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Present and Prospective Future Water Use in Indonesia: Guidelines for A Case Study

Working Paper No. 3

by

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Preface

The Natural Resources Management Project (NRMP) of USAID, with support from NRMP and the Environmental Programming Support Services Project (EPSS) of the Canadian International Development Agency (CIDA), in association with the Institute for Economic Analysis (IEA) of New York University, are carrying out an analysis of the economic, employment and environmental consequences of alternative development paths for the Indonesian economy. The purpose is to provide advice to the Indonesian National Planning Agency (BAPPENAS) to assist in the development of the newest five-year plan (Repelita VI) and the next Long-Term Development Plan. The first stage of this work has already been completed by IEA with the support of EPSS.

The objective of this work is to evaluate the possible trade-offs between the growth of income and employment on the one hand, and the levels of natural resource depletion and degradation of the natural environment on the other, that are likely to be associated with alternative patterns of structural change. For instance, it is important for policy makers to know how the development of the pulp or cement industry over the next 20 years is likely to affect air and water pollution and how costly, or cost saving, it might be to adopt cleaner technologies than are being used now.

The analytic framework includes a dynamic input-output model covering all economic activities and the associated input-output database. The model is dynamic in two senses. First, it incorporates a representation in which levels of sectoral investment depend on expected growth of output, the technology in use, and levels of capacity utilization. Secondly, the model is dynamic in that it explicitly incorporates projections of changes in technology for agricultural sectors, forestry, energy sectors and key manufacturing and service sectors.

Technological scenarios are developed for each sector using detailed information about likely technological and institutional changes obtained from technical experts. This includes expected changes in intermediate inputs, notably energy and raw materials, capital stocks, and human resources of different skill types as well as changes in natural resource usage and environmental degradation associated with current and alternative future technologies.

This is one of a series of working papers being prepared by NRMP and IEA researchers in collaboration with industry experts. The papers provide a critical part of the database for the numerical computations, as well as the methodology for building it.

Part I. The Representation of Water

1. Introduction

The objective of this project is to define and analyze two scenarios about the future of the Indonesian economy, one intended to describe an aggressive approach to sustainable development and the other, a more moderate path. Sustainable development is interpreted to include not only an improvement in the material standard of living and the distribution of income but also careful use of natural resources and land as well as reduced pollution of air and water.

The case studies that are being carried out for this project involve the formulation of the sector-level assumptions which constitute the scenarios. This Working Paper is an attempt to establish a conceptual framework for subsequent analysis and to describe the ways in which water is used in some of the sectors of the economy which are candidates for case studies. It also touches on the kinds of technological and institutional changes, affecting individual sectors or relevant for a broad range of sectors, that can economize on future water requirements or reduce water pollution.

A number of case studies will be carried out in Jakarta under the direction of Dr. Clive Hamilton. The case study work will include the completion of data sheets quantifying the changes in inputs and outputs that can be anticipated in individual sectors under the technological and institutional assumptions of the two

scenarios. The current design for the data sheets for each sector includes several items of information specifically about water that should prove extremely informative in this first round of work about water use and water pollution in Indonesia. These are the volumes of water input and of water discharge per unit of sectoral output, independent of water quality; and three aggregative measures of the pollutant content of the effluent: BOD, or biological oxygen demand, which measures the weight of oxygen needed by bacteria to degrade and stabilize biodegradable waste materials contained in the discharge; and the total amount of solids, distinguishing the dissolved solids from the suspended solids. More specific information associated with each sector should also be indicated on the appropriate data sheet. The purpose of this Working Paper is to identify the kinds of information that will be needed.

The remainder of this paper consists of a discussion of water-related issues facing all sectors of the economy (Sections 2-4). We propose a new representation for water in an input-output model and identify the eight sectors making the most intensive use of water (section 5). Part II of the paper contains guidelines for case study analysts (Section 6) and a more detailed description of the way water is used in selected sectors (sections 7 through 14). The latter descriptions, admittedly uneven in scope and level of detail, are based on the literature about technologies which have been employed in different countries (mainly the US) at different

points in time over the past 30 years (the list of references provides citations to the works on which this paper is based). While this literature does contain some figures quantifying water withdrawals and discharges associated with individual technologies, we have chosen not to include these numbers in the paper. First, these figures will not be consistent over the different sources, in part because of the long time span and in part because of the widely differing assumptions, classifications, and units (especially value units) employed in the source studies. Second, they may be very misleading about the present, and prospective future, situation in Indonesia. The quantification of technical parameters for this study will depend entirely upon the collection of information in Indonesia.

This paper lays out a general framework for situating the use of water and describes the kinds of questions the case study analysts will need to ask of industry experts. The discussion is intended to provide a basis not only for estimates of the volume of water requirements and discharges for major water-using sectors in Indonesia at the present time but also for an initial set of projections of sector-level changes in water use over the next 25 years.

This study will include only a very preliminary description of the use of water. It will hopefully be possible to follow it up in a new study with a sharper focus on water. For that purpose, much more detailed and concretely defined classifications for water

quality and water pollutants will be required to guide the collection of information. A possible classification scheme is shown in Annex A; it will be useful in identifying the principal pollutants in the discharge of each sector. The sectoral classification scheme is included as Annex B.

2. The Growing Importance of Water

Ranked according to the quantity of average annual per capita runoff of water, Indonesia appears to be a relatively water-rich nation. However, the geographic distribution of fresh water is rather uneven because of differences in climate, soil characteristics, and land-use management (Mahbub et al., 1983); and over 60% of the population lives on Java with less than 10% of the country's runoff.

Per capita daily water withdrawals for the country as a whole are low at 700 liters compared to 1200 for China, 2000 for Mexico, and 7200 for the US in 1980. In that year, 86% of water withdrawals in Indonesia were for use in agriculture and only 3% for industrial use (Postel, p. 107). These figures are consistent with the experience in other countries as industry generally accounts for less than 10% of withdrawals in developing countries compared to 60 - 80% in developed economies.

With industrialization and the intensification of agriculture, however, there will be significant and to some extent predictable changes in the ways and places in which water is delivered and used. As demand for water grows, substantial attention will need

to be devoted to establishing a system of legal rights to water as well as to planning for technical and organizational means of supplying water, treating water and preventing the pollution of water in the country as a whole and especially in the most densely populated regions. The need for situating these concerns in the context of an integrated national environmental policy is generally recognized (Partoatmodjo and Moestadji, 1983). However, it is becoming increasingly important for industry, as well as government, to plan and monitor the volume and quality of water used and discharged as water-related expenses will represent an increasingly significant portion of industrial production costs. A dynamic input-output analysis can provide a basis for planning these activities in both the public and private sectors.

The direct use of water for social and economic purposes is associated with the extraction of raw materials, the production of goods and services, activities carried out within households, and "in-stream" activities. In this paper we are concerned with withdrawals of water for the first three, the economic activities associated with the production and consumption of goods and services.

In-stream use of water is for activities like recreation, navigation, or fishing. By contrast with the other economic activities, they generally do not involve withdrawals or diversions of water or the discharge of potentially polluted water and for this reason will not concern us in this initial assessment. The

dilution of wastes is another in-stream demand for water, but we will not attempt to address it directly at this stage. Of course, water serves many other valuable and even indispensable purposes, notably in maintaining individual ecosystems and the entire biosphere. All of these social and "natural" uses, unlike the economic uses, tend to be accorded low or even zero value by the marketplace. While they cannot be ignored in the planning process, the conceptual framework described in this paper must be developed first; only then can one hope to integrate other uses of water into the economic model.

3. Characteristics of Water Use and Water Management

The principal management issues related to water have to do with where the water is obtained, how it is used and treated, and where it is disposed of. The principal alternatives are enumerated in Table 1 and are discussed in this section, except for the technological options for conserving water which are the subject of Section 4.

For many economic purposes, water is obtained from the surface or the ground and then returned to these sources after use. The withdrawal of water needs to be distinguished from the consumption of water. Water consumed is rendered unavailable for specific further uses. Usually this means that the water is embodied in a product or lost to evaporation (or transpiration by vegetation in the case of agriculture) rather than being r[illegible]ed to the surface

Table 1. Principal Characteristics of Water Use

1. Source
surface water
ground water
public utility

2. Uses
irrigation
cooling and condensing
raising steam
cooking
diluting
transporting solids
washing and cleaning
incorporation in product
personal use by employees

3. Technological Options for Reducing Water Intake
good housekeeping
- turn off taps when not in use
- keep waste streams separate
- avoid spills
- keep outside areas clean to avoid dirty storm water

reuse
recycling
process modifications
- dry processing
- replacement of water as coolant
- internal recovery of heat

4. Treatment
primary-physical
secondary-chemical
tertiary-biological
recovery of by-products

5. Disposal Sites
streams and non-tidal rivers
sea
groundwater
land spreading
evaporation
public sewers

6. Characteristics of Effluent
oxygen demand (biological and chemical)
total solids
- nutrients
- harmful substances (toxics)
- microbiological discharges (pathogens)

Source: Institute for Economic Analysis

or groundwater. However, the distinction is not always clearcut; for example, heavily polluted water is "consumed" in the sense that it is not available for other uses. In fact, any discharge not only may be unusable itself but may also render the receiving waters unfit for certain purposes.

Most industrial use of water is non-consumptive in the sense that the volume of water discharged is nearly as large as the withdrawal. Most of the water withdrawn for agricultural purposes, by contrast, is consumed (through evapotranspiration). The special characteristics of water use in agriculture are discussed in Section 7.

Another distinction needs to be made between self-provided water and metered water where the latter is delivered by a public utility. The source of a sector's water supply will affect both the sector's cost structure and the characteristics of the water obtained.

In the developed countries, the rights of industrial users to obtain their own water from surface or ground sources is controlled and licensed. The industrial user also incurs the costs related to pumping, maintenance of pipelines, screening, filtration, and any other treatments that may be applied. All plants are required by law to obtain potable water for employee use and for use in certain production processes.

Many industrial users will prefer to obtain their water from a public utility when there is a choice. However, metered water

may contain dissolved mineral impurities that are undesirable for the production of certain products, notably chemicals. Many newer processes and more sophisticated products require demineralized process water of very high purity. Thus, while metered water is generally sterile and potable, it may still require pre-treatment. Sectors that use large quantities of water will find it cheaper to provide their own.

For many uses such as material cooling or crude washing, the quality or variation in quality of the water is not important as long as it is free of suspended matter and has acceptable hardness and dissolved solids content. Temperature variation in river water may be of more concern than other characteristics of the water.

Most industrial water is used to transport solids, in solution or suspension, or to convey heat (i.e., to cool) in the production process. A small amount may be evaporated, decomposed by chemical reaction, or be incorporated in products or waste. Perhaps as much as 80% of industrial intake of water is for condensing and cooling. The purpose of a cooling system is to remove unwanted heat by raising the temperature of water. Other important industrial uses of water are raising steam, now often part of a cogeneration system in which "waste" heat is exploited for the production of electricity, and as a process material. It is also used for cleaning, conveyance of materials, personal use by employees, fire fighting, and air-conditioning.

There are basically five options available for the disposal of industrial, water-borne effluent from industrial firms (Hewson, p. 95): it can be discharged to public sewers, to streams and non-tidal rivers, to the sea (where the tide disperses it), to the ground, or by evaporation or incineration. The severe problems in Indonesian costal waters include chemical run-off from the full range of economic activities and are exacerbated by the changing nature and increasing quantity and variety of industrial wastes and thermal and radioactive wastes (Soegiarto, 1983)

In the developed countries discharge practices are regulated. In particular, the effluent has to meet certain criteria to qualify for discharge to rivers and streams. These criteria include standards for BOD content, suspended solids, pH, toxics (cyanides, phenols, ammonia, sulphides, chlorine, toxic metals, many organic compounds like pesticides), and content of oil and other immiscible liquids. Criteria for discharge to tidal waters are less stringent, but recently statutory control over these discharges has been implemented as well.

There are also regulations governing discharges of water-borne effluent to public sewers. In this case the effluent will be treated by the municipal treatment system before it is ultimately disposed of into the environment. To comply with regulations, the effluent generally needs to be treated at the manufacturing plant before it is discharged, whether this is to public sewers or directly to the environment.

4. Technological Options for Reducing Water Intake

While increasing energy use tends to accompany economic development, the intensity of energy requirements generally levels off after a society has reached a certain level of affluence. This same levelling off is also observed for water. Much of the saving in the case of water is due to reuse and recycling, practices that are not possible for energy. Other factors are efficiencies achieved with larger-scale production, replacement of water as the cooling medium, and the use of internal methods of heat recovery. These options were summarized in Table 1. Most technological changes will affect more than one of these and will affect other inputs and outputs as well.

As industry faces rising water costs, local shortages of water, and legal constraints on the disposal of effluent, technologies that conserve on water withdrawal and consumption are increasingly attractive. This is one of many reasons that old technologies from the developed countries may not be good choices for Indonesia.

A significant amount of water can sometimes be economized through good housekeeping techniques. Simple practices are to shut off taps when no water is needed and to use some washwaters more than once. Another valuable practice is to separate waters by quality and maintain multiple streams of waste which are treated differently. A more complex change is the replacement of "wet processes" by "dry processes." The latter -- in sectors as diverse

as the cement industry or food processing -- require not only less water but generally also less energy for drying. Another important opportunity is the recovery of process heat which reduces the need for a coolant while also saving energy.

The basic example of **reuse** is when water is withdrawn, used, and then put back into a river for use by others downstream. The same concept applies to multiple use of water, for different processes, in one plant. This is possible when the downstream uses are less demanding of quality and the water has not been seriously degraded. For example, steam concentrate can be reused for other purposes. However, risks of contamination are considerable in some sectors (e.g., chemicals).

Recycling refers to the reuse of water in the same process. An example is the recirculation of cooling water; the heated water is cooled and returned to the system for reuse as cooling water. Process water is regularly recycled in sectors including paper manufacture, metal finishing, viscose rayon, and vegetable canning where it is economic because of the value of the solids recovered.

In some cases it is possible to reuse the total factory effluent. Use of treated public sewage for low-grade industrial water supply is also sometimes practiced.

The effective use of these techniques usually requires changes in present practices. A complication impeding their adoption is that, in all but one-product operations, a modern plant generally experiences changing patterns of water use and corresponding

changes in the composition of used waters. Variation can be considerable and unpredictable. Furthermore, the in-plant treatment of waste requires storage capacity to collect and hold the different streams of effluent for mixing to the uniform composition required for a particular treatment. The more variation is experienced, the more capacity is required. These are some of the reasons that a more detailed evaluation of specific technological options in Indonesia is required.

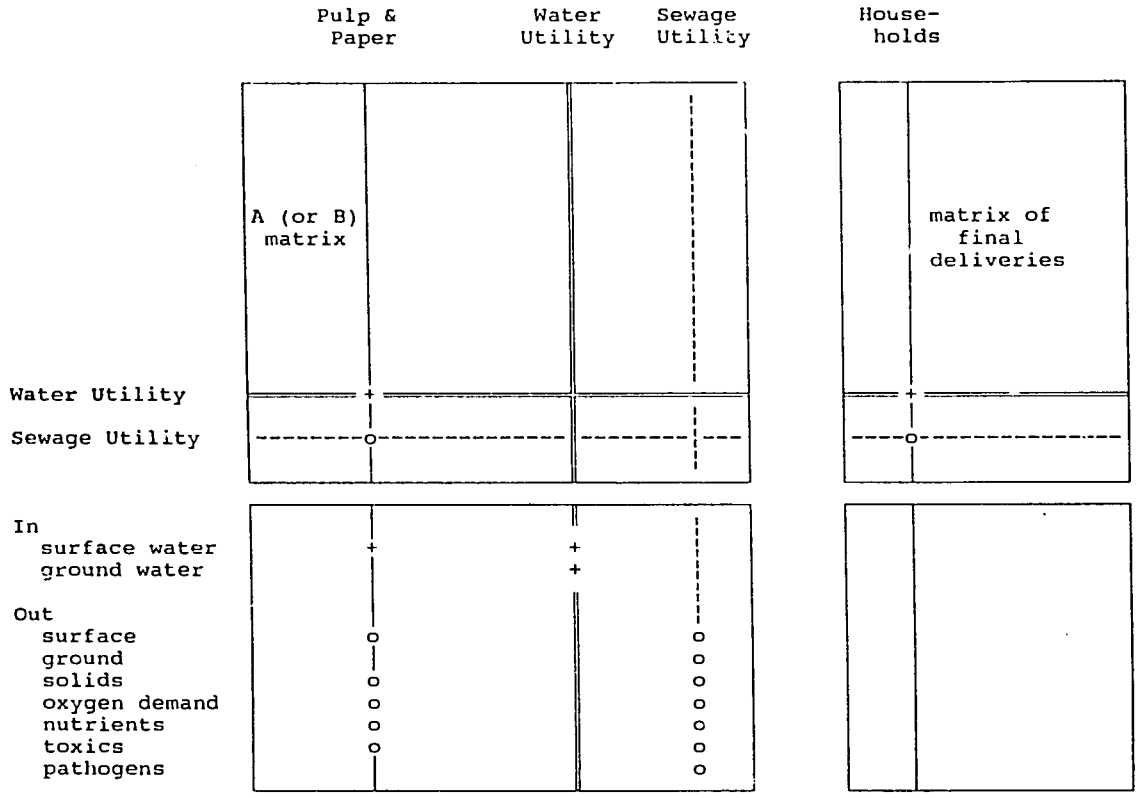
To the extent that effluent is processed in a plant, the options available for physical, chemical, and biological treatment are similar to those for municipal treatment systems. Sometimes industry-specific treatment plants are maintained. Often arrangements are negotiated for joint industry/municipal plants.

5. Representation of Water Use, Discharge, and Treatment in an Input-Output Framework

In the Working Paper on Input-Output Case Study Methodology (IEA WP#2), we laid out ten steps for executing a case study and these will be discussed below. There was the implicit assumption that the existing dynamic model of the Indonesian economy already included the variables and parameters which needed to be quantified. This is not true, however, in the case of water. Consequently, our first step has been to develop the algebra needed to accommodate this case study based on the general understanding of water use that has been described in previous sections.

A schematic representation for water in input-output matrices is shown in Figure 1. Two new sectors -- a water utility and a sewage treatment sector -- and a number of characteristics of in-

Figure 1. Water Use, Discharge, and Treatment in the Input-Output Model



Notes:

1. + designates inputs; and
   o designates outputs
2. The basic static equation is

$$x_i - \sum a_{ij} x_j = y_i \quad \textit{where} \quad x_i$$

may be the amount of processed water or of sewage processing services.

3. See text for further discussion.

coming and discharged water are included in the figure. This representation, relevant for either a static or a dynamic analysis, has been developed expressly for this study.

It is relatively straightforward to add an exogenous row of coefficients measuring water inputs, and another for water discharges, per unit of sectoral output to an input-output matrix. However, this simple representation has a number of serious shortcomings; in particular, it fails to capture the economic resources and activities that are required to render water fit for consumption and for discharge. The formulation in Figure 1, by contrast, has the advantage of "closing" the model for the activities of the water utility and the (future) sewage treatment plants. This assures that for every additional unit of water distributed to users, the water utility will automatically increase its level of activity. Likewise, the sewage utility will purchase the required amount of additional inputs for each additional unit of sewage (or other effluent discharged into the sewage system) that it needs to process. In a standard input-output table, such as those compiled by BPS, the water utility is aggregated with the electric and gas utilities in a single sector while the sewage utility (in economies where it exists) is included with other government activities as a part of final deliveries. Thus, the new representation requires disaggregating electricity, gas, and water; this has already been done for the present study to enable a closer analysis of energy use. The new representation also requires

creating a column (or disaggregating the existing column of government deliveries and moving it into the matrix in cases where the sewage utility is already operational) and corresponding row for the potential sewage utility.

The new matrix in the lower left of Figure 1 provides for representing the intake of water from the surface or the ground as alternatives to the water utility. It also allows for the discharge to surface or ground water, as an alternative to the sewage system, and for a description of the principal pollutants. The rows of this matrix are likely to be refined considerably in the course of detailed case studies.

The sectors of the Indonesian economy, identified according to their codes in the input-output classification scheme, can be organized into the following groupings for the purposes of quantifying the use of water:

Agriculture	#1-4
Forestry	5
Fisheries	6
Mining	7-10
Food/Bev/Cig	11
Paper	13
Chemicals, etc.	14-15
Yarn/Text/App	17.1-17.2
Petroleum Refining	18
Other Manuf.	12, 16, 17.3-17.10, 19
Electricity	20
Water Supply	22
Other Services	21, 23-30

Most of these groupings are discussed in Sections 7-14 of this paper which highlight the distinctive features of water use in the corresponding sectors.

Part II. Case Study Guidelines

6. Guidelines

With the variables and parameters now specified, let us turn to the 10 steps for a case study (Duchin and Lange, IEA WP#2):

1. Choose the subject of the case study.
2. Identify the relevant sectors
3. Describe the sectors.
4. Distinguish column issues from row issues.
5. Identify possible future technologies.
6. Compile control totals for evaluating the work.
7. Define two alternative scenarios, S1 and S2.
8. Customize the data sheets on which the information will be recorded.
9. Fill in the data sheets.
10. Provide documentation.

Our subject is the use, treatment, and discharge of water measured in cubic meters and tons per meter of pollutant content. The relevant sectors, in addition to the water and prospective future sewage utilities, are the principal water-using sectors in Indonesia.

The column issues of the water and sewage utilities refer to their input requirements per unit of water delivered or sewage processed. These will depend upon the scale of an individual plant, the condition of the water with which it deals, and the technologies adopted. The column issues for other sectors, say

pulp and paper, were suggested in Figure 1 which shows this sector taking a portion of its water from the surface and the rest from the water utility and discharging some of its effluent to the sewage system and the remaining, heavily polluted water to the surface waters. How the industry determines these proportions, and the technological changes it may adopt in order to reduce its intake of water or the pollutant load of its discharge, are column issues.

The row issues for the water and sewage utilities have to do with determining who their clients are or could be and the amount of service delivered to each. The row issues concerning water use are simply a complementary way of addressing the column issues that were described in the last paragraph for the pulp and paper industry. If, for example, all major water-using sectors were able to economize 20% of the water they would otherwise purchase from the water utility by using improved house-keeping methods, one can reduce all coefficients in the utility row by 20% instead of having to examine each one individually. The art of the case study is to cover the entire matrix as economically as possible; this requires working sometimes by row and sometimes by column.

It is always useful to collect control totals, that is, measurements, estimates, or projections that are made outside the case study, for comparing against the data developed in the course of the case study. Unless the control totals are direct measurements, they are generally not superior to the case study

work and therefore cannot be considered "controls"; they may still provide additional information.

The purpose of the case study is to define two scenarios defining alternative future paths for the sectors under study that differ by the importance laid on avoiding environmental degradation in the choice among alternative technologies. The scenarios will be called S1 and S2 to align them with the scenario assumptions made for other sectors in other case studies. (After each case study, it may be necessary to revise previous ones to assure their compatibility with the assumptions of the new one.) In the case of water, where no data exist for the base year in the official input-output table for 1985, it will be advisable to proceed in smaller steps and to start by simply gathering information about the use and management of water at the present time in the course of the other case studies -- namely, those for agriculture, forestry, and the manufacturing sectors. Additional rows for water use and water discharge have been provided on the data sheets for this purpose.

The remainder of this paper provides some detail about the use and discharge of water in the major water-using sectors and about the technologies that are used, or potentially used, in these sectors. These sections are intended to give the case study analysts some background that will enable them to ask the right questions of industry or technical experts in order to elicit a quantitative description of current water use and future prospects in the course of the initial inquiry. The basic questions are:

•What is the source of water for this sector and how is it used?

•What is the volume of water intake and discharge?

•Where is water discharged and what are the principal constituents of the effluent?

•Is the water treated before discharge?

•What are the prospects for improved house keeping, water reuse and recycling, and process change in this sector?

7. Agriculture, Forestry, and Fisheries (#1 - 6)

1 Paddy
2 Other Farm Food Crops
- 2.1 Hand-pounded rice
- 2.2 Maize
- 2.3 Root crops and flour
- 2.4 Vegetables & fruits
- 2.5 Other farm food crops

3 Other Agricultural Crops
- 3.1 Rubber
- 3.2 Sugar cane & brown sugar
- 3.3 Coconut
- 3.4 Crude coconut & palm oil
- 3.5 Tobacco
- 3.6 Coffee
- 3.7 Tea
- 3.8 Cloves
- 3.9 Pepper & nutmeg
- 3.10 Other estate crops
- 3.11 Other crops

4 Livestock Products
- 4.1 Livestock products
- 4.2 Slaughtering
- 4.3 Poultry & products

5 Forest Products
- 5.1 Wood
- 5.2 Other forestry products

6 Fishery Products

There are 6 agricultural sectors in the 30-sector classification. The agricultural case studies include estimates of the volume of water for irrigation, or other purposes, used in each sector in Indonesia. (See the draft of NRMP WP#4 for preliminary figures.) In this discussion we focus mainly on crops.

The large volumes of water required for irrigation often compete with other uses in precisely the same way that crop agriculture competes for land with forests, grazing, and urbanization. Crop yields can vary enormously depending upon the farming system used, and the choice of crop mix will depend in part on the availability of water throughout the season.

The availability of water and the cost of irrigation are not the only water-related problems, for crop agriculture is a major source of water pollution. The waterborne wastes are the excesses and residues from growing crops and from the initial processing of raw agricultural products. The seasonal nature of agricultural operations, and therefore of the generation of associated wastes, makes it difficult to adopt water-control techniques that produce consistent results. Especially with the increasing intensity of agricultural production, there is clearly a need to develop alternative methods to minimize the generation of agricultural wastes and to handle, treat, and dispose of them with minimum contamination of the environment.

One of the principal problems with runoff from agriculture is the build-up of excess nitrogen and phosphorus compounds in surface waters due to high rates of fertilizer application which can cause eutrophication of the receiving bodies of water. The nitrogen can take many forms. Nitrates are of greatest concern as they are water-soluble, subject to leaching, and will move with the surface water. Excessive nitrates render groundwater and surface water unfit for many uses and alter the effectiveness of chlorination. They may also be responsible for ammonia toxicity to fish and reduced nitrogenous oxygen demand in surface waters. Key factors regulating the leaching of contaminants, such as compounds of nitrogen and phosphorus, from the soil are the quantity of rainfall or drainage water and the permeability of the soil. The risk to

groundwater from nitrates is greatest in shallow wells near feedlots, barnyards, or manure piles.

There is also increasing water pollution due to pesticides, especially chlorinated hydrocarbon insecticides used in irrigated rice culture and export crop production. While organochlorines are substantially less expensive than alternatives, the build-up of such persistent pesticides threatens the culturing of fish in irrigation canals, rice paddies, and ponds fed by irrigation water. Both fresh water and brackish water aquaculture are at substantial risk. This could result in the loss of an important source of animal protein.

Agriculture is a major contributor to the huge quantities of sediment that wash into streams and rivers each year. There are many motivations for attempting to limit the transport of sediment. Sediment can reduce the recreational value of water and silt up dams constructed for hydro-power and flood control; it also increases water treatment costs and carries away plant nutrients, crop chemicals, and plant and animal bacteria. This erosion loss is not distributed evenly throughout the country. Losses are relatively small in areas of high-density natural vegetation and larger in areas where agriculture is more intense. Agriculture and fisheries are among the principal victims of their problem. The motivation to limit the transport of sediment is considerable. Over a recent 8-year period, the silt content of major rivers in

the most densely populated islands of Indonesia increased tenfold (Haeruman, 1983).

8. Food and Related Products

11 Food and tobacco products
- 11.1 Food processing and preserving
- 11.2 Oil and fat
- 11.3 Cereal mill products
- 11.4 Flour
- 11.5 Sugar
- 11.6 Other food products
- 11.7 Beverages
- 11.8 Cigarettes

Water is used in the food processing industry for the transfer of heat and the transport of solids. Where high quality water is plentiful, fresh water can be used at each stage of processing. A shortage of high quality water requires conservation, primarily through reuse of water or alteration of basic processes.

Continuous reuse of water through different processing stages is possible, but this requires more expensive machinery and special handling because of the potentially hazardous or corrosive nature of the chemicals which must be added to reused water to maintain its quality.

A substitution of dry for wet processing, for eaxmple, dry peeling of fruit and vegetables, can also substantially reduce water requirements (Spiedel, 1988, p. 222). Most dry processing techniques are fairly recent, however, and their prospects in Indonesia need to be assessed.

Aqueous effluent from the food industry generally contain animal, fish, or vegetable fat, protein, and carbohydrates which are particularly high in BOD. Because fatty matter in food industry wastes is almost always readily biodegradable, it

contributes totally to BOD. Therefore, strict controls are needed on discharges to surface waters, rivers, and coastal waters. Fatty effluent from the food industry, especially animal products whose wastes are all classified as fatty matter, require more costly treatment than separable solids.

Fatty wastes may be treated by biological, chemical, or physical systems, or some combination of the three. Biological means are generally adequate for most fatty matter waste processing although the biological treatment of wastes may require chemical pre-treatment.

In physical treatment systems, the separation of oil and water is accomplished essentially by gravity, sometimes with the addition of chemicals to destabilize the emulsion. The objectives are to reduce the pollutant load being discharged and recover potentially usable fat. In the future, the separation may be achieved using membranes.

Waste particulate solids are removed from food-bearing effluent for reuse, disposal, or transformation. Then the remainder of the "fines" and solubles in suspension or solution in the effluent is transformed by aerobic or anaerobic means. The end products include very low grade biomass (fertilizer-grade), energy in the form of heat, or methane. The major methods of recovering soluble protein are by membrane filtration and adsorption techniques. Because of the nature of food water pollutants, land-spreading is an alternative for disposal.

9. Pulp and Paper

13 Pulp, paper and products

Pulp mills use vast amounts of water; this input is second in volume only to the fiber itself. Water requirements per ton of sulphite pulp are even greater than for kraft pulp. Water is used to raise steam (e.g., for drying), and for cooking, washing and transporting fibers throughout the production process and to cool pumps and machines. Most of the water use is eventually discharged, along with a great quantity and a large variety of waste including heavy solids like fibers, bark, uncooked wood chips, and dirt; dissolved solids like carbohydrates (sugar and sugar derivatives) and soluble wood matter; and cooking and bleaching chemicals. Rivers have traditionally been used both for water supply and to receive the effluent. The amount of waste material discharged from a pulp mill is measured in BOD. Other annoying discharges are foam (from resins, fatty acids, and chemicals in the effluent) and dark color which can block sunlight.

In recent years there has been vast improvement from an environmental point of view in the pulp and paper industries of developed countries. This includes the use of lumber wastes for fiber in pulp mills, simultaneous provision of process heat and electricity through cogeneration, recycling of papers, and the recent move toward replacing conventional inks, which contain heavy

metals, with inks of vegetable origin. These measures result in at least indirect economies of water use. One of the most important changes directly affecting water use is the greatly increased recycling of cooking liquors.

Within an individual plant, water can be economized through good housekeeping practices for the reduction of spills and leakage, greater water recycling, and reuse of spent liquors. On-site effluent treatment is common and includes primary sedimentation, secondary treatment in ponds or lagoons, and tertiary physical and chemical methods such as microscreening and reverse osmosis.

10. Chemicals

14 Fertilizer and pesticides
15 Chemicals

While the chemical industry is a major user of water, water use in most countries has not grown as rapidly as output, in large part because of recycling and reuse. Nonetheless, the industry must find additional ways to reduce water use as it faces rising water costs, local shortages of water, and disposal constraints for effluent.

For uses such as material cooling or crude washing, the quality or variation in quality of the water is not important. On the other hand, water containing dissolved mineral impurities is unacceptable for operations involving brewing, dyeing, pigments, and plastics. In addition, many newer processes and more sophisticated products require demineralized process water of very high purity.

Most water in the chemical sectors is used to convey materials, in solution or suspension, or to convey heat (i.e., for cooling) in the production process. Perhaps as much as 80% of the industry's intake of water is for condensing and cooling. While there has been a decided move toward heat recovery to improve energy efficiency, surplus heat is still removed by raising the temperature of water. A small amount of water may be evaporated, decomposed by chemical reaction, or be incorporated in products or waste (perhaps 5%). As in other sectors, water is also used for

cleaning, personal needs of employees, fire fighting, and air-conditioning.

There are several approaches to reducing water use: recycle water used as a conveyor (of both heat and materials), have water fulfill more than one function before it is discharged, or replace water by some other medium. Generally, all reuse requires some treatment of water.

Both cooling water and process water can be recycled. Cooling water, often obtained from a natural supply because of the large quantities required, may need considerable treatment to remove insoluble material, prevent the formation of hardness scale, for disinfection, or to minimize corrosion. Rinse waters in metal finishing and other chemical processes are frequently recycled especially when it is economic to recover process materials.

Outgoing contaminated water can be used to wash a dirty product; in many cases, only the final product needs to be washed in clean water. In some sectors, such as electricity and petroleum refining, water has been replaced by air or other media for cooling at a substantial savings in capital and operating costs. It is likely that some segments of the chemical industry can use these techniques as well.

Wastewater and Its Treatment

The organic chemical industry is the major industrial source of hazardous chemicals in wastewater, accounting in the US for about 80% of these discharges to surface waterways and to sewage plants; most of the remainder in the US is released by metal finishing and by the iron and steel sector (Sarokin, p. 17 - 18). The organic chemical industry also accounts for about half of the hazardous chemicals injected into underground wells; another 25% is accounted for by petroleum refining.

In addition to organic chemical waste discharges, there are even more vast quantities of effluent which are highly saline, acidic, alkaline, or containing large amounts of suspended insoluble matter. The materials in these concentrations are not considered valuable enough to merit recovery on purely economic grounds and, in any case, may be so mixed and complex as to defy analysis. Typical treatment requirements are the following:

.neutralization of acidity or (less commonly) alkalinity

.sedimentation of suspended solids

.removal of floating scum, oil, tars, etc.

.biological oxidation of organic impurities (to meet sewage standards) by percolating filter treatment or, for chemicals that decompose slowly or not at all, activated sludge treatment.

These procedures are similar to those in municipal sewage treatment plants, except that the latter are able to use more elementary design.

11. Textiles

17.1 Yarn spinning
17.2 Textile, leather & wearing apparel
- Weaving
- Made-up textile goods, except wearing apparel
- Knitting
- Wearing apparel
- Carpet, rugs, rope, etc.
- Other textiles
- Tanned and finished leather
- Footwear & leather products

In some sectors, water availability is a major potential problem and motivates reuse and process modifications. In the textile industry, the major concerns are the discharge of waste products to water and measures to reduce and treat these discharges. The wastes from a textile finishing mill come from two sources: the natural impurities present in natural fibers and the chemicals used to process natural and synthetic fibers. The industry uses a large amount of salt, ionic dyes, inorganic catalysts, detergents and bleaching agents that add to the dissolved solids concentration of the wastewater. The natural impurities are the largest source of pollution in the processing of natural fibers (cotton and, especially, wool) and are contained in a highly concentrated effluent. The finishing wastes from synthetic fiber are lower in volume and concentration per gallon of water used but contain toxic materials from the dyeing process.

There are basically three approaches to reducing the volume of wastewater that must be treated and the concentration of pollutants

in the wastewater: in-plant waste reduction, joint mill-municipal waste treatment, and textile mill waste-treatment plants.

Within the mill, the following six measures can be taken:

1. Reduction of wastewater volume by counterflow processing and water reuse techniques

An important example is closed cycle dyeing. Dye water is typically used only once because it needs to be relatively pure for high-quality colored fabrics (Spiedel, p. 220). Then it is treated to remove the color. New techniques like reverse osmosis, or hyperfiltration, have been used (by the US Environmental Protection Agency) to filter the water for recycling.

2. Reduction of the amount of process chemicals by closer analysis of requirements

3. Recovery and reuse of process chemicals

4. Process modifications

Continuous operations generally require less space, less water, and less chemicals than batch operations. An example of possible process modifications is pumping process liquor to a storage tank and saving it for reuse in the next similar bath. It is also possible to use heat exchangers to transfer the high temperature of some effluent to incoming process water or to use solvent processing (non-aqueous) and recover the solvent.

5. Substitution of chemicals

An example is the substitution of low BOD for high BOD chemicals (e.g., synthetic detergents for soaps). Sometimes the substitution is satisfactory from many points of view, but there may be drawbacks like high cost or other undesirable effects.

6. Good housekeeping practices can often reduce the pollutant load by 5 - 10%. For example, close control over the mill's operations makes it possible to avoid spillages and better handle those that do occur.

If in-plant guidelines have been followed, the effluent may be clean enough or low enough in volume to discharge to a municipal sewage treatment facility. Municipal plants that are able to handle this load from a textile mill may require larger capacity and pre-processing with trickling filters or a chemical coagulation process which would not otherwise have been needed. In joint treatment arrangements, the municipality may find it essential to limit the rate of flow or the temperature of the effluent it will accept. It may also place limits on the Ph, the concentration of toxics, and the concentration of BOD and suspended solids.

If there is no existing municipal capability, a joint venture that will include domestic sewage treatment may be cost-effective. For a simple installation, this will require land, labor, electricity, chemicals, supplies, and maintenance.

If it is not possible to discharge effluent to a municipal sewer, a large mill is likely to require its own waste treatment plant. Preliminary processing is necessary to remove grit and solid material. Then the primary processing removes settleable and floatable solids. Secondary processing removes biodegradable organic matter. Tertiary treatment may be needed to remove materials resistant to secondary treatment.

Preliminary and primary stages may involve **segregation** of waste streams, to isolate toxics, for example. Treatment includes equalization, to make the waste uniform; this can be accomplished by mixing and storing the effluent in ponds and basins. The mixed liquors from a textile plant are generally alkaline and may require **neutralization**. **Disinfection** can destroy wastes which would be toxic to the microbes utilized in the secondary stage. When done as final treatment step, it may prevent undesirable items from reaching the receiving stream. **Screening** removes solid wastes and **sedimentation** removes suspended settleable solids. Another method of separation of solids from liquids is flotation with flocculation.

The secondary treatment involves oxidation of organic matter by aeration, chemical or biological methods, or a combination. Wastes stored in equalization and sedimentation basins are subject to anaerobic decomposition and fecal odors.

Tertiary treatment removes organics by adsorption, foam separation, and chemical oxidation, e.g., by activated carbon.

12. Petroleum Refining

18 Petroleum refining

In the refining of petroleum, water is used for three purposes: cooling, production of steam, and desalting (Russel, p.67). Each process involves different amounts of treatment before the water can be used, and recirculation to each use requires a different treatment of the effluent. Cooling water withdrawals are about 90% of the total and require little pretreatment, while water for the boiler needs to be demineralized to reduce scaling. The desalter removes salt-water brines found in the oil; a few gallons of makeup water are required to carry away the brines from an average barrel of oil.

A refinery discharges three major types of water streams: cooling water, spent caustics and acids, and process steam condensate containing dissolved sulfide and phenols as well as suspended and dissolved solids, BOD, and heavy metals. Historically, the amount of water discharged has decreased substantially as the cost of providing water of different qualities has increased. Economy of water use is achieved through the use of cooling towers, secondary and tertiary treatment of effluent to return it to the boilers, and adoption of equipment with a lower heat-rejection rate.

Treatment of the spent caustics and acids releases "spent acid," which is incinerated, and "spent water," which is treated

with the water from the desalter (discussed below) except that it has no oil content.

The treatment of process condensates (except for water from desalting) requires the sour-water stripper where some chemicals (e.g., H_2S and ammonia) are recovered. Then an oil-water separator recovers most of the oil. Desalter water requires an individual separator (before the oil-water separator) because of its high load of solids.

Subsequently the stream may be discharged, used as make-up water for the cooling tower, or subjected to biological treatment. The latter process produces a sludge.

13. Electricity Generation

20 Electric utilities

The bulk of water used by industry in industrial countries, and probably in all economies, is for the production of electricity. There is generally little consumptive loss, and the principal disposal problem is the elevated temperature of the water. The disposal problems are less complex than in other industries where water is used as a coolant, lubricant, and process component.

Electricity generating plants use fresh water for cooling, and certain fuel conversion processes require water as a feedstock. Currently, fresh water is used; in the future it may be possible to substitute dry cooling or to use agricultural waste water, piped seawater, or water that has been desalinized. Hydroelectric power plants consume water in the sense that there are evaporation losses from artificial lakes.

The major ways of cooling steam electric power plants are once-through without storage, once-through with storage capability which is intended to smooth out the availability of water, and the wet cooling tower (see Hart and El-Gasseir, p. 152, for some representative figures about water use in each case). While the tower method requires by far the lowest amount of water withdrawal, consumption amounts to 2/3 of the amount of withdrawal. The worst combination is once-through water use with storage which has

virtually the same withdrawal requirements as without storage as well as significant consumption due to evaporation.

The cooling required for a light-water nuclear reactor is considerably greater than that for a modern coal- or petroleum-fueled plant of current technology of the same capacity, in part because the latter typically releases 15 - 20% of its waste heat directly into the atmosphere with the flue gases. At equal output of electricity, the former requires 39 to 50% more cooling water.

The production of electricity by nuclear power results in radioactive waste that may be in gaseous, liquid, or solid form. With the development of equipment and facilities to hold and process liquid radwastes, the industry has the capability to hold releases of radioactive material in liquid effluent. These are subjected to various operations to reduce the quantity of liquid or to decontaminate them prior to recycling or discharge.

14. Water Utility and Sewage Utility

22 Water Utility
Sewage Utility (no sector)

In order to accommodate industrialization and to improve the quality of life, it will surely be necessary to expand the public water supply and provide sanitation services over the next 25-year planning horizon to satisfy the requirements of households and other public and private uses.

In the earlier sections of this paper, various industrial processes have been described for removing impurities from surface and ground water; these are similar when performed by a municipal sewage utility. Technologies for the primary, secondary, and tertiary treatment of sewage is likewise similar to the treatment of other effluent containing biological contaminants.

While the development of scenarios about these sectors will need to await the commitment of resources for a new phase to this project, it would be useful if a small case study could be done to estimate:

- .the volume of metered water currently provided
- .the volume of water used by households by its source
- .the principal contaminants of household water
- .the volume of sewage generated and a brief description of any plans to provide sewage treatment facilities.

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Annex A. Proposed Classification Scheme for Water

This Annex identifies four categories of the polluting substances most commonly found in water effluent. The first category, Overall Measures, includes the three aggregate variables that appear on the case study data sheets (see IEA WP#2, Annex C). The other categories provide detail about nutrients, harmful substances, and microbiological discharges.

Five classes of water quality are defined in the second section of this Annex. Then, in Table A.1, each is characterized by an approximate profile of its oxygen regime and detailed suspended or dissolved solids (from the first part of the Annex).

This information reflects the draft ECE standard statistical classification of ecological freshwater quality (as of March 1990) which is reported in (United Nations, 1991, Annex III).

A. List of Polluting Substances

1. Selected overall measures (tons)
   - 1.1 Biochemical oxygen demand of discharges (BOD_5)
   - 1.2 Chemical oxygen demand of discharges (COD-Mn)
   - 1.3 Total suspended solids
   - 1.4 Total dissolved solids

2. Nutrients (tons)
   - 2.1 Total phosphorus
   - 2.2 Total nitrogen

3. Harmful substances (tons)
   - 3.1 Arsenic
   - 3.2 Cadmium
   - 3.3 Chromium
   - 3.4 Copper
   - 3.5 Lead
   - 3.6 Mercury
   - 3.7 Nickel
   - 3.8 Zinc
   - 3.9 Aluminum
   - 3.10 Other harmful inorganic substances
   - 3.11 Petroleum hydrocarbons

3.12 Organic chlorinated hydrocarbons
3.13 Other organic compounds

4. Microbiological discharges (number/100ml)
4.1 Thermo-tolerant coliforms
4.2 Faecal streptococci

B. Water Quality Classes

Table A.1 contains water quality variables and quality ranges by class. Values for flowing water are given in parentheses. Unbracketed values refer to both stagnant and flowing water bodies, or, if accompanied by values in parentheses, to stagnant water.

Overall quality classes are defined as follows:

Class I: Excellent (blue)

Clear, oligitrophic water in natural state or with a very slight, occassional anthropogenic pollution with organic (but not inorganic) matter. Constant near-saturation of oxygen content, low nutrient and bacterial content; provides spawning grounds for salmonids. The buffering capacity of the water is very good.

Class II: Good (green)

Slightly polluted; mesotrophic water receiving small discharges of organic matter from municipal waste-water treatment plants or from diffuse loading. The oxygen saturation of water bodies is good throughout the year. The loadings may lead to slightly increased primary productivity. The buffering capacity of the water is good. Possible influents do not contain harmful substances.

Class III: Fair (yellow)

Moderately eutrophic water receiving considerable amounts of discharge of organic matter and nutrients. Oxygen deficiencies may occur in the hypolimnion. The level of primary production is considerable, and some changes in community structure, including fish species can be observed. The buffering capacity is weak but keeps the acidity of the water at levels which are still suitable for most fish. Loading by harmful substances and microbial pollution are evident. Concentrations of harmful substances vary from natural levels to levels of chronic toxicity for aquatic life.

Class IV: Poor (orange)

Strongly eutrophic, polluted water, receiving discharges of organic matter, nutrients and harmful substances. Oversaturation of oxygen occurs in the epilimnion, and oxygen deficiencies are frequent in the hypolimnion. Algal blooms are common. Increased decomposition of organic matter together with stratification of water bodies may entail anaerobic conditions and fish kills. Mass occurrences of more tolerant species; populations of fish and benthic organisms affected. The buffering capacity is exceeded, leading to considerable levels of acidity which affect the development os spawn. Microbial pollution prevents the use of water for recreation. Harmful substances either discharged or released from sediments affect the quality of aquatic life. Concentrates of harmful substances vary from levels of chronic to those of acute toxicity for aquatic life.

Class V: Bad (red)

Extensively polluted, hypertrophic water. Major problems occur in oxygen regime - i.e., oversaturation in the epilimnion and oxygen deficiency leading to anaerobic conditions in the hypolimnion. Decomposers dominate over producers. Fish or benthic species do not occur permanently. The water is without buffering capacity and its acidity is harmful for many fish species. Concentrations of harmful substances exceed acute toxicity levels for aquatic life.

Table A.1. Variables and Concentration Ranges by Quality Class

	Class I Excellent (Blue)	Class II Good (Green)	Class III Fair (Yellow)	Class IV Poor (Orange)	Class V Bad (Red)
Oxygen regime					
DO (%) epilimnion	90-110	70-90, 110-120	50-70, 120-130	30-50, 130-150	<30,>150
hypolimnion	90-70	70-50	50-30	30-10	<10
total	90-70	70-50, 110-120	50-30, 120-130	30-10, 130-150	<10,>150
DO (mg/l)	>7	7-6	6-4	4-3	<3
BOD 5 (mg O2/l)	(<3)	(3-5)	(5-9)	(9-15)	(>15)
COD-Mn (mg O2/l)	<3	3-10	10-20	20-30	>30
Eutrophication					
Total P (µg P/l)	<10(<15)	10-25(15-40)	25-50(40-75)	50-125(75-190)	>125(>190)
Total N (µg N/l)	<300	300-750	750-1500	1500-2500	>2500
Chlorophyll a (µg/l)	<2.5(<4.0)	2.5-10(4-15)	10-30(15-45)	30-110(45-165)	>110 (>165)
Acidification					
pH	6.5-8.5	6.5-6.3	6.3-6.0	6.0-5.3	<5.3
Alkalinity (mg CACO3/l)	>200	200-100	100-20	20-10	<10
Harmful substances					
Heavy metals and cyanides					
Aluminum (µg/l, pH:<6.5)	-		<5	5-75	>75
(µg/l, pH:>6.5)	-		<100	100-500	>500
Arsenic (µg/l)	<10		10-50	50-100	>100
Cadmium[a] (µg/l)	<0.07		0.07-0.7	0.7-1.8	>1.8
Chromium[a] (µg/l)	<1		1-11	11-16	>16
Copper[a] (µg/l)	<2		2-6.5	6.5-9.2	>9.2
Lead[a] (µg/l)	<0.1		0.1-1.3	1.3-34	>34
Mercury[b] (µg/l)	<0.003		0.003-0.012	0.012-2.4	>2.4
Nickel[a] (µg/l)	<15		15-88	88-790	>790
Zinc[a] (µg/l)	<45		45-59	59-65	>65
Cyanides (µg/l)	<0.5		0.5-5.0	5.0-22	>22
Others					
Dieldrin (µg/l)	0		<0.0019	0.0019-2.5	>2.5
Chlordane (µg/l)	0		<0.0043	0.0043-2.4	>2.4
DDT and Metabolites (µg/l)	0		<0.001	0.001-1.1	>1.1
Endrin (µg/l)	0		<0.0023	0.0023-0.18	>0.18
Heptachlor (µg/l)	0		<0.0038	0.0038-0.52	>0.52
Lindane (µg/l)	0		<0.08	0.08-2.0	>2.0
Malathion (µg/l)	0		0	<0.1	>0.1
Parathion (µg/l)	0		<0.013	0.013-0.065	>0.065
Pentachlorophenol[c] (µg/l)	0		<3.5	3.5-5.5	>5.5
PCBs (µg/l)	0		<0.001	0.001-2.0	>2.0
Toxaphene (µg/l)	0		<0.2	0.2-730	>730
Radioactivity[d]					
Microbial pollution (median No/100 ml)					
Thermo-tolerant coliforms	<10	10-30	30-100	100-1000	>1000
Faecal streptococci	<10	10-30	30-100	100-1000	>1000

a/ Calculated for standard hardness of 50 mg CaCO3/l. Adjustment for different levels of hardness.

b/ Calculated for standard hardness of 50 mg CaCO3. Adjustment formula for different levels of hardness currently under development.

c/ Calculated for standard pH of 6.5. Adjustment for different pH values.

d/ Ranges will be specified according to test results.

Source: United Nations, 1991, Annex III.

Annex B. Sectoral Classification Scheme

This classification scheme has been developed to accomodate both the 30- and the 75- sector classifications. The 2-digit (i.e., #1-30) level corresponds to the 30 sector scheme and the full code (of up to 3 digits, e.g., #11.5) corresponds to the 75-sector scheme. In present work, the unit is 1985 rupiahs unless otherwise noted.

Code	Sector
1	Paddy
2	Other Farm Food Crops
2.1	Handpounded rice
2.2	Maize
2.3	Root crops & flour
2.4	Vegetables & fruits
2.5	Other farm food crops
3	Other Agricultural Crops
3.1	Rubber
3.2	Sugar cane & brown sugar
3.3	Coconut
3.4	Crude coconut & palm oil
3.5	Tobacco
3.6	Coffee
3.7	Tea
3.8	Cloves
3.9	Pepper & nutmeg
3.10	Other estate crops
3.11	Other crops
4	Livestock and Products
4.1	Livestock products
4.2	Slaughtering
4.3	Poultry and products
5	Forest Products
5.1	Wood
5.2	Other forest products
6	Fisheries
7	Coal mining (tons of coal equivalent)
8	Crude oil mining (tons of coal equivalent)
9	Natural gas mining (tons of coal equivalent)
10	Other mining and Quarrying
10.1	Metal ore mining
10.2	Other nonmetallic mining and quarrying
11	Food and Tobacco Products
11.1	Food processing & preserving
11.2	Oil & fat
11.3	Cereal mill products
11.4	Flour
11.5	Sugar
11.6	Other food products
11.7	Beverages
11.8	Cigarettes

12 Wood Products
12.1 Sawn and processed wood
12.2 Plywood & other products
12.3 Wooden construction material
12.4 Wooden furniture and fixtures
12.5 Wood and cork products
12.6 Woven goods other than yarn and plastic

13 Pulp, paper and products

14 Fertilizer & pesticide

15 Chemicals

16 Cement

17 Other Manufacturing
17.1 Yarn spinning
17.2 Textile,leather & wearing apparel
17.3 Rubber & plastic wares
17.4 Glass, clay, and non-metallic mineral products
17.5 Basic iron and steel
17.6 Nonferrous basic metal
17.7 Fabricated metal products
17.8 Machines, electrical mach. & apparatus
17.9 Transportation equipment & repair
17.10 Other products n.e.c.

18 Oil refineries (tons of coal equivalent)

19 Liquid natural gas (tons of coal equivalent)

20 Electric Utilities

21 Gas Utilities (tons of coal equivalent)

22 Water supply

23 Construction

24 Retail & wholesale trade

25 Restaurant & hotels

26 Transportation and Communication
26.1 Railway transport
26.2 Road transport
26.3 Water transport
26.4 Air transport
26.5 Services allied to transport
26.6 Communications

27 Financial and Business Services
27.1 Financial intermediaries
27.2 Real estate & business services

28 Public adm.and defense

29	Services
29.1	Social & community services
29.2	Other services
30	Unspecified sector

Categories of Labor

Code	Sector
L1	Highly trained
L2	Technically trained
L3	Unskilled

Environmental Categories

Code	Sector
	Water
N1.1	Water Input (1000 m^3/unit of output)
N1.2	Water Output (1000 m^3/unit of output)
N1.3	BOD (1000 m^3)
N1.4	Dissolved Solids (kg/1000 m^3)
N1.5	Suspended Solids (kg/1000 m^3)
N1.6	Heavy Metals (kg/1000 m^3)
	Land
N2.1	Land Area (ha/unit of output)
N2.2	Soil Erosion (tons/ha)
N2.3	Deforestation (ha deforested/ha logged)
	Air
N3.1	Carbon (tons/tce)
	oil
	gas
	coal
N3.2	Sulfur Dioxide (tons/tce)
	oil
	gas
	coal
N3.3	Nitrogen Oxides (tons/tce)
	oil
	gas
	coal
N3.4	Particulate (tons/tce)