582.00
Other	9,335,629,162.00	15,772,346,111.00
Total	**27,341,593,897.00**	**51,423,377,461.00**
2. Indirect Damages		
1 Income Losses		
Shop	200,591,737.00	292,209,970.00
Factory	828,890,292.00	1,311,697,216.00
Other	72,897,294.00	96,927,074.00
Sub - Total	**1,102,379,323.00**	**1,700,834,260.00**
2 Traffic Damages		
Time Cost	395,429,054.00	772,800,240.00
Incremental VOC	853,719,402.00	1,691,013,882.00
Sub - Total	**1,249,148,456.00**	**2,463,814,122.00**
Total	**2,351,527,779.00**	**4,164,648,382.00**
3. Damages to Other Unspecified Property Including Infrastructure		
(1 + 2) x 20 %	**5,938,624,335.00**	**11,117,605,169.00**
Grand Total (1 + 2 + 3)	**35,631,746,011.00**	**66,705,631,012.00**

Table 5 - 12 : Estimated Potential Flood Damages

(Unit: Rp.)

Damages Item	Amount of Damages	
	1988	2010
1. Direct Damages to Property		
House	104,053,322,676.00	206,527,742,302.00
Shop	5,272,135,979.00	11,895,166,201.00
Factory	6,279,592,560.00	15,403,102,259.00
Other	56,601,137,649.00	97,668,552,084.00
Total	**172,206,188,864.00**	**331,494,562,846.00**
2. Indirect Damages		
1 Income Losses		
Shop	598,923,376.00	834,065,275.00
Factory	785,060,101.00	1,244,497,055.00
Other	92,543,238.00	118,595,074.00
Sub - Total	**1,476,526,715.00**	**2,197,157,404.00**
2 Traffic Damages		
Time Cost	395,429,054.00	772,800,240.00
Incremental VOC	853,719,402.00	1,691,013,882.00
Sub - Total	**1,249,148,456.00**	**2,463,814,122.00**
Total	**2,725,675,171.00**	**4,660,971,526.00**
3. Damages to Other Unspecified Property Including Infrastructure (1 + 2) x 20 %	**34,986,372,807.00**	**67,231,106,874.00**
Grand Total (1+2+3)	**209,918,236,842.00**	**403,386,641,246.00**

Table 5 - 13 : Estimated Average Annual Flood Damages (Income Losses due to Shop Closure) by Inundation Area in 1988

(Unit: Rp.)

Inundation Area No.	Flood Damages	Inundation Area No.	Flood Damages
1	51,577,470.0	48	4,855,157.0
2	6,617,936.0	49	34,106,559.0
3	2,966,899.0	50	6,877,501.0
4	5,911,887.0	51	77,459,139.0
5	2,488,445.0	52	7,368,638.0
6	2,935,188.0	53	1,154,396.0
7	227,004.0	54	27,488,875.0
8	4,780,128.0	55	20,675,953.0
9	10,840,456.0	56	34,127,449.0
10	4,000,252.0	57	16,819,381.0
11	9,166,025.0	58	2,598,518.0
12	507,202.0	59	236,063.0
13	6,997,860.0	60	42,231.0
14	3,406,435.0	61	16,728.0
15	5,827,957.0	62	3,593,109.0
16	4,259,358.0	63	3,288,275.0
17	6,209,823.0	64	3,219,321.0
18	757,808.0	65	1,134,470.0
19	2,743,588.0	66	825,452.0
20	7,926,354.0	67	1,956,923.0
21	300,075.0	68	498,624,239.0
22	4,712,593.0	69	27,982,903.0
23	4,607,984.0	70	1,113,380.0
24	408,944.0	71	715,200.0
25	16,134,522.0	72	2,888,673.0
26	34,124,925.0	73	46,841.0
27	150,894,212.0	74	31,168.0
28	124,345,428.0	75	66,378.0
29	93,835,006.0	76	4,710,872.0
30	4,571,327.0	77	532,640.0
31	80,029,375.0	78	522,658.0
32	105,081,759.0	79	(2,208,624.0)
33	10,891,614.0	80	274,050.0
34	5,551,036.0	81	904,458.0
35	4,338,897.0	82	(554,389.0)
36	4,392,511.0	83	4,610,651.0
37	3,808,392.0	84	14,170,008.0
38	-	85	2,738,857.0
39	3,542,574.0	86	2,743,737.0
40	10,518,209.0	87	2,309,219.0
41	3,814,289.0	88	1,030,218.0
42	10,197,040.0	89	71,276.0
43	5,824,596.0	90	2,536,902.0
44	6,657,302.0	91	55,952,041.0
45	3,584,054.0	92	2,876,938.0
46	2,249,491.0	93	6,940,600.0
47	785,117.0	94	1,434,067.0
Sub Total	835,349,347.0	Sub Total	880,909,099.0
		Total	**1,716,258,446.0**

Note : Establishments Concerned : Shops and Factories

Table 5 - 14 : Estimated Average Annual Flood Damages (Income Losses due to Shop Closure) by Inundation Area in 2010

(Unit: Rp.)

Inundation Area No.	Flood Damages	Inundation Area No.	Flood Damages
1	75,872,283.0	48	7,213,835.0
2	10,203,606.0	49	51,308,758.0
3	4,077,665.0	50	9,747,507.0
4	8,804,124.0	51	120,854,101.0
5	4,019,535.0	52	10,573,887.0
6	4,314,307.0	53	1,814,050.0
7	227,004.0	54	43,707,241.0
8	6,821,286.0	55	30,398,563.0
9	16,278,545.0	56	53,033,981.0
10	6,013,352.0	57	24,794,860.0
11	13,573,261.0	58	3,960,967.0
12	613,486.0	59	346,226.0
13	10,673,174.0	60	67,569.0
14	5,149,584.0	61	25,092.0
15	9,197,843.0	62	5,363,331.0
16	6,296,449.0	63	4,467,742.0
17	9,075,998.0	64	4,263,377.0
18	1,507,852.0	65	2,164,631.0
19	3,800,055.0	66	1,238,178.0
20	11,546,782.0	67	2,566,015.0
21	450,113.0	68	788,802,005.0
22	6,842,643.0	69	44,087,960.0
23	6,655,978.0	70	1,510,383.0
24	748,144.0	71	1,084,496.0
25	25,579,038.0	72	4,573,415.0
26	51,458,806.0	73	70,261.0
27	237,363,726.0	74	277,619.0
28	194,433,904.0	75	132,755.0
29	136,837,359.0	76	6,865,846.0
30	7,033,247.0	77	823,171.0
31	119,026,483.0	78	765,320.0
32	158,009,679.0	79	(3,140,151.0)
33	17,448,152.0	80	430,650.0
34	9,103,954.0	81	1,181,850.0
35	7,351,944.0	82	(770,571.0)
36	6,325,216.0	83	7,214,966.0
37	5,621,912.0	84	20,766,391.0
38	-	85	4,267,876.0
39	5,416,615.0	86	4,007,943.0
40	15,564,312.0	87	3,519,781.0
41	5,993,883.0	88	1,711,308.0
42	15,108,259.0	89	156,606.0
43	9,359,277.0	90	4,233,296.0
44	10,461,475.0	91	89,101,181.0
45	5,311,200.0	92	4,256,741.0
46	3,290,506.0	93	10,778,942.0
47	1,177,675.0	94	1,936,876.0
Sub Total	1,270,039,691.0	Sub Total	1,376,556,827.0
		Total	**2,646,596,518.0**

Note : Establishments Concerned : Shops and Factories

Table 5 - 15 : Estimated Average Annual Flood Damages (Traffic Damages) by Inundation Area in 1988

(Unit :Rp.)

Inundation Area No.	Flood Damages	Inundation Area No.	Flood Damages
1	41,481,562.0	48	1,689,016.0
2	7,765,296.0	49	59,373,972.0
3	2,522,078.0	50	30,434,392.0
4	2,264,716.0	51	29,536,736.0
5	2,108,074.0	52	9,034,536.0
6	3,785,546.0	53	3,554,920.0
7	2,038,426.0	54	1,106,826.0
8	6,770,538.0	55	21,985,664.0
9	34,575,838.0	56	11,277,796.0
10	1,150,682.0	57	6,749,800.0
11	7,438,286.0	58	6,076,998.0
12	1,106,826.0	59	1,248,502.0
13	31,660,720.0	60	1,736,490.0
14	5,711,904.0	61	3,554,920.0
15	5,223,198.0	62	2,731,966.0
16	7,029,336.0	63	7,561,898.0
17	58,191,726.0	64	5,732,642.0
18	11,605,524.0	65	4,415,928.0
19	28,999,120.0	66	1,360,570.0
20	4,970,172.0	67	5,620,574.0
21	3,302,612.0	68	3,463,590.0
22	10,030,012.0	69	14,789,578.0
23	5,980,614.0	70	1,947,096.0
24	994,758.0	71	790,642.0
25	3,350,086.0	72	3,742,408.0
26	3,786,264.0	73	1,038,614.0
27	2,887,890.0	74	1,225,384.0
28	9,637,690.0	75	3,259,474.0
29	3,743,126.0	76	4,049,398.0
30	1,484,182.0	77	2,404,956.0
31	60,664,894.0	78	6,082,770.0
32	56,943,224.0	79	4,367,018.0
33	4,576,188.0	80	4,291,598.0
34	1,898,186.0	81	5,459,596.0
35	1,596,250.0	82	5,862,056.0
36	833,780.0	83	13,541,794.0
37	1,457,672.0	84	102,937,098.0
38	1,893,132.0	85	26,906,926.0
39	3,103,550.0	86	29,515,280.0
40	237,396,112.0	87	2,985,710.0
41	3,189,108.0	88	5,984,950.0
42	8,643,650.0	89	1,113,316.0
43	1,984,462.0	90	45,896,772.0
44	24,013,982.0	91	10,213,390.0
45	5,200,080.0	92	667,030.0
46	419,776.0	93	3,603,830.0
47	1,774,574.0	94	1,038,614.0
Sub Total	727,185,422.0	Sub Total	521,963,034.0
		Total	**1,249,148,456.0**

Table 5 - 16 : Estimated Average Annual Flood Damages (Traffic Damages) by Inundation Area in 2010

(Unit :Rp.)

Inundation Area No.	Flood Damages	Inundation Area No.	Flood Damages
1	81,812,096.0	48	3,353,690.0
2	15,308,700.0	49	117,105,016.0
3	4,984,496.0	50	60,026,672.0
4	4,479,358.0	51	58,266,452.0
5	4,176,674.0	52	17,812,866.0
6	7,449,860.0	53	7,003,544.0
7	4,021,468.0	54	2,174,254.0
8	13,350,854.0	55	43,397,578.0
9	68,214,706.0	56	22,249,086.0
10	2,243,902.0	57	13,307,716.0
11	14,669,094.0	58	11,967,302.0
12	2,169,918.0	59	2,460,310.0
13	62,438,790.0	60	3,428,392.0
14	11,267,212.0	61	7,002,826.0
15	10,319,150.0	62	5,404,302.0
16	13,882,728.0	63	14,937,086.0
17	114,778,456.0	64	11,310,350.0
18	22,889,410.0	65	8,720,626.0
19	57,174,728.0	66	2,659,372.0
20	9,798,102.0	67	11,094,660.0
21	6,524,198.0	68	6,830,274.0
22	19,788,776.0	69	29,165,636.0
23	11,794,032.0	70	3,848,198.0
24	1,975,192.0	71	1,561,876.0
25	6,589,510.0	72	7,380,212.0
26	7,467,206.0	73	2,045,558.0
27	5,689,640.0	74	2,417,172.0
28	18,997,356.0	75	6,438,640.0
29	7,380,930.0	76	7,994,744.0
30	2,943,992.0	77	4,747,350.0
31	119,635,918.0	78	12,015,494.0
32	112,298,126.0	79	8,628,578.0
33	9,027,646.0	80	8,436,006.0
34	3,756,868.0	81	10,803,550.0
35	3,143,054.0	82	11,547,496.0
36	1,647,434.0	83	26,706,762.0
37	2,875,062.0	84	203,009,172.0
38	3,736,130.0	85	53,084,330.0
39	6,148,248.0	86	58,203,294.0
40	468,230,618.0	87	5,906,048.0
41	6,265,370.0	88	11,794,750.0
42	17,048,182.0	89	2,218,110.0
43	3,892,054.0	90	90,528,386.0
44	47,376,626.0	91	20,137,990.0
45	10,238,646.0	92	1,313,904.0
46	855,296.0	93	7,095,592.0
47	3,471,530.0	94	2,045,558.0
Sub Total	1,434,227,342.0	Sub Total	1,029,586,780.0
		Total	**2,463,814,122.0**

Table 5 - 17 : Summary of Estimated Average Annual Flood Damages

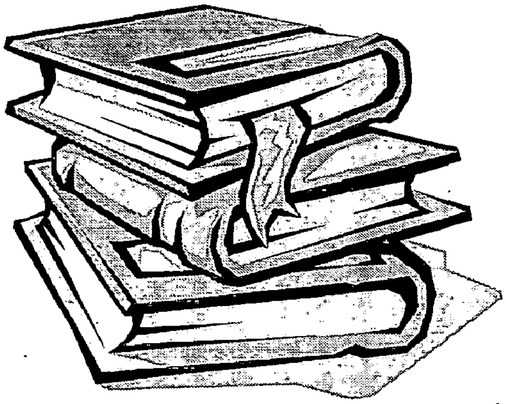
(Unit: Rp.)

Damages Item	Amount of Damages 1988	2010
1. Direct Damages to Property		
House	87,275,281,170.00	174,577,020,150.00
Shop	4,094,995,155.00	9,239,891,965.00
Factory	4,409,349,393.00	10,819,509,397.00
Other Specified Property	46,894,454,198.00	81,299,156,624.00
Sub - Total	**142,674,079,916.00**	**275,935,578,136.00**
2. Indirect Damages		
1 Income Losses		
Shop	570,139,646.00	830,894,216.00
Factory	1,146,118,801.00	1,815,702,301.00
Other Specified Property	114,761,569.00	151,005,002.00
Sub - Total	**1,831,020,016.00**	**2,797,601,519.00**
2 Traffic Damages		
Time Cost	395,429,054.00	772,800,240.00
Incremental VOC	853,719,402.00	1,691,013,882.00
Sub - Total	**1,249,148,456.00**	**2,463,814,122.00**
Total (1 + 2)	**3,080,168,472.00**	**5,261,415,641.00**
3. Damages to Other Unspecified Property Including Infrastructure		
(1 + 2) x 20 %	**29,150,849,678.00**	**56,239,398,755.00**
Grand Total (1 + 2 + 3)	**174,905,098,066.00**	**337,436,392,532.00**

Note : 1) Hotel , Restaurant, Hospital, Office, School (Primary, Junior, General High and High) and Religious Facilities (Mosque, Church & Temple)

2) Hotel, Restaurant and Hospital

Damages to other specified property were estimated based on the ratios between the number of shops / factories and that of other specified property.



CHAPTER VI

ENVIRONMENTAL IMPACT ASSESSMENT OF FLOODS

ENVIRONMENTAL IMPACT ASSESSMENT OF FLOODS

6.1. INTRODUCTION

Literature review shows that so far, no significant progress has been made on development of appropriate methodologies for EIA of floods and flood control measures (structural and nonstructural). This chapter addresses some of the issues involved in EIA.

Procedures for impact assessment widely differ in developed and developing countries. This difference is mainly due to differing perception of impact and inadequacy in database.

Prevalent view in developing countries is that indirect losses are more important in an industrial economy such as the U.S.A. rather than in an agricultural economy like India *(National Commission on Floods 1980)*. This view probably is based on constraint of database and too much faith in economic benefit – cost criteria. It tends to ignore the real value of loss of wages and earnings in rural economy. Disruption of transportation network during flood (which is a common feature) cuts off communication link to a large number of villages located in flood plains. Intangible damages such as prevailing inconvenience etc. are completely ignored.

6.2. APPROPRIATE THEORETICAL BASIS

6.2.1. The Boundary Principle

The first question, which needs to be answered, is whether impacts of flood control schemes should be assessed strictly on the basis of benefits and costs or some other additional consideration. It is not feasible to evaluate exhaustively all likely impact therefore benefit – cost analysis is necessarily incomplete. Governments in developing countries have major responsibility in social welfare programmes. Thus multi criteria approach instead of benefit cost criteria is desirable for flood impact study.

The second question concerns the geographic boundary for impact study. Identification of the region in which flood effects diffuse is rather difficult. This will depend upon how well the remainder of transportation network functions and the interdependence of flood affected area and the surrounding area.

6.2.2. Valuation Principles

Research network on assessment of indirect damages indicates that methods of quantification vary in quality and are frequently based on different premises and no simple relationship exits between direct and indirect benefits. *(Penning Rowsell BC and Chatterton J.B. 1977: "The Benefit of Flood Alleviation: A Manual of Assessment Techniques , Middlesex Polytechnic Flood Hazard Research Centre, England).*

Today's intangibles may become tomorrow's indirect or even direct benefits and costs as evaluation or measurement techniques advance. Intangible impacts which are redistribution in nature or which involve an argument about right may be excluded from impact study.

The expressed preference approach may be used as a viable method of evaluating socially significant intangibles. In this approach people are asked to indicate their willingness to pay or to accept compensation for flooding and to assign weight for various intangible losses relative to direct damage.

6.3. ENVIRONMENTAL IMPACT ASSESSMENT GUIDELINES

The environmental of a flood mitigation scheme can be described in terms of indicators. Documents provide comprehensive lists of indicators, which can be used to describe the relevant component of environment. *(Card J.R. Editor 1984: "Hydro – Environmental Indices – A Review and Evaluation of their use in the Assessment of the Environmental Impact of Water Project", IHP – II Project of UNESCO, Paris).*

6.3.1. Identification

Chaube (2001) has suggested the following guidelines in identifying and classifying potential impact of flood/flood mitigation measures :

(a). Structural and non – structural measures aim at mitigation of adverse effects of flood. However, there may be some positive benefits as well,

(b). Effects may be reversible or irreversible, repairable or irrepairable . Effects (indirect) can be local, regional, national in scale depending upon extent of interdependence,

(c). Effects occur mostly during monsoon season and they may increase over the years due to increasing population pressure on flood plains. Failure of flood control measures may cause much more severe damages,

(d). Effects may have to be valued on different scales or may have to be described in qualitative terms only.

A screening test (table 6.1) may be performed to identify relevant impacts for further study.

6.3.2. Prediction

The aim is to provide such information, which helps in decision-making. Collection of baseline information is the major task (Table 6.1). Specially designed surveys and monitoring have to be conducted to collect entirely new information on flood damages. This may require input from a range of specialists over a period of time sufficient to encompass seasonal variation in impacts.

The next step in the prediction process is to ascertain how the identified factors will change following implementation of a flood mitigation measure. These changes are then assigned significance factors in such a way that help to clarify issues in decision -making.

6.4. THE STUDY AREA - BASE LINE INFORMATION

Present river system and control structures in JABOTABEK region are shown in figure 3.2 of Chapter 3. A brief description of Cisadane basin is given below.

6.4.1. The Cisadane River

The Cisadane river is the largest river in the study area, which originates on the northen side slope crowned by Mt. Kendeny (1,764 m), Mt. Perbrakti (1,699 m) and Mt. Salak (2,211 m). The river flows through the city of Tangerang and flows in to the Java Sea . The river basin involves vast mountainous area in the upper catchments, more than half of the basin.

Table 6.1: Summary Screening Test for Embankment Type Flood Control Scheme

Subelement	Potential Impact	Baseline Data Required
Storm / Flood	Magnitude and frequency of damaging floods ? Is the project being sites in high risk area ?	Historical record of unusual storms and floods in the climatologically homogeneous area, Upstream reservoir.
Drainage / Channel Pattern	Effect on natural drainage pattern, flood carrying capacity, aggradation, degradation	Nature and pattern of drainage sediment load, Land use, and soil erosion (potential and existing) in catchment
Flooding	Cause of flooding. Risk to life & property. To what extent will the project reduce this risk.	Flood plain occupancy, Land use, contour map, Past damages.
Land use and Land capability	Will the project conflict with or improve existing or proposed land use ? Will the project degrade/ up grade land capacity. Likely incrase in value & productivity of land	Land use classification data maps, Development plan of the area. Population pressure on agricultural, other land capability classification data, map.
Socio - cultural	Human, ecological consequences of changes in landuse and economic activities, population redistribution. Resettlement plans for displaced persons. Measures to check the use of banks and riverbed for cultivation	Socio - economic data on population benefitting from the project, population displaced due to project. Their economic and cultural attachment to land and water.
Health	Environmental health problems	Soil and water quality, extent of prevalent diseases, sanitary habits

The catchments area at different location along the river are as given below:

Cianten	=	413 km^2
Cisadane before confluence with Cianten	=	433 km^2
Cisadane after confluence with Cianten	=	846 km^2
Cisadane at pasar Baruweir	=	1248 km^2
Cisadane at estuary	=	1411 km^2
Average slope	=	1 / 70; total length 137.8 km
Max elevation	=	2100 m , min elevation = 0.0 m

In the upper and middle reaches, the Cisadane river has formed extremely deeply dissected Valley. On the other hand, river flows through alluvial coastal plain in the lower reaches; natural levees have been distributed along the river course, on which partial embankments have been constructed. Bankful capacity varies from 25 cumec to 175 cumecs and with freeboard, it is 20 cumec to 100 cumec. The alluvial terrace with elevation above 12.5 m has been utilized for the city of Tangerang, and the coastal flood plain has been utilized for agricultural land mainly composed of paddy field and for Sukarno – Hatta airport. In the middle reached, large-scale urbanization, like Modern Land, Lippo Village, Bumi Serpong Damai and others, are extending from Kodya Tangerang southward to Kecamatan Serpong. Overall river improvement works have not been carried out yet; only local portion works such as partial embankment and protection works have been executed.

The Pasar Baru weir, which was constructed in 1937 for irrigation and has a width of about 120 m, is always damming up the water level of the Cisadane river by about 20 m. As result, in the city of Tangerang, upstream of the weir, water level of Cisadane river is considerably high.

The Pasar Baru weir has 10 gates. Problem exists in operation of gates due to poor maintenance. In flooding period, it is feared that the weir may prevent floodwater from flowing down smoothly, consequently may cause inundation in the city of Tangerang.

6.4.2. Flooding Condition

Flooding has occurred along the embanked reaches in coastal plain, downstream of the toll road from DKI Jakarta to Merak, (figure 6.1) and the city of Tangerang (Cisadane basin) mainly by dike breach and overflow. Flooding in December 1981 and February 1985 were big flooding in these decades. The dike breach occurred at Desa Kedang Wetan in 1981 and 1985 repeatedly.

The Cisadane river has overflowed in the city of Tangerang in 1981 and 1985 Figure 6.1 shows flooded areas. One of the reason of flooding is supposed to be prolonging backwater effect of the Pasar Baru weir located down stream; dam up of water level reaches by about 10 m. Judging from the maintenance condition at present, it is supposed that the gates could not be operated appropriately in flooding time.

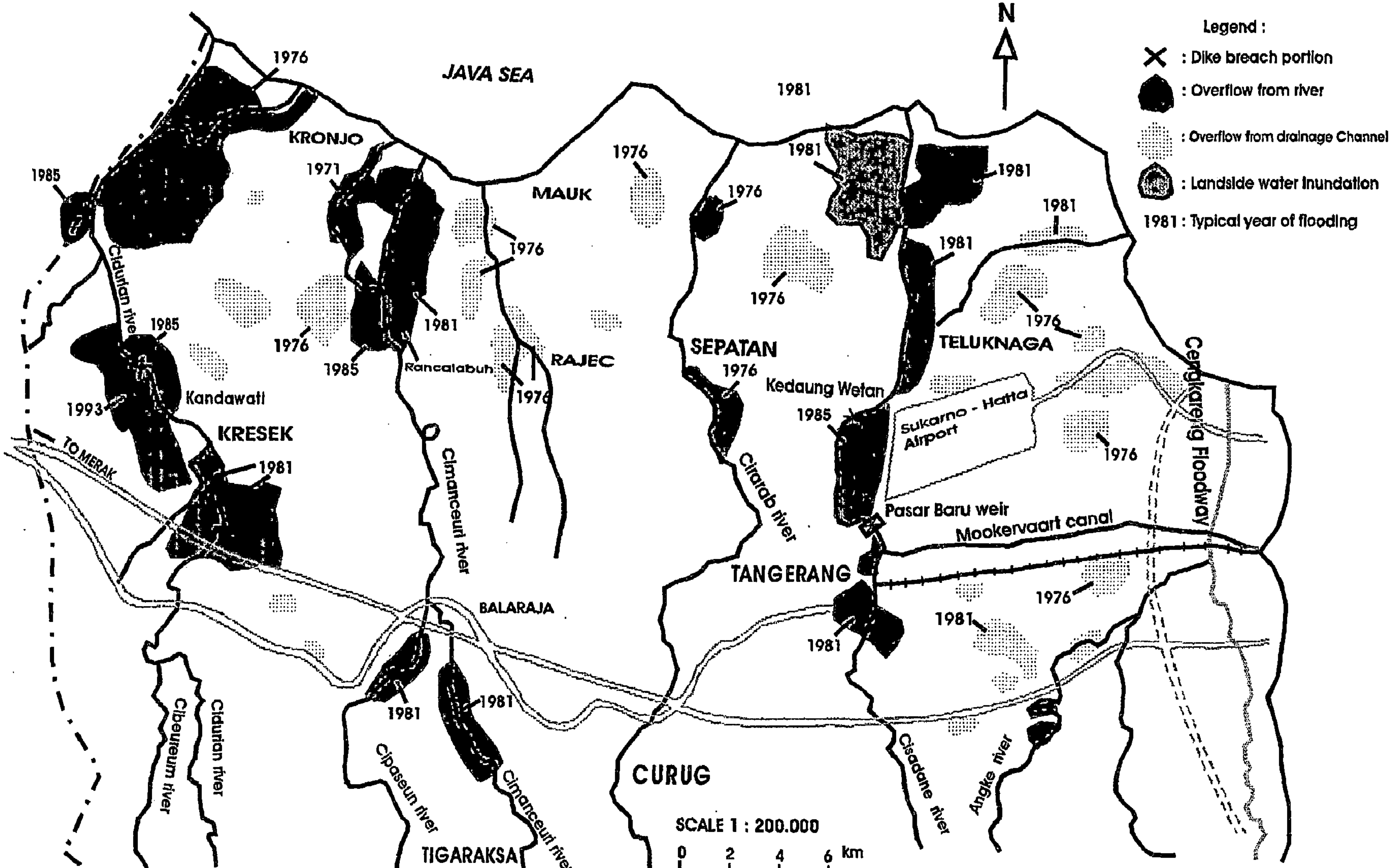


Figure 6.1 : FLOOD AREA MAP IN TANGERANG

Flooding in Bogor city is not serious (figure 6.3). The Cisadane river flows along the west margin of the city of Bogor having deeply dissected valley; the Ciliwung river also flows through the center of the city forming dissected valley; whereas; the city of Bogor is located on the considerably high hilly area.

Parungbadak is a proposed dam on Cisadane river for control of floods in the downstream region. A Catchment area upstream of the proposed Parungbadak reservoir is 860 km^2.(figure 6.4)

6.4.3. Environmental Status in Upstream and Downstream of Dam

6.4.3.1. Vegetation and wild Life : The area of the proposed reservoir is a presently devoid aquatic weed. However, Lido lake a source of the Cisadane river, does contain aquatic weeds such as Eicchornia Crassipes, Nitella Sp. And Salvinia Cucultata. The Lido lake source could be the venue for the colonization of the reservoir environment by aquatic weeds. Rice fields are the second source of weed introduction. Species such as Salvinia Cuculata .S. Nafans and Pistia Stratiofes commonly occur in the stagnant paddy environments.

Shoots, seeds can be escape from upstream areas and be carried into the reservoir. Weeds existing in paddies contained in the reservoir would also be released during flooding.

Urban and a grain development have already displaced any historical wild life population that might have existed in the area. There is no endangered species of wild life threatened by project option.

6.4.3.2. Reservoir Area: The major crops planted in the proposed reservoir area are rice, palawija (maize, sweet potatoes, cassava, peanuts), rubber and some vegetable, which are usually grown in paddy lands and upland.

Fruits are usually grown on subsidence basis in the mixed garden area. Rubber, an important cash crop is also cultivated on plantation estates covering about 350 HA. Rice cultivation accounts for approximately 49 % of land use area followed by mixed garden (vegetables) cultivation at 27 %. Urban areas occupy only 8 %of the proposed reservoir area.

Paddies represent the largest area under cultivation (2,692 ha), followed by sweet potatoes (223,9 ha) and maize (96,6 ha).

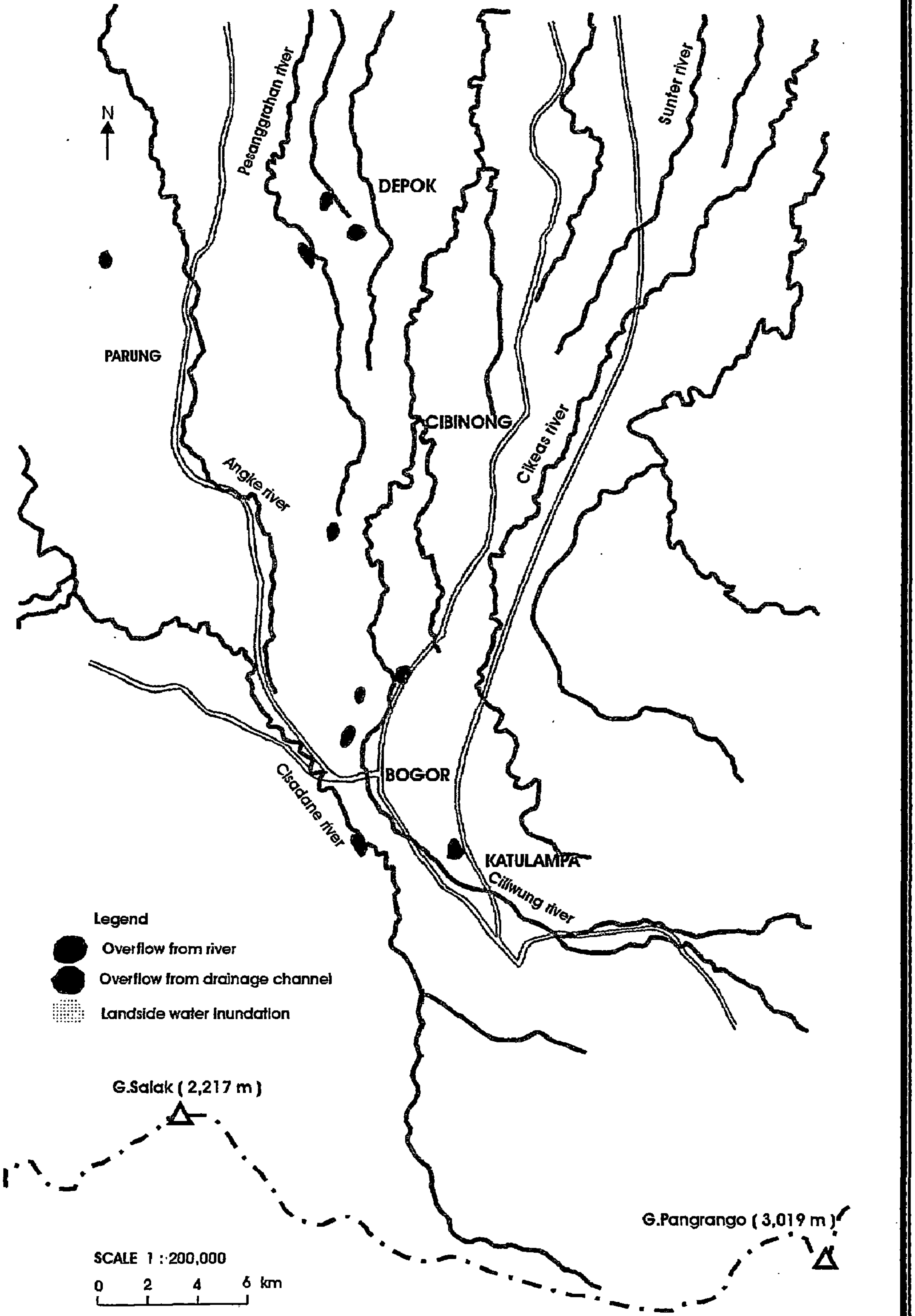


Figure 6.3 : PAST FLOODING AREA IN BOGOR

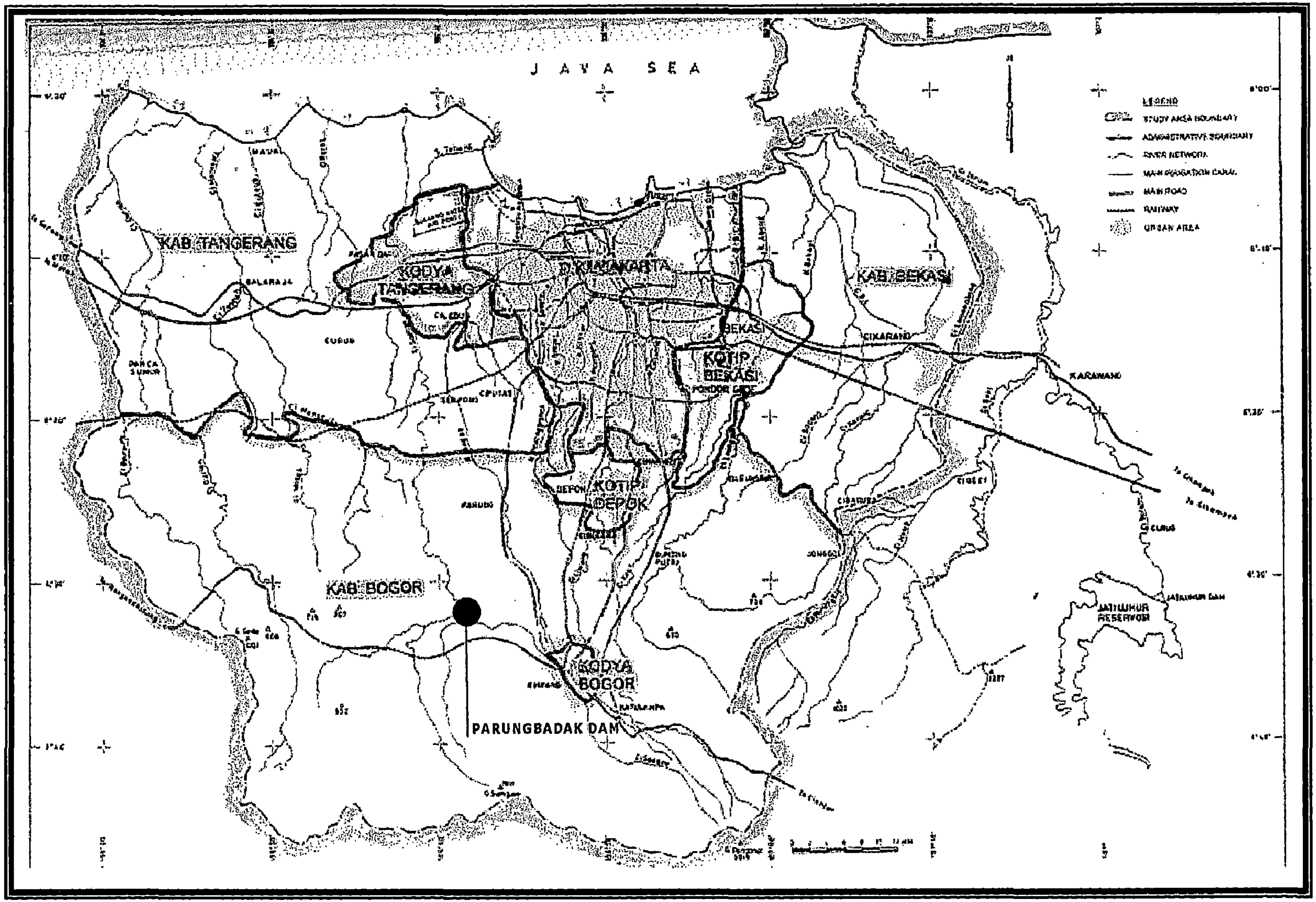


FIGURE 6.4 : LOCATION OF PARUNGBADAK DAM

6.4.3.3. Downstream Areas: Development of water resource project will improve the availability of irrigation water and influence agriculture production in areas below the dam. Dam will reduce flood flows downstream.

Primary crops grown are lowland rice (yield 4.75 t/ha) and upland rice (yield 2.26 t/ha), maize, peanuts, soybeans and mungbeans. Continued expansion of urban and industrial zones in these areas will remove agricultural land from production.

6.4.3.4. Forestry: Currently no major active exploitation of forestry resources occurs in the proposed reservoir or immediate vicinity. While portions of areas may appear forested, most of the tree covered areas, in Parungbadak reservoir are devoted to estate crops such as rubber. However, the implementation of a reforestation and regreening program in upstream areas of the proposed dam has the potential to stabilize soil conditions, reduce erosion, extending reservoir life and provide the opportunity to develop another resource base for the local economy. Through proper management the development of a forested area will act to safe guard the reservoir investment and contribute to improve livelihoods in the region.

The potential tree species which can be used for reforestation in the upper watershed areas are mainly Rasamala (altingia excelsa), Damar (Agathia loramthifolla) and Pinus, Tusam (Pinus – mercusii).

6.4.4. Flood Control Plan in Lower Reach

In general carrying capacity should increase along the channel, in downstream direction but Cisadane River shown wide fluctuations in carrying capacity even in lower reaches indicating the need for river improvement works with priority for lower reaches. Figure 6.2 shows conceivable countermeasures for flood control. These measures mainly consist of river improvement, rehabilitation of existing structure and flood plain zoning as depicted in Figure 6.2.

Structure measure (river improvement) from Pasar Baru weir to estuary 21 km to carry safety 50-year flood discharge (1900 cumec). Nonstructural measure (flood plain zoning) from outlet of Angke floodway to Pasar Baru weir (14.6 km) is proposed.

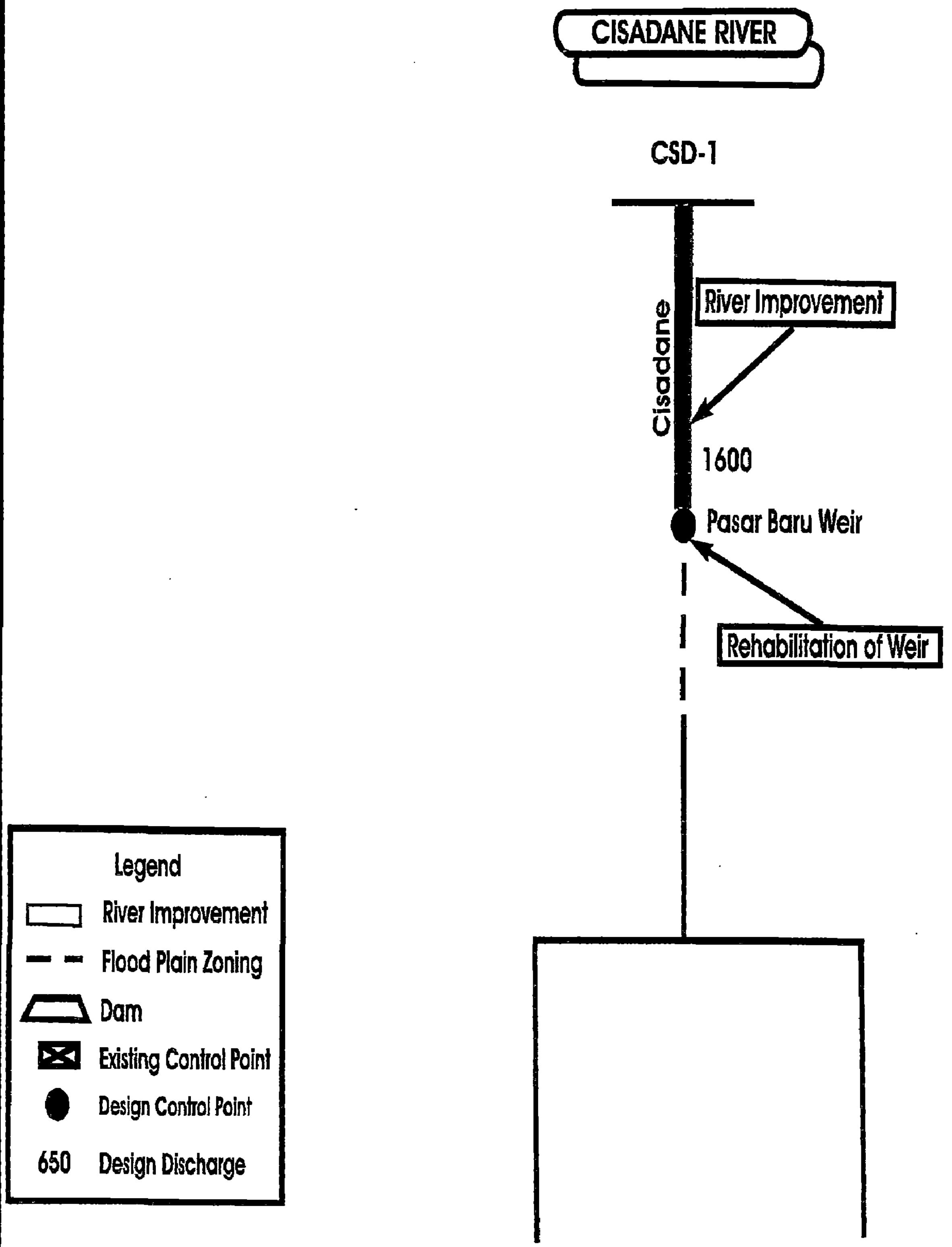


Figure 6.2.. CONCEIVABLE COUNTERMEASURES OF FLOOD CONTROL

6.5. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

The main objectives of the IEE Study are to clarify environmental issues related to possible measures for the flood control alternative scheme, and to provide information to guide EIA in the feasibility study.

6.5.1. Environmental Items

The work components of possible measures of flood control are; 1) dyke system, 2) river channel improvement, 3) construction of flood control dam, 4) flood way. Thus, the environmental items for the IEE are principally selected from common items related to these measures based on the existing guidelines such as *UNESCO (1984), GDWRS (1985).*

The following items are selected for the IEE:

Social environmental	Nature environmental	environmental Pollution Issues
- Resettlement	- Encroachment into Precious ecosystem	- Air pollution and noise
- Impairment of the transportation	- Aesthetics & landscapes	- Deterioration of water quality
- Communities	- Change of river regime	
- Encroachment on historical assets	- Watershed erosion and sedimentation	
- Inundation of mineral resources		

6.5.2. Relative Significance of IEE Items:

Various environmental items are to be evaluated for a whole project implementation period: 1) pre-construction period, 2) construction period, 3) operation - period. However, specific items to be selected for a project would depend on the respective project feature, implementation period, socio-economic conditions and nature conditions around project area.

Significant for proceeding EIA among the IEE items has been classified by the following classes; (A) mostly significant, (B) significant, (C) significant but relative minor, (D) No effect is expected. However, since no exact data information about historical assets have been available, this item is classified by (B).

The flood prone areas along the lower reach of Cisadane are mainly utilized as agricultural land included in the Cisadane-Prosida irrigation areas and the Government has provided flood dikes in order to protect these areas.

The major construction works involved in river improvement projects are improvement of the existing dyke, rehabilitation of existing weir, and river dredging. The significant environmental impacts to be caused by these works are estimated as follow on the basis of available information.

Resettlement:

The resettlement of families displaced by water resources project is undoubtedly a very delicate and sensitive issue. It is essentially a human problem and further requires attachment to with a human face. By and large, people have a deep attachment to the land, tradition, culture and way of life and normally do not want to part them. Unlike reservoir submergence due to Parungbadak Dam, resettlement is not a major environmental item in river improvement project expect in the case of improvement existing dyke.

Rehabilitation of existing weir and river dredging would not cause any resettlement problem (impact assigned is D). Area being densely populated any relocation of existing dyke or change in section would have significant adverse impact on population there fore impact assigned is B.

Encroachment into precious ecosystem:

Precious ecosystem can be disturbed by the improvement of existing dyke and river dredging. Taman Wisata Tanjung Pasir is a proposed nature conservation area in the delta of Cisadane river keeping in view the existence of rich wild life. Therefore the improvement and river dredging may have significant impact on ecosystem (A) and weir may have no impact (D).

Change of river flow regime:

Change of river flow can influence the characteristics of the river it self- Rehabilitation of existing may significant effect regime (A) due to large variation in upstream and downstream discharges.

Air pollution, noise and vibration:

This is not major environmental item. However during construction for improvement of existing dyke there may be little effect on air pollutions, noise and vibration due to use of roads as access route to construction site.

Water Quality:

River dredging work may worsen river water quality with respect to increasing suspended solids during construction stage (A). Similarly waterside embankment portion may cause change in water quality during the construction through not so much (C).

Major environmental items	Improvement of existing Dyke	Rehabilitation of Existing weir	River Dredging
Resettlement	B	D	D
Encroachment into precious ecosystem	A	D	A
Change of river flow regime	D	A	D
Air pollution , noise & vibration	C	D	D
Deterioration	D	C	A

Note :

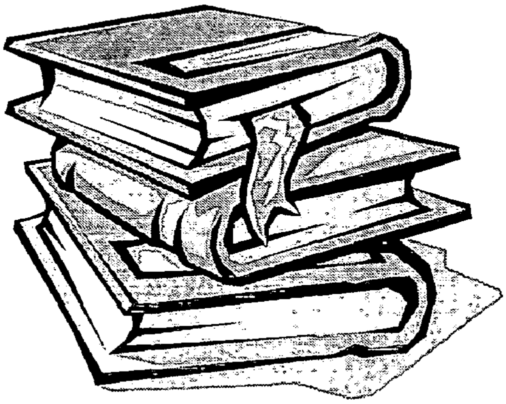
A: Mostly significant item B: Significant item

C: Significant but relative minor item

D: No effect is expected and/or no relation

As described, the majority of land uses in these areas are paddy fields, cultivated lands villages. The number of households to be relocated is estimated at about 10 – 90 households based on the earlier studies. If the resettlement plan acceptable for inhabitants to be relocated is established, there is expected to be no serious impact to be induced by improvement of the existing dyke.

Rehabilitation of the existing Pasar Baru weir, which is an irrigation water intake for Cisadane-Prosida system, is a major work of Cisadane River System. It is suggested to maintain the present water supply during rehabilitation of the weir.



CHAPTER VII

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Procedures for estimation of benefits costs and for economic appraisal of flood control projects differ from country to country. The methodology for economic appraisal of flood control projects and existing deficiencies in the procedure are explained.

Stage – damage functions for residential area, agricultural crops, fisheries, traffic etc are graphically depicted. Stage –damage, stage – discharge and discharge – frequency relations with and without a flood control project provide a scientific basis for assessment of expected annual damage. Type of damage, assessment procedure and data required are summarized in the tables based on study of literature.

Emphasis in this Dissertation work is on assessment of various types of urban flood damages using the available data for Jakarta City.

The Jakarta City is about 662 km^2 in area, which is drained by several rivers and drainage channels connecting with the rivers. There are 11 large rivers which originate in the southern mountainous region located outside the Study Area.

The flood ways have been already constructed to divert floods. The West Banjir Canal diverts floods from river Krukut, Cideng, Kalibaru, Kalibata and Ciliwung, while Cengkareng flood may divert the floods of the Mookervart, Angke, Pesanggrahan and Grogol rivers. The East Banjir Canal is planned to divert the floods of Cipinang, Sunter, Buaran, Jatikramat and Cakung rivers into the Bay of Jakarta.

This Dissertation work is limited to the floods in the major urban drainage channels (caused by local rainfall). The total drainage area of 662 km^2 of the Study Area is divided into 27 subs – drainage area. There are 43 rain gauge stations and 9 automatic water level gauging stations. Anticipated major flood damages in the Jakarta City are:

1. Direct damages to house, shop, factory and other properties.
2. Income losses due to closure of shop, factory, and other enterprises.
3. Damages to traffic and infrastructure.

The above flood damages as caused by the habitual and potential floods are analyzed. Habitual flood is defined as the flood that occurs more than once in a year.

Potential flood is based on three floods in 1977,1979 and 1981 floods as explained in chapter III.

Assessments of urban flood damages are estimated based on the sampling questionnaire survey. So, the flood damages due to habitual and potential floods in the future can be estimated. The flood maps of the above floods are also available as well high rainfall depths, which were recorded for the whole Study Area. The data obtained from report are: inundation depths and inundation durations in each flood area, covered 92 flood areas, 1,000 houses, 192 shops and 120 factories.

Basic figures for estimation of traffic damages were worked out based on data of sampling questionnaire survey, which obtained 100 samples each for household and companies. Vehicles were classified into four types: Passenger car, bus, truck, and motorcycle.

The potential flood map for the areas other than the inner areas of the East Banjir Canal was prepared by overlaying the 1977 and 1981 flood maps on the 1979 flood map to fill the shortage of flood area in the 1979 flood map. Also the habitual flood areas were incorporated into the potential flood map in case the habitual flood areas lie outside the potential flood areas.

Since the potential flood covers the three major floods above, the return period of the potential flood is estimated at 40 years approximately.

The flood damages assessment in Jakarta city is carried out into 4 categories:

1. Flood damages due to habitual flood in the urban development condition of 1988 and 2010
2. Flood damages due to potential flood in the urban development condition of 1988 and 2010
3. Flood damages to traffic and income loss due to closure of shops and factories
4. Annual flood damages

The flood assessment is initiated by finding relationship between inundation depths / durations by inundation area and flood damages based on questionnaire survey data for both flood years. Further, using the unit values of property from literature, and the number of property, flood damages are calculated.

The average flood damages per unit house in 1988 habitual year is Rp. 19,239,- while income loss per unit shop is Rp. 11,537,- in 1988 habitual flood year.

Flood damages to traffic for passenger car are calculated as Rp. 2,168,- for car, Rp. 8,314 ,-for bus, Rp. 7,483,- for truck and Rp. 359,- for motorcycle.

Estimated habitual flood damage for 1988 habitual flood year are Rp. 20,994,817,560,- while in the report is Rp. 27,341,593,897,-. The results are different. Beside, the average income loss in 1988 habitual flood year is Rp. 820,972,761,- compared to the Rp. 1,102,379,323,- as given in report. For traffic damages, the flood damages in 1988 habitual flood is Rp. 1,249,148,456,- compared to Rp. 1,249,148,456,- in the report . Further, average annual flood damages to property in inundation area no.1 in year of 1988 are Rp. 3.623 million.

An empirical relationship between the flood damage and the occurrence frequency of the event from which the damage arises has been developed for the city of Djakarta (Indonesia).

Damage has been evaluated as a percentage of the total value of the damaged properties, depending on water depth. New percent – damage relationships have been obtained for socio – economic conditions different from the analyses ones, leads to an overestimation of the benefits produced by some proposed protection measures.

The estimation of average value of property, carried out considering that replacement cost of a structure can be deemed as the appropriate structure value, is a fundamental phase in applying the adopted methodology.

The comparison, in terms of expected annual damages, between the damage – frequency relationships obtained for different mitigation measures proposed in the analyzed zone allows evaluation of the efficiency of the proposed interventions.

The accuracy of the methodology is, of course, limited by the various simplifying hypotheses under which it has been developed, and by the precision of the economic estimations. Nevertheless, it can be considered as a quick and reliable tool for general or detailed local studies in small and strongly urbanized basins having hydrologic and socio – economic features similar to the city of Djakarta.

Impacts of flood or flood control measures cannot be assessed strictly on the basis of economic benefits and costs. Often indirect and intangibles benefits are more significant though not quantified in monetary terms due to paucity of data and standard procedures. Today's intangibles may be become tomorrow's indirect or even direct benefits as advances in measuring techniques such as remote sensing, geographic information system, mathematical modeling etc are taking place.

Theoretical basis for EIA of floods has been provided. Baseline information and initial environmental examination for flood control on Cisadane River in the study area have been discussed.

It would have been useful to analyze and compare the practice followed in India and other countries for assessment of urban flood damage. However such literature for urban damages in India is not available. National Flood Commission Report (1980) of Government of India does not elaborate on assessment procedures for indirect damages, which are more important in urban areas.

It is hoped that this study would serve as an useful reference material for estimation of various type of urban flood damages.

A comprehensive list of references on the available literature has been compiled for further research on this important subject.

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