ECONOMIC AND SOCIAL COMMISSION
FOR ASIA AND PACIFIC

ACCOUNTING AND VALUATION OF ENVIRONMENT

VOLUME II

CASE STUDIES FROM THE ESCAP REGION

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SD / TECPUB / 1

FOREWORD

The concept of economic growth through sustainable development is being widely accepted by countries within and outside the ESCAP region. Among the contemporary issues receiving government attention is the integration of environment and development in decision making. Towards that end, Agenda 21 which was adopted at the Earth Summit in 1992 recommended the establishment of systems for integrated environmental and economic accounting.

Under the guidance of the ESCAP Committee on Statistics, the secretariat is charged with the responsibility of promoting statistical capability in the region. Accordingly, in 1992, the Statistics Division developed a multiple-year project entitled Systems of Environmental and Resource Accounting, for which the Government of The Netherlands has generously provided financial support. The project enabled five countries in the region to undertake studies for the presentation of environmental and resource accounts for specific resources of major concern to their countries. Guidelines for environmental and resource accounting were developed by consultants. The project culminated in a regional Seminar on Environmental and Resource Accounting, which was organized at Seoul from 27 to 31 May 1996, for which the Government of the Republic of Korea, through its Korea Environmental Technology Research Institute, provided supplementary financial support. The Seminar recommended that a publication based on that meeting be produced for wide circulation.

The Seminar noted that few countries in the region had undertaken compilation of environmental and resource accounts. It is hoped that the publication will be useful to statisticians embarking on this type of work in their countries. The publication will be issued in two volumes. Volume I contains a Primer on Environmental and Resource Accounting, while Volume II presents selected proceedings of the Seminar.

The ESCAP secretariat is grateful to the Government of The Netherlands and the Government of the Republic of Korea for their financial support. We wish to express our appreciation to the principal consultants, Dr. Kirit Parikh and Dr. (Mrs.) Jyoti Parikh of the Indira Gandhi Institute of Development Research (IGIDR), Mumbai, India for their excellent contribution to the project. The consultants have been involved and provided valuable guidance in various activities of the project, including advising country experts in the preparation of country studies, the development of the guidelines as presented in Volume 1, and the conduct of the Seminar. We are grateful to the Indira Gandhi Institute of Development Research for organizing the present publication, with funds provided by the Government of The Netherlands.

Adrianus Mooy
Executive Secretary

PREFACE

This volume contains country case studies of accounting and valuation of the environment for some countries of the Asia Pacific region. It is a follow up to Volume I, a primer for developing countries, in which we had provided the motivation for environmental accounting and explained basic concepts and different approaches to the subject. It had also set out a step-by-step process, leading to a system of integrated economic and environmental accounts on the lines proposed by the United Nations Statistics Division, viz. system of integrated economic and environmental accounts (SEEA).

Case studies in this volume illustrate how accounting and valuation can be carried out in specific situations for air, solid waste, forestry, water and fisheries.

These studies were carried out over a period of one or two years and presented at the seminar on environmental resource accounting, held in Seoul in 1996 with the support of the Government of The Netherlands. Subsequently, these studies were modified. Contributions that needed to be highlighted and placed in the public domain were identified by the editors and polished substantially to transform them from a project report format to an almost text-book level presentation. In doing so, we have enlarged our audience from statisticians and national accountants – who are traditionally working in national statistics – to also include other environmental experts, policy-makers, teachers, students and interested lay-persons.

Chapter 1 carries out an environmental assessment for India to help decide which environmental resources are of importance and what type of satellite accounts need to be constructed at the national level. It identifies air pollution, solid waste, degradation of land and loss of biodiversity as some of the major problems in India.

Chapter 2 shows how to prepare accounts for air quality in a step-by-step manner, by using different sectoral information. Since air pollution levels and impact vary from place to place and often the problem is more intense at a local level, a national approach may be misleading. Therefore, the chapter also includes a case study of Mumbai city. Here, the valuation is based on the cost of illness method to capture the health impact of air pollution, using health and air pollution data over several years.

The problem of solid waste management is also acute in large cities. Chapter 3 describes how to incorporate solid waste management in the satellite accounts. This covers the impact on resources such as air, land and water and the fuel necessary for transporting waste. The case study for Mumbai includes not only the formal sector, namely the municipality, but also the ragpickers who sort and recycle 25 per cent of the waste in the city.

Rivers and groundwater in many developing countries are highly polluted. Chapter 4 describes the water account in the Republic of Korea where water quantity and quality status for several years is discussed for surface water, ground water, drinking water and waste water. These water accounts also connect water quality with the sectoral activities that impact on it, viz. industry, household, transport and agriculture. Such a connection helps in directing policy efforts to appropriate activities and sectors.

Chapter 5 describes the forestry sector in the Philippines, where 50 per cent of the total land area is characterized as forest land. It investigates the depletion in major types of forests such as dipterocarp, pine, and rattan and provides a valuation for such depletion.

Chapter 6 describes the fishery account for the Philippines which has 7,100 islands and islets with a coastline of about 18,000 km. Its territorial waters cover about 2.2 million square km, 12 per cent of which is coastal while eighty-eight per cent is oceanic, including the Exclusive Economic Zone (EEZ). Here, the catch obtained using different fishing mechanisms is analyzed and valued to examine how fishery can be sustainable. The change in the stock of fisheries is also valued.

Chapter 7 describes Guam's environmental situation. Since this is a small island, it has a limited amount of problems, all of which are described along with their relationship to different polluting activities. The chapter anticipates environmental problems in the future so as to take appropriate preventive action.

This material is now suitable to use in training courses on environmental accounting and valuation. For example, the forestry chapter can be used in a forest management training course. In addition, specialized training courses can also be conducted using these volumes.

The efforts our collaborating authors, the ESCAP staff and ourselves have put in will be worthwhile if they are used to generate further case studies, or spread awareness on the value of environmental resources accounting.

We would like to acknowledge the major contributors for each chapter. They are :

Chapter 1: Jyoti Parikh and Kirit Parikh, with the help of Vijay Laxmi Pandey.

Chapter 2: Kirit Parikh and Jyoti Parikh, with the assistance of N. Satyanarayana Murthy, Sudhir Sharma, Nandini Hadker and Muraleedharan.

Chapter 3: Jyoti Parikh and Kirit Parikh, with the assistance of N. Hadker.

Chapter 4: Seung Woo Kim and his colleagues at KETRI and KEI.

Chapter 5: Estrella Domingo, Loida Cruz, Vivian Schimmel and other colleagues.

Chapter 6: Estrella Domingo, Loida Cruz, Vivian Schimmel and other colleagues.

Chapter 7: Eugene Li.

We additionally acknowledge Patrick Lewis and Mahesh Mohan for secretarial assistance and Meena Menon for editorial assistance. T. Raghuram and G. Haripriya helped us to go through the proofs.

The chapters on India and those contained in Vol. 1, were extensively revised at the United Nations University (UNU)/Institute of Advanced Studies (IAS), Tokyo, where Jyoti Parikh spent a year. She is grateful to extensive revisions of all chapters that took place for which outputs from the Capacity 21 project of UNDP were also very useful.

We hope that these case studies will show the feasibility as well as the need and usefulness of carrying out environmental accounting and valuation.

Jyoti K. Parikh

Kirit S. Parikh

Contents

LIST OF ABBREVIATIONS

ASE	Annual Survey of Establishments, Philippines
BAS	Bureau of Agricultural Studies, Philippines
BFAR	Bureau of Fisheries and Aquatic Resources, Philippines
BOD	Biochemical oxygen demand
CPI	Consumer Price Index
COD	Chemical oxygen demand
CVM	Contingent Valuation Method
CPCB	Central Pollution Control Board, India
CPUE	Catch Per Unit Effort
CSO	Central Statistical Organisation, India
DO	Dissolved Oxygen
DALY	Disability Adjusted Life Years
E coli	Escherichia coli
EDI	Environmentally adjusted net disposable income
EADP	Environmentally adjusted domestic product
EEZ	Exclusive Economic Zone
ENRA	Environmental and Natural Resource Accounting
ENRAP	Environment and Natural Resources Accounting Project, Philippines
EVA	Environmentally adjusted net Value Added
FAO	Food and Agricultural Organization
FLIA	Farm Land Improvement Association, Philippines
FSP	Fishery Sector Programme
GDP	Gross Domestic Product
GEPA	Guam Environment Protection Agency
GVA	Gross Value Added
Ha	hectares
Hp	Horse Power
ICLARM	International Centre for Living Aquatic Resource Management, Philippines
IEEA	Integrated Environment and Economic Accounts
I-O	Input Output
IPIN	Implicit Price Index
ISIC	International Standard Industrial Classification
KEPCO	Korea Electric Power Corporation
KOWACO	Korea Water Resources Corporation
MCGB	Municipal Corporation of Greater Bombay
Mgd	million gallons a day
Mha	Million hectares
MPCB	Maharashtra Pollution Control Board
MOE	Ministry of Environment, Korea
MOEF	Ministry of Environment and Forests, India
MPFD	Master Plan for Forestry Development, Philippines
MPR	Margin for Profit and Risk
MSY	Maximum Sustainable Yield
MTDP	Medium Term Development Plan, Philippines
NEDA	National Economic and Development Authority
NEERI	National Environmental Engineering Institute, India
NGLS	North Guam Lens Study
NPM	Net Price Method
NRA	Natural Resource Accounting
NRAP	National Resources Accounting Project, Philippines
NSCB	National Statistical Co-ordination Board, Philippines
NSO	National Statistical Office, Philippines
NVA	Net Value Added
OLS	Ordinary Least Square
PCARRD	Philippine Council for Agriculture Forestry and Natural Resources Research and Development
PFS	Philippine Forestry Statistics
PS	Purse Seine
PUAG	Public Utility Agency of Guam
REA	Resource Ecological Assessment
SA	Statistical Abstract
s. d.	statistical discrepancy
SEEA	System for Environmental and Economic Accounts
SNA	System of National Accounts
SPM	Suspended Particulate Matter
SSNA	Sector Specific Satellite National Accounts
SWM	Solid Waste Management
SW	Solid Waste
UNIDO	United Nations Industrial Development Organization
US EPA	United States Environment Protection Agency
VOC	Volatile Organic Compounds
WHO	World Health Organization
WPI	Wholesale Price Index
WTP	Willingness to pay

1

An Environmental Assessment of India

1.1 Introduction

An overview of the environmental problems of a country is an essential exercise that precedes environmental accounting in order to determine priorities for data collection and analysis. We illustrate how this could be done with the example of India. Very often, a country may have a few serious environmental problems, for instance, land, water or forests, while the remaining may have a small or insignificant impact with a negligible effect in the system of national accounts (SNA).

The scope of environmental problems in a developing country such as India is very wide, and a detailed study requires an integrated approach involving various disciplines. Therefore, only some selected problems which relate directly to human life and environment are considered here. These encompass topics such as air-quality management, water resources, health and sanitation, industrialization, deforestation and soil erosion, confirmed by our earlier studies (Pande V., and others, 1997).

A country's environmental problems are affected by the level of its economic development, the availability of natural resources, and the population, along with its life-style. Poverty presents special problems for a heavily-populated country with limited resources. The human population of India is expected to reach approximately 1500 million by the middle of next century. To accommodate this population pressure, various human activities, including agriculture and industry, must be in harmony with the environment, i.e. with air, water, soil, forests, flora and fauna.

The per capita income of India was estimated as Rs. 9,578/- per year in 1995-96 at current prices (India, Ministry of Finance, 1997-98). This is a serious limiting factor because ecological issues are not a priority when the country is adopting fire-fighting tactics to solve its immediate economic problems. Solutions to environmental problems are postponed due to lack of finances and become prohibitively expensive. Some problems even reach a point of total disaster, claiming a heavy toll on human life, the environment, the quality of life and productivity.

1.1.1 Environmental assessment and linkages with SNA

Figure 1.1 shows that environment assessment is a stock-taking exercise which outlines the importance of different environmental resources in a country, island or region and the major impact of various activities that affect these resources. Understanding environmental resources - land, air, water, forests, fisheries, biodiversity – helps in structuring the satellite accounts. For example, if it is known that forest fires take place deliberately to gain agricultural lands, then the loss of forest lands has to be connected with the increase in cultivated area.

The economic activities that impact these can be broadly described in a few sectors viz. household, transport, agriculture and industry. A more detailed treatment in the input-output (I-O) framework may be also possible for some countries. Depending on the characteristics of these production, consumption and trade activities, one may wish to detail the satellite accounts. For example, heavy metal pollutants due to industry, suspended particulate matter (SPM) due to households, or sulphur oxides and hydrocarbons due to the transport and the power sector, (important when there is an acid rain phenomenon) and so on, can make significant contributions to the respective accounts, be it air, water or forests. These details would have to be included in the satellite accounts.

1.2 Status of Environmental Quality

1.2.1 Air quality

Development processes have degraded air quality to an extent where it has imperiled human life. Air is a precious gift of nature to society and there is no price for this resource. Fuel consumption which generates oxides of carbon and particulates, is creating major pollution problems, apart from industries which generate pollutants such as SOx, H_2S, ammonia, oxides of nitrogen, hydrocarbons, and other toxic substances - including ozone, lead

and fluorides. Besides this, hazardous processes, particularly in the paper and pulp, leather and chemical industries, expose workers to toxic substances. Occupational health is not treated with the gravity it deserves in India. We discuss urban air quality and rural air quality separately.

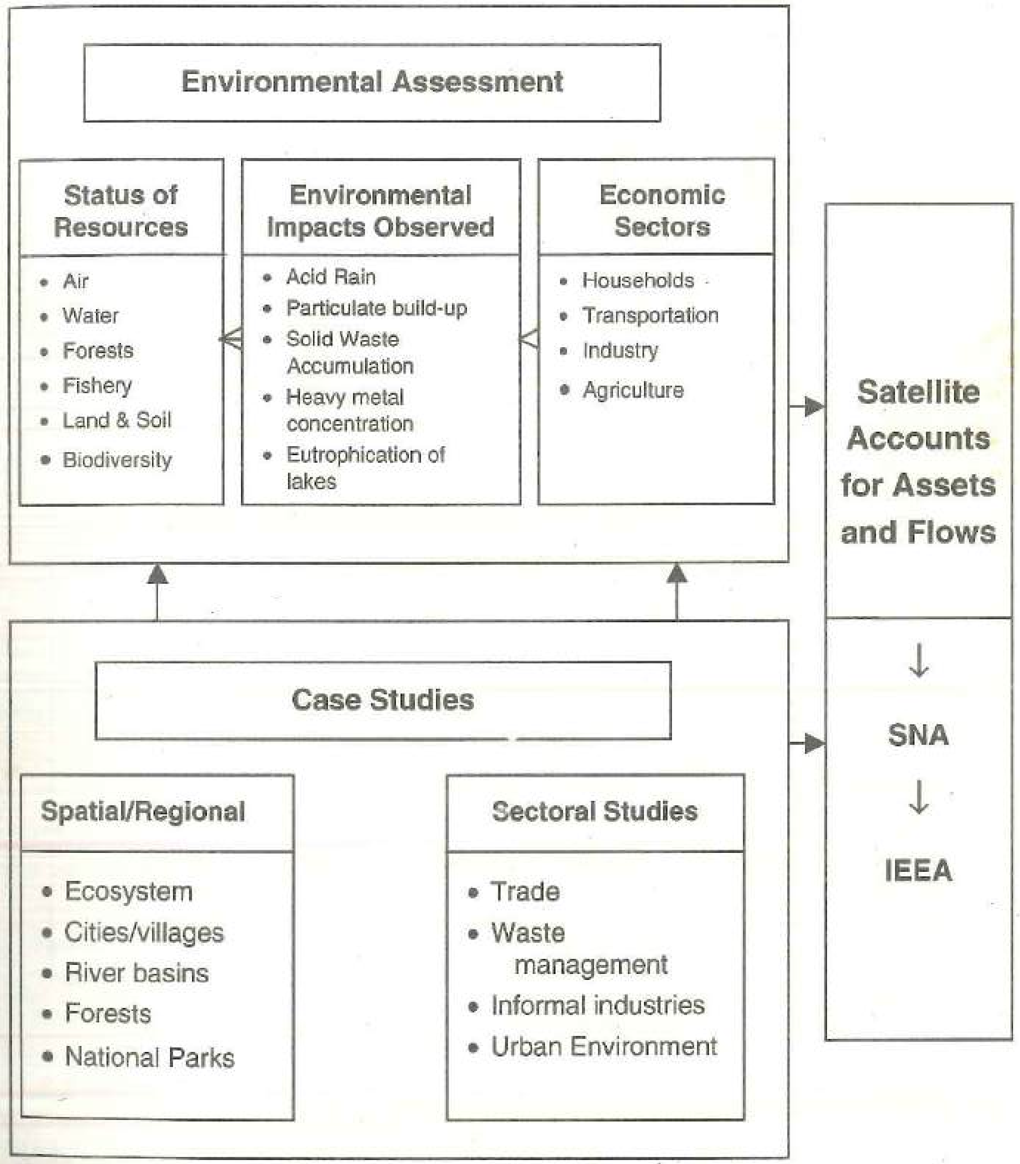

Figure 1.1: Linkages between environmental assessment, case studies and satellite accounts

Urban air quality: Growing industrialization with no priority for pollution abatement, and motorized vehicles of inferior quality, generate considerable quantities of pollutants. The National Environmental Engineering Research Institute (NEERI, 1996), observed the annual mean concentration trends for various atmospheric pollutants in 1996 for some cities. While the NO_2 concentration trend is stabilizing for Mumbai, Calcutta, and Chennai(Madras), SO_2 concentrations are decreasing in Delhi but are marginally increasing in Mumbai and Calcutta. Suspended Particulate Matter (SPM) concentrations show a somewhat increasing trend in many of these cities. The levels of some cities of India are indicated in Table 1.1.

Table 1.1: Annual average levels of SPM in the ambient air of 36 Indian cities in 1995

City	SPM*	Status	City	SPM*	Status
Kanpur	471	Critical	Jaipur	217.6	Critical
Agra	423	Critical	Bhopal	206.4	High
Delhi	410	Critical	Nagpur	186.2	High
Indore	388	Critical	Jabalpur	183	High
Ludhiana	375	Critical	Hyderabad	179.2	High
Calcutta	344	Critical	Kottayam	146	High
Patna	331	Critical	Shimla	142.4	High
Dehradun	323	Critical	Chennai	141.8	High
Faridabad	318	Critical	Pune	129.5	Moderate
Bhilai	289	Critical	Jamshedpur	118	Moderate
Jalandhar	287	Critical	Kochi	113.3	Moderate
Dhanbad	275	Critical	Haldia	103.5	Moderate
Ahmedabad	269	Critical	Mysore	97.5	Moderate
Surat	267	Critical	Guhawati	93.3	Moderate
Satna	254	Critical	Bangalore	90.8	Moderate
Mumbai	246	Critical	Kozikode	88.2	Moderate
Kota	242	Critical	Tuticorin	52.5	Low
Varanasi	238	Critical	Shillong	42.2	Low

* Suspended particulate matter in micrograms per cubic metre

Source: India, Central Pollution Control Board (CPCB), (1995).

CPCB rating scheme:

Critical = >210; High = 140 - 210; Moderate = 70 – 140; and Low = <70. SPM in $\mu g/m^3$

Apart from acid rain, air pollution causes diseases of the respiratory tract, lungs, skin and eyes, and lead (pb) pollution can result in the loss of IQ. Rain water analysis of the urban environment indicates that the pH of the first rain after the summer was always lower than that of the subsequent rains. Studies conducted by NEERI on atmospheric chemistry in some of the cities, show a minimum pH of 4.5, while the average pH of all precipitation events in all the urban agglomerations ranged from 6.2 to 7.6.

Apart from damaging human health and property, air pollution also causes economic damages to crops, forests and aquatic life. It contributes to ecological degradation, leading to changes in the natural habitat of diverse plants and animals.

Rural indoor air quality and energy consumption: The rural population uses a substantial quantity of non-commercial fuel i.e. crop residues, animal dung or wood. Although they are decreasing as a percentage of total fuel consumption, in per capita terms, they still provide 80 per cent of rural energy for cooking. Air pollutants due to the burning of non-commercial fuels are summarized in Table 1.2. The effects are manifested in a very high incidence of eye trouble and respiratory diseases, and in other health problems, particularly in women and children.

Table 1.2: Estimated major pollutants from non-commercial sources (Kg per ton of fuel)

Pollutant	Firewood	Dry cattle dung	Agricultural waste products
Carbon Monoxide	1.63	0.691	1.594
Sulphur Dioxide	19.60	8.182	18.75
Nitrogen Oxide	3.90	1.636	3.75
Organic (including hydrocarbons)	23.50	9.818	22.05
Particulates	31.40	13.091	30.00
Hydrogen Sulphide	1.20	0.454	1.125
Ammonia	1.20	0.454	1.125
Hydrogen Chloride	1.20	0.454	1.125
Total	83.63	34.777	79.52

Source: Parikh, J., (1977).

1.2.2 Water resources and quality

With several major rivers, India is rich in surface water resources. It is estimated that the overall availability of water is about 4000 km^3 annually. This includes precipitation, snowfall, river run-offs and an additional 200 km^3

brought into the country by rivers originating from outside. Industrial and untreated sewage pollute the rivers and water supply sources, posing a grave threat to safe drinking water. There is increasing pressure on water supply from domestic and industrial users apart from farmers. In the urban areas, 85 per cent of the population, and in the rural areas, 78 per cent of population, receive piped water supply, leaving 200 million persons dependent on surface or ground water which is untreated (India, Central Statistical Organization (CSO), 1997) and contaminated.

In India, approximately 21 per cent of all communicable diseases (11.5 per cent of all diseases) are water-borne. Each year, 30.5 million disability adjusted life years (DALY) are lost due to poor water quality and sanitation. This can be prevented by supplying safe drinking water. Despite shortage, wastage of water in domestic use is about 16-25 per cent. The quantity of over-use in industries and workshops is about 20 per cent, in construction work, 25 per cent, and in commercial establishments, ten per cent (Brij Kishore, 1992).

1.2.3 Urban environment and solid waste

The risk of morbidity and mortality due to air pollution, contamination of water supplies, recreation water and the food chain is increasing. Urban stress results from congestion, exposure to hazardous substances and lack of proper sanitation facilities.

Human exposure to volatile organic compounds (VOC) in water can occur from pathways other than direct ingestion. These pathways include inhalation of contaminants transferred to the air from showers, baths, toilets, washing machines and cooking. Cumulative human exposures through inhalation, ingestion and dermal absorption to VOC decides the extent of health risk.

Water-borne diseases spread due to inadequate sewage disposal facilities and waste matter mixing with open-water resources. Eighty per cent of the children in villages suffer from parasitic helminthic diseases caused by mixing of night soil in open water sources.

The problems of large metropolitan cities have grown tremendously in the last 40-45 years. There is an increase of 36.2 per cent in the urban population in the last one decade, without a corresponding increase in investment in augmenting or improving water supply and sanitation systems (Tata Services Limited, 1996-97). Only 48 per cent of the population in the urban areas are provided with sanitation facilities. In the rural areas, sanitation is much worse, with only three per cent of the population having access to proper facilities. (India, CSO, 1997).

In the last few decades, the quantity of domestic, industrial and urban wastes has increased tremendously. The problem of waste disposal from both domestic and industrial sources has become quite acute in some towns and cities, with disposal facilities lagging far behind the total quantity of waste generated. On an average, the total collection efficiency is only 60 per cent in some of the cities and towns (Table 1.3).

Table 1.3: The total amount of solid waste collected and the collection efficiency in some towns and cities (1992)

Cities/Towns	Solid waste (tonnes) per year		Collection efficiency (%)*
	Generated	Collected	
Mumbai	3200	3100	97
Chennai	1819	1637	90
Bangalore	1800	1225	68
Ahmedabad	1200	1080	90
Kanpur	2142	1500	70
Pune	1000	700	70
Lucknow	600	500	83
Coimbatore	175	113	65
Madurai	310	160	52
Indore	120	100	83
Cochin	321	193	60
Bhopal	230	120	52
Tiruchi	321	300	93
Calicut	130	60	46
Meerut	200	75	37
Hubli_Dharwad	120	70	58
Trivandrum	75	60	80
Salem	120	75	62
Mysore	130	25	19
Thane	204	122	50
Jamnagar	350	200	57

Source: India, CSO, (1997).

* This does not consider "timely" collection, in the absence of which garbage appears accumulated.

Taking an average figure of 0.5 kg per capita per day of refuse generation, the quantity generated in large cities with a population of one million and above will exceed 500 tonnes per day. Thus, it is clear that systematic efforts will be needed for effective disposal of waste.

1.2.4 Natural resources: forests, land and biodiversity

Forest cover: Forests have a multi-faceted role to play, directly affecting human life in a variety of ways. They thwart the dangers of cloud drifting, soil erosion, floods, wind erosion, and ground water evaporation. They also protect a wide variety of flora and fauna, provide recreation, and can effectively control air pollution of a moderate magnitude. The importance of forests not only for human beings but also for other forms of life, cannot be over-emphasized. Forests in India will face serious dangers in the future, unless drastic steps are taken to improve the situation. Already, the devastation is considerable due to overgrazing by cattle, frequent fires, and diversion of forest land for non-forest purposes.

India has a total forest cover of 63.96 million hectares (Mha), which constitutes only 19.45 per cent of the total geographic area (India, MOEF, 1996-97). In fact, even in the protected forest areas, one finds considerable tracts of small shrubs that have gone through tremendous qualitative changes which have remained unrecorded and unnoticed. The closed forest, having a crown density of 40 per cent or more, is approximately 38.57 Mha or 11 per cent of the country's total land area. However, remote sensing shows an encouraging increase in the area under closed forest by almost one per cent from 1981-83 to 1987-89 (India, MOEF, 1993-94).

The rural population requires an estimated 157 million tonnes of firewood for fuel every year, whereas production is only 58 million tonnes. The rest of the demand is met by illegal loping, felling and a variety of ways that result in the degradation and encroachment of forests. Even if no further net deforestation takes place, the forest area could reduce to 0.07 hectare per capita due to increase in population by the year 2000 (India, Ministry of Information and Broadcasting, 1994). In addition, over the next 25 years, forests will be increasingly exploited for fire-wood, and this figure will reduce further. To this, should be added the effects of overgrazing by increasing

numbers of livestock which in 1992, totaled about 470 million (India, CSO, 1997).

A wide range of flora and fauna are fast disappearing as their natural habitats are destroyed, further impoverishing the remaining Indian forests. While there are some increasing trends in the forest area and the quality of forest, massive afforestation programmes are needed.

Land resources and their degradation: The land management situation in India shows that at least 23 per cent (Table 1.4) of our total available area is suffering from serious degradation of one or the other type (Gautam N.C., 1997). Therefore, it is necessary to intensify efforts to curb soil erosion, to retain and increase the productivity of agricultural land, and to contain the expansion of desert areas and landslides.

Table 1.4: Degraded lands in India (1988-89)

Categories	Area (Million Hectares)	% of Total
Gullied and/or, Ravinous land	2.02	0.62
Land with/without Scrub	26.51	8.06
Waterlogged land	1.22	0.37
Marshy/Swampy land	0.82	0.25
Salt affected land	1.99	0.60
Shifting cultivation	2.82	0.87
Degraded Forest land	18.09	5.50
Degraded Grazing land	3.10	0.94
Sandy Area (Coastal/Desertic)	5.57	1.69
Mining/Industrial Wasteland	0.12	0.03
Barren, Rocky, Stony Waste	6.25	1.91
Snow covered	6.99	2.14
TOTAL	75.52	22.98

Source: Gautam, N.C., (1997).
Note: Estimated from maps of 1:250,000 scale obtained from remote sensing.

Soil is a non-renewable natural resource which supports all terrestrial plant life and consequently, human life. Under favorable conditions in India, it takes almost hundreds of years to form only 2.3 cm of a soil layer from weathered rocks (Patnaik N.N., 1975). Soil erosion due to rain and river run-off in the hilly areas causes landslides and floods. Deforestation, grazing, traditional agricultural practices, construction of roads, indiscriminate quarrying, and other activities, have exposed hillsides to heavy soil erosion. In the arid west in the Rajasthan, expansion of the desert occurs due to dust storms and whirl-winds. Shifting sand covers the land and makes it sterile. In the plains, one notices stream-bank erosion due to floods and eutrophication due to agricultural run-off.

In the mountains specially, the practice of shifting cultivation reduces soil fertility and causes changes in the physical condition of soil. Large patches of forests are burnt and the cleared land used for growing paddy, oil seed crops and millet.

Preservation of biodiversity: Biodiversity is a national asset of immense importance. Unfortunately, its valuation on a national scale is very difficult. Valuation is often carried out for some specific eco-systems such as wetlands or mangroves. Nevertheless, one needs to continue with physical assessment till such time when valuation methods are perfected.

India has a rich heritage of species and genetic strains of flora and fauna. It is tenth among the plant- rich countries of the world, eleventh in terms of the number of endemic species of higher vertebrates and sixth among the centers of diversity and origin of agri-biodiversity. The total number of living species identified in India (Table 1.5) so far is 150,000 (India, CSO, 1997), (Khoshoo, T.N., 1995). With the shrinking forest cover, many of these are fast becoming extinct or on the verge of extinction. These species and varieties provide a challenge to geneticists, conservation biologists, botanists, zoologists, economists, and many others who have a lot to learn about them and from them. In India, 1143 animals comprising 71 species of mammals, 88 species of birds and five species of reptiles are on the rare and endangered list (India, MOEF, 1993). Many plant species, which have forests as their sustaining source, are also disappearing rather rapidly. In order to preserve them, special bio-reserves should be created. In Table 1.6, the approximate number of rare and threatened species of vascular plants and animals are shown.

Table 1.5: Number of biota in India

Taxon	No. of Species
Bacteria	850
Algae	2500
Fungi	23,000
Lichen	1,600
Bryophyta	2,700
Pteridophyta	1,022
Gymnosperms	64
Angiosperms	17,000
Protozoa	2,577
Mollusca	5,042
Crustacea	2970
Insecta	50,717
Other invertebrates	11,252
Protochordata	116
Pisces	2,546
Amphibia	204
Reptilia	428
Avis	1228
Mammalia	372

Source: Khoshoo T.N., (1995).

Table 1.6: Rare and threatened species

Category	Approximate Number of vascular plants	Approximate number of vertebrates
Rare	237	32
Vulnerable	117	58
Endangered	170	62
Possibly Extinct	38	3
Extinct	21	3

Source: India, CSO, (1997).

Their loss needs to be recorded in the national assets. They require new concepts such as option value or existence value, which will assume greater importance in the future. When a more specific understanding increases, it may be possible to develop satellite accounts.

1.3 Activities Generating Environmental Impact

In addition to understanding the state of environmental resources, we need to envisage the growth of crucial activities which may have an impact in the present and future. In this section we consider the impact of four sectors – transport, industry, agriculture (that requires pesticides and fertilizers) and the household.

1.3.1 Transport

The growth of motor vehicles in the country during the last four decades is given in Table 1.7, which shows that in 1995, there were 27 million vehicles of which 18 million were two wheelers, 3.6 million automobiles and the rest, buses and trucks. These figures, though much smaller in per capita terms when compared to developed countries, are concentrated in a few large cities. The expected air emissions from this traffic in metropolitan cities are given in Table 1.8. A major fraction of these pollutants are dispersed in urban areas, causing damage to health, property, and plant and animal life.

To reduce emissions due to vehicles and facilitate traffic flow, it would be essential first to minimize and regulate transport through better urban design or telecommunications. There is a need to introduce rapid mass transit systems in the urban areas.

Table 1.7: Growth of motor vehicles in the country (in 000)

Year	All Vehicles	Two wheelers	Cars, jeeps & taxis	Buses	Goods vehicles	Others
1951	306	27	159	34	82	4
1961	665	88	310	57	168	42
1971	1965	576	682	94	343	172
1981	5336	2599	1147	159	542	889
1991	21374	14200	2954	331	1356	2533
1994*	26464	17936	3446	390	1791	2901
1995*	27229	18166	3630	412	1901	3120

Source: India, Ministry of Surface Transport.
* Estimated Figures from Statistical Outline of India, (1996-97).

Table 1.8: Estimated vehicular emission loads in 1994 (Tonnes per day)

City	Particulates	SO_2	NOx	HC	CO	Total
Delhi	10.33	8.96	126.46	249.57	651.01	1046.33
Mumbai	5.59	4.03	70.82	108.21	469.9	658.55
Calcutta	3.25	3.64	54.69	43.88	188.24	293.70
Bangalore	2.61	1.76	26.22	78.32	195.36	304.27
Ahmedabad	2.95	2.89	40.00	67.75	179.13	292.72
Pune	2.38	1.28	16.20	73.2	162.24	255.30
Chennai	2.34	2.01	28.21	50.46	143.22	226.24
Hyderabad	1.94	1.56	16.83	56.32	126.17	202.82
Jaipur	1.18	1.25	15.28	20.97	51.27	89.95
Kanpur	1.05	1.08	13.36	22.23	48.42	86.14
Lucknow	1.14	0.94	9.68	22.5	49.22	83.48
Nagpur	0.55	0.40	5.08	16.32	34.99	57.34
Grand Total	37.31	31.8	422.8	809.7	2299.2	3596.80

Source: For Delhi, Mumbai and Calcutta, CPCB, (1995).

Data for other cities are extrapolated from 1987 measurements, assuming similar percentile growth.

1.3.2 Industry

The rapid growth of industries in various pockets in the country has posed serious problems of pollution. This is more due to the inadequate measures adopted for effluent treatment rather than to the intensity of industrial activities. The share of the manufacturing sector in the total GNP is 24.1 per cent at current prices (India, CSO, 1993). Industrialization leads to water pollution and presents a diversity of hazardous waste disposal problems. The manufacture of paper, paper products and wood has multiplied 12 and 7 times respectively, leather products, 36 times, and chemicals, 10 times, during 1966-91 (India, Ministry of Industries, 1992). These industries pose risks to human health, apart from polluting the environment.

Most of the industries are medium or small-scale and the cost of effluent treatment per unit production is and will remain rather high.

1.3.3 Agriculture

Agriculture in India is now turning its attention to adequate crop protection after achieving some success with high-yielding varieties of seeds. The Indian farmer is expected to go in for an increased use of pesticides and fertilizers in the coming years. The fertilizer ($N+P_2O_5+K_2O$) consumption has increased from 7.7 million tonnes in 1984 to 13.9 million tonnes in 1995-96. The use of technical grade pesticides has increased from 24,305 tonnes in 1971 to 85,030 tonnes in 1994-95 (India, CSO, 1995). Aerial spraying of pesticides is also prevalent in some places.

Extensive use of pesticides has polluted the land, water and air and although some of its ingredients are biodegradable, those belonging to the chlorinated hydrocarbon group are stable and accumulate in soil. Similarly, the presence of mercury is reported to be increasing in rivers, ponds, and wells.

The cultivable area of the country is now expected to expand only through an increase in cropping intensity. The area under principal crops has nearly remained the same-- from 124.3 Mha in 1970-71 to 123.4 Mha in 1995-96 (India, Ministry of Planning Programme Implementation, 1997). The increase in multiple cropping makes it necessary to replace soil nutrients to ensure increased production. This, in turn, will boost fertilizer requirements.

The fertilizer run-off leads to nutrient increase in the receiving water bodies leading to eutrophication. The agricultural run-off, which contains residues of fertilizers and pesticides and agricultural wastes of the residues, accumulate and enter the food chain through marine products, birds, mammals, vegetables and fruits, causing ecological disturbances. This could, in the long run, lead to the extinction of some of the animal and plant species. On the other hand, some varieties may undergo environmental mutagenesis. Moreover, pesticide and pollutant-resistant varieties may also develop. This may alter the ecological balance and also cause human health problems.

1.4 Case Studies

The environmental assessment presented here helps us to focus on activities and impacts of importance. Urban air pollution and waste accumulation are perceived as major problems. Therefore, in Chapter 2, an exercise for physical accounts for air pollution at a national level has been carried out. A pilot case study for Mumbai city has been undertaken in the area of air pollution and health.

Another satellite account is needed concerning the management of solid waste. In Chapter 3, this is presented where contributions of the formal sector and informal sector are highlighted. This case study also demonstrates the methodology of satellite accounts and the integration of environmental cost into SNAs. Here, again a local level valuation analysis is shown for Mumbai city.

These two satellite accounts at national level are presented along with local level case studies for valuation.

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2

Air Resources Accounts for India

Part – A

2.1 Air Quality Accounts

2.1.1 Air quality: A natural resource of importance

Air quality is an important resource for human well-being and its deterioration has harmful consequences for health. In fact, the unique character of the earth's atmosphere has to be maintained if life on earth, as we know it, is to survive. Economic activities such as production and consumption, are accompanied by emissions of various by-products into the atmosphere. Natural processes absorb these within limits and air quality is restored. However, these limits are exceeded in most countries and the air quality of many cities in developing countries is very poor. The discomfort, disease and death that it causes, apart from the loss in property values, can no longer be neglected.

It is now widely recognized that air pollution due to the use of bio-fuels in many rural areas and in poor urban communities, causes severe health hazards. Even while the ambient air quality in rural areas is good, the air quality in poorly-ventilated kitchens and crowded settlements expose people, particularly women and children, to severe air pollution. The costs of this are substantial. Therefore, it is important to account for the deterioration in air quality in the Integrated Environment and Economic Accounts (IEEA).

2.1.2 Issues in air quality accounting

The physical accounts for air quality pose a problem as air pollution concentrations vary over time and across space. Even when the average ambient air quality in a country is satisfactory, it may deteriorate for some critical periods in selected cities or in the kitchens of the poor. In a sense, this is no different from man-made machines and capital. There is heterogeneity in capital. But one values it and aggregates the values. We can treat air quality at different places and different times as separate resources and value the deterioration separately and then add up the losses in value.

Two alternative approaches to the valuation of a resource depreciation are: valuation as per the maintenance cost and as per the cost of impact and resulting damage. The maintenance cost estimate would involve estimating the costs of reducing emission by factories and vehicles, commercial and service activities, as well as by households. The maintenance or the avoidance cost approach has a number of advantages when used for air quality accounting. It avoids the problem of distribution of air quality over space, its variation over time and the complex problems of estimating exposure, determination of health impact and valuation of morbidity and mortality. All we need to know is the source and quantity of emissions and what it would it cost to reduce them to acceptable levels.

While the maintenance cost approach estimates how much it would cost to preserve air quality, the impact assessment approach provides an estimate of how much it is worth to society to preserve air quality. Ideally, one would like to have air quality at a level where the marginal cost of abatement equals the marginal social cost of air quality change. Such valuation can guide policy- making.

To assess the impact of air quality on health, we need data on exposure, i.e. how many persons are exposed to different levels of air pollution. Since pollution levels differ from place to place, and people move from place to place over the day, the exposure level depends on how much time is spent by the person in different places. In principle, however, this data can be collected, for example, by making a sample of persons carry exposure metres all day.

Even when we have the data on the levels of exposure of different groups of persons, we need information on dose-response functions. While individuals react differently to the same level of exposure, such relationships can be established in a statistical sense. Many studies have been carried out in developed countries on establishing such dose-response functions. Unfortunately, data for developing countries is hardly available. Dose-response relationships differ according to genetic backgrounds and nutritional

status and also depends on the state of public health facilities. When using data from different countries, these aspects have to be kept in mind.

Apart from these problems, the dose-response functions themselves are difficult to establish in a convincing manner. For example, the cigarette industry disputed causality between smoking and a whole host of diseases for decades, despite strong evidence.

Air pollution also affects property prices. The impact on property prices can be assessed if property markets are free and data on property prices and air quality levels are available for a large number of properties. One can estimate a hedonic demand function for the price of property with a range of attributes. Such attributes may include, area, type of construction, facilities within the house, access to jobs, shops, schools, hospitals or public transport, and various air quality parameters. Again, in principle, such sample surveys can be carried out when data is not already available.

Even from the brief discussion above, it is clear that the maintenance or avoidance cost approach is a simpler one and poses fewer problems. It is also recommended by the UN SEEA.

2.1.3 Air quality accounts: A step-by-step approach

We begin with Table 2.1 from the UN - STAT handbook on IEEA, which shows how air quality accounting is to be integrated with environment and economic accounts. Air is shown as a non-produced natural asset. Air quality is affected by residuals and emissions during production and final consumption. This is shown in row 13. Air quality can recover over time due to the natural absorption of pollutants. This is shown in row 19 in the table. Finally the closing stocks are shown in row 21.

This broad structure of the SEEA matrix is further elaborated for air quality in Table 2.2. Rows 13 and 19 and column 3.2.4 are split up to account separately for different attributes of air quality such as PM10 (suspended particulate matter < 10 micron) SO_x, NO_x, lead, ozone, CO, etc. This makes physical accounting possible.

Table 2.1 : SEEA matrix with linked physical and monetary accounting (version III): product and raw material flows

	1.1 Domestic production of industries			2. Final consumption		3. Non-financial assets (uses and stocks of assets)								4. Exports	5. Total uses
	Agri. forestry, fishing	Mining, electricity, water	Other Industries	2.1 Individual	2.2 Collective	3.1.1 Produced assets of industries		3.2 Non-produced natural assets							
						3.1.1.1 Man-made	3.1.1.2 Natural	3.2.1 Wild biota	3.2.2 Subsoil	3.2.3 Water	3.2.4 Air	3.2.5 Land (ecozones) -			
												3.2.5.1 Soil	3.2.5.2 Area		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 Opening stocks				B		B A	B A	B A	B A	B A	B	B	B** A		
Use of products of industries Domestic production 2 Natural growth products 3 Other imports 4 Natural growth products 5 Other	B A B A B A B A	B A B A B A B A	B A B A B A B A	B A B A B A B A		B A B A	B A B A		A				A	B A B A B A B A	B A B A B A B A
Use of non-produced natural assets Depletion of domestic assets 6 Wild biota	B (+)			B (+)				B (-)							
7 Subsoil resources		B (+)							B (-)						
8 Water	B (+)	B (+)	B (+)	B (+)						B (-)					
9 Use of air, wind etc.	B (+)	B (+)	B (+)	B (+)							B (-)				
10 Soil erosion										B (+)		B (-)	B (+)		
11 Wild biota	B (+)														B (+)
12 Use of land etc.													B** (+,-)		
13 Discharge of residuals	B (-)	B (-)	B (-)	B (-)		B (-)	B (-)			B (+)	B (+)	B (+)		B (+)	B (+)
14 Treatment of residuals	B (-)	B (-)	B (+,-)	B (-)		B (-)	B (-)							B (+)	B (+)
15 Use of produced fixed assets	A (+)	A (+)	A (+)			A (-)	A (-)								
16 Net value added/NDP	B* A	B* A	B* A	B*											
17 Gross output of industries	B A	B A	B A												
Other volume changes 18 Due to economic decisions physical data only				B (+,-)				B A (+,-)	B A (+,-)	B A (+,-)	B (+,-)	B	B** A		
19 Due to natural and multiple causes				B (+,-)		B A (+, -)	B A (+, -)	B A (+,-)	B A (+,-)	B A (+, -)	B (+, -)	B	B** A		
20 Revaluation due to market price changes						A (+,-)	A (+,-)	A (+,-)	A (+,-)	A (+,-)			A		
21 Closing stocks				B		B A	B A	B A	B A		B	B	B** A		

Note: A-matrices denote monetary data (market values); B-matrices physical data. Source: Peter Bartelmus, (1993).

Additional rows for calculating maintenance costs are introduced. Rows 23 to 26 do not have to be part of the accounts as they are in the nature of a work-sheet and can form a separate table. They are used here to provide a complete picture of the data required and to show the steps involved in the preparation of the accounts. The valuation steps are shown separately in Table 2.3.

These are the steps to be taken for preparing the accounts :

(a) Select the pollutants to be considered

(b) Estimate emissions by sector

(c) Estimate avoidance costs

(d) Complete the accounts

k = number of pollutants considered

n = number of production sectors

m = number of consumption sectors activities

Dimensions:

k x n — [B1] = Matrix of emissions from production sector. $B1_{ij}$ is *i*th type of pollutant emitted by the *j*th production sector.

k x m — [B2] = Matrix of emission from final consumption activities. $B2_{ij}$ is *i*th type of pollutant emitted by *j*th final consumption activity.

1 x k — S0, S1 = Row vectors of stocks of pollutants in air at the beginning and end of period respectively.

k x k — [B3] = Diagonal matrix of pollutants emitted during the year by production and consumption activities.

1 x k — [-B4] = Row vector of reduction in pollutant stocks due to natural absorption.

1 x k — [B5] = Row vector of additions in pollutant stocks due to other natural causes such as volcanic erruptions and forest fires.

Table 2.2: SEEA matrix - details of air quality accounts

		1. Domesticn Production activities	2. Final consumption			3. Non-produced Natural Assets 3.2.4 Air				
			2.1 Individual	2.2 Collective		3.2.4.1 PM10	3.2.4.2 SO_x	3.2.4.3 NO_x	3.2.4.4 Pb	
1.	Opening stocks							SO		
13.	Discharge of Residuals									
	13.1 PM10									
	13.2 SO_x	B1	B2	B2				B3		
	13.3 NO_x									
	13.4 Pb									
	Other Volume Changes									
19.	Due to Natural Causes									
	19.1 Natural absorption							-B4		
	19.2 Volcanic eruption, etc.							B5		
21.	Closing stocks					S1	-S0	-B3+	B4+B5	
22.	Change in Stocks					Δ	S-S1-	SO		
23.	Maintenance Cost Coeff	C1		C2						
24.	Maintenance Cost Matrix.	A1		A2						
25.	Maintenance Cost for manmade emissions	uA1		uA2		uA	$(u^T+$	$uA2)^T$		
26.	Total maintenance cost net of natural absorption									Z

Notes to Table 2.2

k x n [C1] = Matrix of maintenance cost coefficients for production sectors. $C1_{ij}$ is the cost of reducing by 1 unit of emission of *j*th pollutant by the *i*th sector.

k x m [C2] = Matrix of maintenance cost coefficients for final consumption activities. $C2_{ij}$ is the cost of reducing 1 unit of emission by the *j*th pollutant by the *i*th activity.

k x n [A1] = Matrix of maintenance costs for the production sectors by pollutant. $A1_{ij}$ is the cost to abate *i*th pollutant by the *j*th production sector $A1_{ij} = C1_{ij} B1_{ij}$

k x m [A2] = Matrix of maintenance costs for the final consumption activities. $A2_{ij}$ is the cost to abate *i*th pollutant by the *j*th final consumption activity, $A2_{ij} = C2_{ij} B2_{ij}$

1 x * u = Unit row vector all elements of which are 1.0 with required dimension (indicated by a symbol *)

* x 1 u^T = Unit column vector with required dimension.*

Z = Total maintenance cost of air quality degradation net of natural absorption and natural disasters.

$$= \sum_{j=1}^{k}\left\{\left[\sum_{j=1}^{n} A1_{ij} + \sum_{j=1}^{m} A2_{ij}\right]\right\}\left(B3_{i_i} - B4_i\right) \Big/ BB_{ii}$$

Physical attributes of air quality: The attributes or pollutants have to be determined first. This may, for example, include Suspended Particulate Matter(SPM), Nitrous Oxide (NO_x), Sulphur Oxides (SO_x), lead and particulates of less than 10 microns (PM_{10}), ozone, or volatile organic compounds. For each of these we need to estimate the change in air quality. In Tables 2.1 and 2.2 we have shown only PM_{10}, SO_x, NO_x and lead. If data is available, others can be added as additional rows and columns.

Sources of emissions: The sources of emissions have to be identified in order to estimate avoidance costs. Ideally, sample surveys should be carried out to measure emissions from different economic activities. Often, the pollution control boards monitor these for major pollutants. From this data, emission coefficients for the input- output table can be generated. If such measurements are not available, one could use coefficients from other countries as a first approximation.

Emissions depend on the fuel used, the technology employed and the processes involved. They differ from sector to sector and may also vary from country to country. If local data is not available, one may use data from other countries. Table 2.4 uses data from the US (Hettige H., and others, 1995, World Bank). The same data source also gives information on pollution by value added or pollution by persons employed. Using these coefficients and the value of output of different International Standard Industrial Classification (ISIC) sectors, one can obtain the matrix B1 of Table 2.2. Table 2.3 also gives estimates of industrial pollution in India, worked out on the basis of these coefficients. Table 2.4 gives coefficients and estimates of industrial emissions in India based on value added.

The steps required to obtain emissions estimates for India using the coefficients given in tables 2.3 and 2.4 are given below.

We first obtained the output and value added figures for 1989-90 as per the ISIC code. These are available in the Industrial Statistics Yearbook, UNIDO, in Indian Rupees. Table 2.5 shows the data on prices. The monthly average exchange rate for 1987, the year to which the emission coefficients of Tables 2.3 and 2.4 refer to, was Rs.12.919 per 1 US$.

The emission E_{ij}, *j*th type of emission from *i*th industry, was worked out as follows:

$$E_{ij} = e_{ij} \frac{Y_{it}}{e_{87}} \cdot \frac{WPI_{i,87}}{WPI_{it}}$$

where e_{ij} is the emission coefficient for US in 1987 in pounds of *j*th type emission per US$ million output of sector i.

$WPI_{i,t}$ is the whole sale price index of sector I in year t,

e_{87} is exchange rate domestic currency/US$ in 1987 and

Y_{it} is output of *i*th sector in year t.

Table 2.3 : Emission coefficients (lower bound estimates) by ISIC sectors (pounds per 1987 million worth of output US$ and emission estimates for India (1989/90)

	Emission Coefficients						Industrial Emissions in India 1989/90					
	Pounds per 1987 US $ million of output						000s of tonnes in 1989/90					
ISIC code	SO_2	NO_2	CO	VOC	PM	TSP	SO_2	NO_2	CO	VOC	PM	TSP
3111	195	1997	499	10	6	56	0.005	0.048	0.012	0.000	0.008	0.001
3112	141	198	35	9	0	73	0.149	0.210	0.037	0.010	0.000	0.077
3113	736	375	72	136	5	73	0.049	0.025	0.005	0.009	0.000	0.005
3114	173	76	5	2	2	32	0.024	0.011	0.001	0.000	0.000	0.004
3115	9387	3360	750	2572	5901	9615	27.647	9.896	2.209	7.575	17.380	28.319
3116	328	262	51	277	542	1616	0.556	0.444	0.086	0.470	0.919	2.740
3117	16	36	5	179	0	16	0.004	0.008	0.001	0.040	0.000	0.004
3118	6428	6171	3306	1094	135	4258	11.875	11.400	6.107	2.021	0.249	7.866
3119	97	20	3	2	0	10	0.005	0.001	0.000	0.000	0.000	0.001
3121	432	439	94	132	12	196	0.671	0.682	0.146	0.205	0.019	0.305
3122	745	205	56	24	308	1341	0.109	0.030	0.008	0.004	0.045	0.196
3131	3887	1351	253	13355	170	325	0.815	0.283	0.053	2.801	0.036	0.068
3132	462	70	6	1	0	48	0.015	0.002	0.000	0.000	0.000	0.002
3133	2146	1690	105	176	3	118	0.254	0.200	0.012	0.021	0.000	0.014
3140	1265	766	100	252	10	24	0.876	0.531	0.069	0.175	0.007	0.017
3211	2422	3342	448	917	65	433	14.766	20.375	2.731	5.591	0.396	2.640
3212	18	11	3	126	0	26	0.000	0.000	0.000	0.003	0.000	0.001
3213	217	90	37	73	13	136	0.058	0.024	0.010	0.020	0.003	0.037
3214	0	0	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
3215	2075	648	904	1261	0	1094	0.107	0.033	0.047	0.065	0.000	0.056
3219	748	309	56	5938	0	445	0.077	0.032	0.006	0.610	0.000	0.046
3220	32	12	3	8	0	1	0.019	0.007	0.002	0.005	0.000	0.001
3231	1299	343	126	3819	41	157	0.412	0.109	0.040	1.212	0.013	0.050
3232	932	219	52	584	21	788	0.000	0.000	0.000	0.000	0.000	0.000

ISIC code	Pounds per 1987 US $ million of output SO$_2$	NO$_2$	CO	VOC	PM	TSP	000s of tonnes in 1989/90 SO$_2$	NO$_2$	CO	VOC	PM	TSP
3233	0	16	3	285	0	10	0.000	0.000	0.000	0.005	0.000	0.000
3240	16	2	0	134	0	1	0.003	0.000	0.000	0.024	0.000	0.000
3311	1036	2342	5901	2509	92	3258	0.232	0.523	1.319	0.561	0.021	0.728
3312	1	2	8	41	18	268	0.000	0.000	0.000	0.001	0.000	0.006
3319	2968	1923	4293	5818	1755	4373	0.049	0.032	0.072	0.097	0.029	0.073
3320	243	172	182	5510	160	547	0.005	0.004	0.004	0.118	0.003	0.012
3411	25585	13349	29203	4043	1453	5028	24.893	12.988	28.413	3.934	1.414	4.892
3412	201	1472	341	446	8	46	0.033	0.239	0.055	0.072	0.001	0.007
3419	417	128	39	700	0	10	0.021	0.007	0.002	0.036	0.000	0.001
3420	26	34	129	862	0	14	0.015	0.019	0.073	0.490	0.000	0.008
3511	11656	8658	6687	6766	395	1873	15.811	11.745	9.071	9.178	0.536	2.541
3512	1106	1065	212	1008	47	307	3.418	3.291	0.655	3.115	0.145	0.949
3513	5185	13477	1993	9862	4	792	5.026	13.064	1.932	9.560	0.004	0.768
3521	246	217	31	1819	74	146	0.162	0.143	0.020	1.200	0.049	0.096
3522	1825	775	91	908	13	345	3.079	1.308	0.154	1.532	0.022	0.582
3523	476	567	196	184	193	255	0.492	0.586	0.203	0.190	0.200	0.264
3529	5291	1652	53782	4098	1361	1847	4.102	1.281	41.694	3.177	1.055	1.432
3530	12664	7285	6579	6705	128	1117	57.974	33.350	30.118	30.694	0.586	5.113
3540	20866	12982	9828	3259	641	8004	15.707	9.772	7.398	2.453	0.483	6.025
3551	3797	1312	161	3844	54	420	3.384	1.169	0.143	3.426	0.048	0.374
3559	1	5	1	384	1	2	0.000	0.002	0.000	0.171	0.000	0.001
3560	56	12	4	676	12	17	0.049	0.011	0.004	0.594	0.011	0.015
3610	295	148	103	1151	0	349	0.032	0.016	0.011	0.125	0.000	0.038
3620	3378	6721	1810	862	142	1348	0.977	1.943	0.523	0.249	0.041	0.390
3691	3029	29265	6952	2378	4681	22972	0.818	7.908	1.878	0.643	1.265	6.207
3692	128688	59751	7273	340	107003	62238	159.013	73.831	8.987	0.420	132.218	76.904
3699	3195	1425	684	392	1953	5383	1.710	0.763	0.366	0.210	1.045	2.882

ISIC code	Pounds per 1987 US $ million of output SO$_2$	NO$_2$	CO	VOC	PM	TSP	000s of tonnes in 1989/90 SO$_2$	NO$_2$	CO	VOC	PM	TSP
3710	17867	7761	27843	2392	4938	4140	101.108	43.919	157.561	13.536	27.944	23.428
3720	38646	1259	17977	1406	355	3246	53.785	1.752	25.019	1.957	0.494	4.518
3811	161	1035	83	260	0	45	0.049	0.318	0.025	0.080	0.000	0.014
3812	43	36	14	2855	0	27	0.001	0.001	0.000	0.040	0.000	0.000
3813	155	653	261	714	10	34	0.026	0.112	0.045	0.122	0.002	0.006
3819	161	362	1850	1556	7	129	0.109	0.245	1.253	1.053	0.005	0.087
3821	612	445	1993	663	4	163	0.448	0.326	1.459	0.485	0.003	0.119
3822	2573	700	896	1511	0	430	1.073	0.292	0.374	0.630	0.000	0.179
3823	37	8	850	535	0	7	0.009	0.002	0.210	0.132	0.000	0.002
3824	497	426	75	322	1	99	0.526	0.451	0.079	0.341	0.001	0.105
3825	5	4	0	64	0	2	0.002	0.002	0.000	0.025	0.000	0.001
3829	479	181	399	608	2	43	0.480	0.181	0.400	0.609	0.002	0.043
3831	2865	754	118	469	1	53	3.721	0.979	0.153	0.609	0.001	0.069
3832	67	34	9	408	3	5	0.085	0.043	0.011	0.516	0.004	0.006
3833	2	15	2	696	1	0	0.000	0.003	0.000	0.129	0.000	0.000
3839	391	846	1772	412	11	306	0.411	0.890	1.863	0.433	0.012	0.322
3841	335	150	20	1243	336	105	0.034	0.015	0.002	0.127	0.034	0.011
3842	6814	2729	486	1898	1	1812	3.390	1.358	0.242	0.944	0.000	0.902
3843	279	141	189	1298	12	140	0.652	0.330	0.442	3.035	0.028	0.327
3844	264	154	44	7430	0	160	0.235	0.137	0.039	6.609	0.000	0.142
3845	106	87	222	329	3	16	0.012	0.009	0.024	0.036	0.000	0.002
3851	14	23	3	34	0	4	0.002	0.003	0.000	0.005	0.000	0.001
3852	84	130	3	157	0	32	0.001	0.002	0.000	0.003	0.000	0.001
3853	0	0	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
3901	189	63	16	52	0	61	0.031	0.010	0.003	0.009	0.000	0.010
3902	80	599	142	1870	52	132	0.001	0.006	0.001	0.018	0.001	0.001
3903	9	13	2	553	53	66	0.000	0.000	0.000	0.008	0.001	0.001
3909	29	14	11	408	0	7	0.004	0.002	0.002	0.063	0.000	0.001
Total								0.270	0.334	0.125	0.187	0.183

Table 2.4 : Emission coefficients (lower bound estimates) by ISIC sectors (pounds per 1987 million worth of Value added US$ and emission estimates for India (1989/90)

	Emission coefficients						Industrial emissions in India 1989/90					
	pounds per 1987 US $ million of value added						000s of tonnes in 1989/90					
ISIC code	SO_2	NO_2	CO	VOC	PM	TSP	SO_2	NO_2	CO	VOC	PM	TSP
3111	1081	11103	2774	56	31	313	0.004	0.046	0.011	0.000	0.000	0.001
3112	532	748	133	34	2	274	0.081	0.113	0.020	0.005	0.000	0.042
3113	1553	791	152	287	11	154	0.012	0.006	0.001	0.002	0.000	0.001
3114	618	272	19	8	6	115	0.008	0.004	0.000	0.000	0.000	0.002
3115	36704	13138	2933	10056	23075	37598	6.157	2.204	0.492	1.687	3.871	6.307
3116	628	503	97	531	1039	3098	0.053	0.043	0.008	0.045	0.088	0.262
3117	25	57	7	280	0	25	0.001	0.002	0.000	0.012	0.000	0.001
3118	22751	21841	11702	3871	476	15069	8.233	7.903	4.235	1.401	0.172	5.453
3119	188	38	6	4	0	20	0.002	0.000	0.000	0.000	0.000	0.000
3121	903	916	197	275	25	409	0.309	0.313	0.067	0.094	0.009	0.140
3122	2287	629	172	73	945	4118	0.029	0.008	0.002	0.001	0.012	0.052
3131	6529	2269	424	22429	285	546	0.348	0.121	0.023	1.195	0.015	0.029
3132	1070	161	14	3	0	112	0.009	0.001	0.000	0.000	0.000	0.001
3133	4080	3214	199	334	6	224	0.091	0.072	0.004	0.007	0.000	0.005
3140	1840	1113	145	366	14	34	0.321	0.194	0.025	0.064	0.002	0.006
3211	5572	7688	1032	2109	149	997	6.784	9.360	1.256	2.568	0.181	1.214
3212	40	25	6	285	0	59	0.000	0.000	0.000	0.001	0.000	0.000
3213	467	193	81	157	28	293	0.019	0.008	0.003	0.006	0.001	0.012
3214	0	0	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
3215	3970	1239	1729	2412	0	2092	0.040	0.013	0.017	0.024	0.000	0.021
3219	1642	679	124	13038	0	977	0.024	0.010	0.002	0.193	0.000	0.014
3220	60	23	6	15	1	3	0.007	0.003	0.001	0.002	0.000	0.000
3231	3813	1007	371	11208	120	460	0.136	0.036	0.013	0.399	0.004	0.016
3232	1622	382	91	1016	37	1370	0.000	0.000	0.000	0.000	0.000	0.000
3233	0	29	5	514	0	19	0.000	0.000	0.000	0.002	0.000	0.000

	pounds per 1987 US $ million of value added						000s of tonnes in 1989/90					
ISIC code	SO_2	NO_2	CO	VOC	PM	TSP	SO_2	NO_2	CO	VOC	PM	TSP
3240	30	4	0	257	0	2	0.001	0.000	0.000	0.009	0.000	0.000
3311	2582	5833	14701	6250	230	8117	0.092	0.207	0.523	0.222	0.008	0.289
3312	2	5	20	98	42	634	0.000	0.000	0.000	0.000	0.000	0.002
3319	5561	3602	8041	10899	3287	8192	0.019	0.012	0.028	0.038	0.011	0.028
3320	457	323	343	10365	301	1028	0.002	0.001	0.002	0.046	0.001	0.005
3411	51745	26998	59062	8176	2938	10169	10.226	5.335	11.672	1.616	0.581	2.010
3412	533	3896	904	1180	21	122	0.012	0.091	0.021	0.027	0.000	0.003
3419	846	259	79	1418	0	20	0.006	0.002	0.001	0.010	0.000	0.000
3420	39	51	195	1301	1	21	0.006	0.007	0.028	0.189	0.000	0.003
3511	25698	19088	14742	14915	871	4129	7.228	5.369	4.146	4.195	0.245	1.161
3512	2056	1980	394	1874	87	571	0.742	0.714	0.142	0.676	0.031	0.206
3513	11759	30563	4519	22366	9	1796	2.582	6.712	0.992	4.912	0.002	0.394
3521	501	443	62	3713	152	298	0.067	0.059	0.008	0.498	0.020	0.040
3522	2544	1080	127	1265	18	480	0.972	0.412	0.049	0.483	0.007	0.183
3523	769	916	317	296	312	412	0.117	0.139	0.048	0.045	0.047	0.063
3529	8780	2741	89240	6800	2259	3065	1.304	0.407	13.256	1.010	0.336	0.455
3530	105264	60552	54684	55731	1063	9287	60.054	34.545	31.198	31.795	0.606	5.298
3540	59277	36881	27921	9259	1820	22737	4.797	2.985	2.259	0.749	0.147	1.840
3551	7123	2462	302	7210	102	788	1.082	0.374	0.046	1.095	0.015	0.120
3559	2	9	2	692	2	4	0.000	0.001	0.000	0.048	0.000	0.000
3560	112	24	8	1347	23	34	0.013	0.003	0.001	0.151	0.003	0.004
3610	423	212	147	1648	0	499	0.013	0.006	0.004	0.050	0.000	0.015
3620	5959	11858	3194	1521	251	2379	0.380	0.757	0.204	0.097	0.016	0.152
3691	5074	49023	11645	3983	7842	38482	0.343	3.311	0.787	0.269	0.530	2.599
3692	244955	113734	13844	647	203679	118469	55.668	25.847	3.146	0.147	46.288	26.923
3699	6183	2759	1324	759	3780	10418	0.737	0.329	0.158	0.090	0.451	1.242
3710	41044	17829	63961	5494	11344	9510	31.618	13.735	49.272	4.232	8.739	7.326
3720	123489	4022	57444	4492	1135	10371	35.711	1.163	16.612	1.299	0.328	2.999

ISIC code	SO$_2$	NO$_2$	CO	VOC	PM	TSP	SO$_2$	NO$_2$	CO	VOC	PM	TSP
	pounds per 1987 US $ million of value added						000s of tonnes in 1989/90					
3811	259	1671	133	419	0	73	0.018	0.118	0.009	0.029	0.000	0.005
3812	74	61	24	4877	0	45	0.000	0.000	0.000	0.014	0.000	0.000
3813	327	1379	552	1508	22	72	0.012	0.051	0.020	0.056	0.001	0.003
3819	333	749	3825	3217	14	267	0.041	0.093	0.475	0.399	0.002	0.033
3821	1252	910	4080	1356	8	334	0.183	0.133	0.596	0.198	0.001	0.049
3822	5272	1434	1835	3095	0	882	0.409	0.111	0.142	0.240	0.000	0.068
3823	62	14	1439	905	0	12	0.004	0.001	0.099	0.062	0.000	0.001
3824	991	849	150	642	3	197	0.229	0.196	0.035	0.148	0.001	0.045
3825	9	7	1	119	0	4	0.001	0.001	0.000	0.012	0.000	0.000
3829	872	330	725	1107	4	78	0.218	0.082	0.181	0.276	0.001	0.019
3831	5255	1383	216	860	3	98	1.850	0.487	0.076	0.303	0.001	0.034
3832	114	57	15	695	4	9	0.032	0.016	0.004	0.194	0.001	0.003
3833	4	29	5	1377	2	1	0.000	0.001	0.000	0.041	0.000	0.000
3839	694	1502	3145	732	20	542	0.139	0.301	0.631	0.147	0.004	0.109
3841	606	271	36	2246	606	189	0.010	0.004	0.001	0.037	0.010	0.003
3842	13007	5209	928	3623	2	3459	2.455	0.983	0.175	0.684	0.000	0.653
3843	843	425	570	3920	36	424	0.446	0.225	0.301	2.073	0.019	0.224
3844	772	450	128	21771	0	468	0.080	0.046	0.013	2.247	0.000	0.048
3845	186	152	390	577	5	29	0.003	0.003	0.007	0.011	0.000	0.001
3851	20	35	5	52	0	6	0.001	0.002	0.000	0.002	0.000	0.000
3852	129	199	4	241	0	49	0.001	0.001	0.000	0.001	0.000	0.000
3853	0	0	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
3901	444	149	37	121	0	142	0.010	0.003	0.001	0.003	0.000	0.003
3902	130	971	230	3029	84	213	0.000	0.003	0.001	0.009	0.000	0.001
3903	16	23	3	1012	97	121	0.000	0.000	0.000	0.003	0.000	0.000
3909	50	24	19	710	0	13	0.002	0.001	0.001	0.024	0.000	0.000
						Total (mt)	0.243	0.126	0.144	0.069	0.063	0.068

Source: IPPS, PRDEI, World Bank; Lower bound estimates

Table 2.5: Wholesale price indices for output and value added ISIC sectors in India

ISIC Code	Four Digit ISIC Description	WPI-1987	WPI-1989/90	Output 10^6 Rs	Value added factor values
3111	Meat Products ~ Meat	158.7	189.4	824	140
3112	Dairy Products	149.5	187.1	37781	5401
3113	Preserved Fruits & Vegetables	128.1	148.8	2188	260
3114	Fish Products	147.4	171.4	4595	451
3115	Oils And Fats	170.4	177.5	87380	4977
3116	Grain Mill Products	129.8	173.3	64484	3221
3117	Bakery Products	137.0	156.8	7220	1411
3118	Sugar Factories & Refineries	115.8	152.0	69061	13528
3119	Confectionery Products	128.5	144.6	1670	297
3121	Food Products, N.E.C.*	155.4	168.8	48082	10582
3122	Prepared Animal Foods	136.5	154.8	4716	411
3131	Distilled Spirits	122.3	149.6	7308	1856
3132	Wine Industries	122.3	149.6	1120	300
3133	Malt Liquors And Malt	158.6	171.8	3650	690
3140	Tobacco Manufactures	149.6	211.9	27946	7048
3211	Spinning, Weaving, & Finishing Textiles ~ Cotton	123.1	160.1	225831	45096
3212	Made-Up Textiles Except Apparel ~ Manmade	108.7	130.1	703	118
3213	Knitting Mills ~ Woollen	119.1	147.4	9474	1445
3214	Carpets And Rugs	138.5	168.1	1996	381
3215	Cordage, Rope & Twine ~ Jute	150.9	245.1	2380	468
3219	Textiles, N.E.C.	138.5	168.1	3552	511
3220	Wearing Apparel	138.5	168.1	20653	4129
3231	Tanneries And Leather Finishing ~Sheep And Goat Skin	102.0	148.9	13199	1481
3232	Fur Dressing And Dyeing ~ Textiles	123.0	158.2		
3233	Leather Products ~Leather And Leather Products	139.0	185.7	695	121
3240	Footwear ~Western	166.0	215.2	6632	1226
3311	Sawmills, Planing & Other Wood Mills	153.7	157.7	6530	1039
3312	Wooden & Cane Containers; Small Cane Ware	153.7	157.7	600	98
3319	Wood & Cork Products, N.E.C.	153.7	157.7	487	101
3320	Furniture & Fixtures, Nonmetal	153.7	157.7	625	130
3411	Pulp, Paper, & Paperboard	147.9	185.5	34754	7059
3412	Paper & Paperboard Containers & Boxes	147.9	185.5	5797	831

ISIC Code	Four Digit ISIC Description	WPI-1987	WPI-1989/90	Output 10^6 Rs	Value added factor values
3419	Pulp, Paper & Paperboard Articles,	147.9	185.5	1825	244
3420	Printing & Publishing	196.9	247.0	20328	5180
3511	Industrial Chemicals Except Fertilizer	126.5	147.6	45093	9350
3512	Fertilizers & Pesticides	110.5	104.2	83005	9689
3513	Synthetic Resins, Plastics Materials, & Manmade Fibres	122.6	145.9	32872	7447
3521	Paints, Varnishes, & Lacquers	154.6	193.6	23529	4786
3522	Drugs And Medicines	127.8	140.4	52793	11949
3523	Soap, Cleaning Preps., Perfumes, & Toilet Preps.	149.4	155.0	30557	4498
3529	Chemical Products, N.E.C.	148.1	161.1	24018	4602
3530	Petroleum Refineries	125.6	129.7	134638	16779
3540	Misc. Petroleum & Coal Products	125.6	129.7	22139	2380
3551	Tyres And Tubes	129.4	145.8	28598	4873
3559	Rubber Products, N.E.C.	146.7	157.8	13666	2140
3560	Plastic Products, N.E.C.	146.7	157.8	26937	3439
3610	Pottery, China, & Earthenware	109.0	113.6	3212	908
3620	Glass And Glass Products	180.6	216.4	9866	2179
3691	Structural Clay Products	166.5	199.5	9221	2305
3692	Cement, Lime, And Plaster	140.8	152.1	38017	6992
3699	Non-Metallic Mineral Products, N.E.C.	139.3	159.2	17424	3880
3710	Iron And Steel	138.6	188.8	219547	29887
3720	Non-Ferrous Metals	147.9	242.6	65018	13510
3811	Cutlery, Hand Tools & General Hardware	133.3	189.5	12425	2848
3812	Furniture & Fixtures Of Metal	146.5	290.3	793	157
3813	Structural Metal Products	140.1	209.2	7267	1570
3819	Fabricated Metal Products	140.1	209.2	28793	5280
3821	Engines And Turbines	126.3	149.8	24732	4938
3822	Agricultural Machinery & Equipment	127.9	161.9	15029	2795
3823	Metal & Wood Working Machinery	133.1	173.0	9126	2556
3824	Special Industrial Machinery & Equipment	133.1	173.0	39170	8540
3825	Office, Computing, & Accounting Machinery	111.8	121.5	12202	3108
3829	Machinery & Equipment, N.E.C.	133.1	173.0	37097	9236
3831	Electrical Industrial Machinery	126.7	158.8	46365	12564
3832	Radio, TV, & Communication Equipment	112.1	134.1	43119	9508

ISIC Code	Four Digit ISIC Description	WPI-1987	WPI-1989/90	Output 10^6 Rs	Value added factor values
3833	Electrical Appliances & Housewares	116.6	134.4	6066	983
3839	Electrical Apparatus And Supplies, N.E.C.	126.7	158.8	37534	7158
3841	Shipbuilding And Repairing	133.3	166.2	3624	579
3842	Railroad Equipment	142.8	192.2	19073	7235
3843	Motor Vehicles	132.2	163.2	82205	18589
3844	Motorcycles And Bicycles	138.4	164.9	30177	3501
3845	Aircraft	133.3	166.2	3863	649
3851	Professional & Scientific Equipment	109.6	117.2	4620	1453
3852	Photographic And Optical Goods	109.6	117.2	530	143
3853	Watches And Clocks	109.1	127.2	4260	1210
3901	Jewellery And Related Articles	109.6	117.2	5017	687
3902	Musical Instruments	109.6	117.2	293	93
3903	Sporting And Athletic Goods	109.6	117.2	453	83
3909	Manufacturing Industries, N.E.C.	109.6	117.2	4699	1013

Source: India, Ministry of industry, Wholesale Price Indices.

Value added and Output data from Industrial Statistics Yearbook, UNIDO.

Notes: 1981/82 = 100; For some ISIC codes the WPI was available for a related sector only, identified with the tag ~.

*NEC = Not elsewhere classified.

Using US data for India may pose problems. Sectoral prices may be different and merely converting the exchange rate of the value of the domestic output may be unsatisfactory. A more detailed set of coefficients in physical terms is given in Annexure 1 from the WHO publication by Economopoulos A. (1993). With data on domestic production from different sectors, it is possible to work out a more satisfactory matrix of emissions by sectors (matrix B1 in Table 2.2).

Tables 2.3 and 2.4 only refer to industrial sectors. Other production activities such as agriculture, mining, electricity, transport and services also cause air pollution. Air pollution in agriculture is mainly from the use of diesel for pumps and tractors, and indirectly from the use of electricity for pumping. The small amount of air pollution from tractors and diesel pumps is ignored due to lack of data. In the mining sector, particularly in open cast mining, there is a lot of dust pollution. Again, for want of data, this is not included here.

However, air pollution due to electricity generation and due to the use of various transport vehicles are calculated. Indirect emissions due to transportation of agriculture products and mined commodities are also calculated. Table 2.6 provides estimates of air pollution from electricity generation in India. It is based on a plant by plant calculation and the type of fuel used by each plant.

Table 2.6: Air pollution from power generation: 1989-90

Parameter	Unit	Estimated emissions
Total Cost	Bill. Rs.	75.8
Total Carbon	Mill. Tons	43.8
Total Ash	Mill. Tons	41.2
Total Sulphur Dioxide	000 tons	565.0
Total NOx	000 tons	720.0
Total Fly Ash	000 tons	477.0
Emission Factor	Kg Carbon/ MWh	210.0
Coal Consumption	Mill. Tons	111.7
Gas Generation	GWh	7673.0
Gas Gen. as % of Total Generation	Rs./ton C.	3.7
Marginal Cost of Reduction		

Total generation in all cases = 209464 GWh.
Source: Chattopadhyay and Parikh, (1993).

Emission coefficients from transport for each type of vehicle are given in Table 2.7. Table 2.8 gives the estimated total emissions from the stock of transport vehicles. The stock of vehicles is used for both production activities as well as for the final consumption of transport. Table 2.8 corresponds to part of matrix B1 and part of matrix B2 of Table 2.2.

Table 2.7: Emission coefficients per vehicle (t/yr)

Vehicle	CO	HC	NOx		SO_2	Pb
Two-wheelers	0.04	0.03	-	-	0.006	0.001
Three-wheelers	0.21	0.17			0.006	0.001
Cars/Jeeps	0.22	0.05	0.02		0.006	0.001
Taxi	0.44	0.08	0.03		0.006	0.001
Diesel vehicles	0.21	0.08	0.39	0.01	0.13	0.0

The coefficients have been derived from IIP, (1985)

Table 2.8: Estimated emissions from various vehicles (in 1000 tonnes)

Type of Vehicle	Number of vehicles (000)	CO	HC	NOx	Particulates	SO_2	Pb
Two-wheelers	12531	538.8	388.5	-	-	75.2	12.5
Three-wheelers	652	139.7	108.4	0.0	-	3.9	0.7
Cars/Jeeps	2681	581.8	121.8	66.1	-	16.1	2.7
Taxis	55	24.4	4.3	1.6	-	0.3	0.1
Diesel vehicles	1619	332.0	128.4	626.9	20.6	210.5	0.0
Total	17538	1616.7	751.4	694.6	20.6	306.0	15.9

Source: CMIE, (1996).

If information was available on how much of the stock of transport vehicles was used for final consumption and how much for input into production activities, Table 2.8 could have been appropriately split up.

We now turn to emissions by final consumption activities. Two important sources here are the use of fuels by households for cooking and heating, and the use of vehicles for transportation. Transportation has already been accounted for in Table 2.8. The use of bio-fuels by households should also be accounted for as this is often a large source of domestic fuel in developing countries (more than 30 per cent in India). The emission coefficients are already given in Chapter 1, Table 1.2. These emissions depend on the type of equivalent fuel and for example, with a more efficient wood stove, emissions could be reduced. Table 2.9 shows the estimated emissions from household fuels.

Table 2.9 corresponds to part of emissions corresponding to matrix B2 in Table 4.2. The matrix B2 may have m columns if various types of consumption activities are differentiated. For example, consumption by poor households, by middle- income households, rich households or public consumption, may all be shown separately.

Table 2.9: Emissions of major pollutants from different household fuels

Fuel	Total consumption (Million tonnes)	Total Emission from Household sector (x 10^6 Kg)				
		CO	SO_2	NO_x	HC	SPM
Firewood	146.00	238.0	2861.60	569.4	3431.0	4584.4
Cattle dung	132.00	91.2	1080.00	216.0	1296.0	1728.0
Agricultural Waste	48.50	77.3	909.40	181.9	1069.4	1455.0
Kerosene	7.22	4.6	43.30	15.9	6.07	2.6
Charcoal	3.12	13.0	3.70	3.1	0.6	Na
LPG	2.24	1.5	0.02	6.3	0.1	Na
Total	339.10	425.6	4898.10	992.5	5803.2	7770.0

Source: Consumption data from TEDDY (1995), Emission and IGIDR estimates derived from J. Parikh (1977).

Table 2.10: Summary table of physical emission accounts during the year 1989/90 (1000 tonnes)

Sector	SO_2	NO_2	CO	VOC	SPM	Pb
Industrial	243.0 (4)	126.0 (4.9)	144 (6.6)	69.0 (1.0)	131 (1.5)	-
Households	4898.1 (81.5)	992.5 (38.5)	425.6 (19.5)	5803.2 (87.6)	7770 (91.2)	-
Transport	306.0 (5.1)	694.6 (27.0)	1616.7 (74.0)	751.4 (11.3)	206 (2.4)	15.9 (100)
Power	565.0 (9.4)	765.0 (29.7)	-	-	410 (4.8)	-
Total	6012.1	2578.1	2186.3	6623.6	8517	15.9

Source: IGIDR, Calculated from previous tables. Numbers in brackets show percentages.

Matrix B3 is the sum of the rows of B1 and B2, arranged as a diagonal matrix i.e.

$$B3_{ii} = \sum_{j=1}^{n} B1_{ij} + \sum_{j=1}^{m} B2_{ij}$$

Sectoral emissions for India are shown in Table 2.10, Table 2.11 gives percentage shares of each sector.

Ambient levels after absorption, deposition and dispersion: Some of the pollutants are absorbed, deposited or dispersed by nature. To that extent, avoidance costs may have to be modified. For example, the residence time for 99 per cent of SPM in air is less than six hours a day and for 99.9 per cent, it is less than a day. If it causes damage during this period, then the avoidance cost should be accounted for. Some pollutants on the other hand, have an effect only where their concentrations exceed threshold levels. Their build-up would depend both on the rates of emissions, the location where they are emitted as well as natural absorption and dispersion. Depending on the extent of absorption, the avoidance cost has to be modified. For example, household emissions due to bio-fuels are often deposited on walls, floors, clothing and of course, in people's lungs. Thus, row vector B4 in Table 2.2 will have to be estimated based on scientific consultations. This can be directly inferred if there are measurements of ambient air quality and emissions available over a period of time.

Emissions from any other natural event such as a volcanic eruption or forest fires which may affect air quality, need to be estimated and shown as new vector B5.

Valuation: As pointed out earlier, either the maintenance cost approach or the impact assessment approach can be used for valuation. Abatement costs should be estimated for each individual activity. Ideally, sample surveys should be carried out to obtain an abatement supply curve for different industries. This could then be combined into a national/regional level supply function.

Data from other countries could be used in the absence of surveys. A World Bank study by Hartman and others (1994) provides estimates of marginal replacement costs based on US data. Note that Table 2.11

corresponds to matrix C1 of table 2.2 shown in a transposed form.

Table 2.11: Average abatement cost by sector, 1979-1985 ($1993/tonne)

ISIC		Particulates	Sulfur Oxides	NO_2, CO_2	Hydrocarbons	Lead	Hazardous Emissions	Other
3110	Food	1 86	521	229	162	46612	55	55
3130	Beverages	156	271	11918	11918	76	76	76
3140	Tobacco	268	167	167	12030	128	128	167
3210	Textiles	396	396	1379	1379	1191	1191	1191
3211	Spinning	272	535	1431	188	781	188	188
3220	Apparel	445	61	61	61	61	61	61
3230	Leather	132	377	8430	633	132	324	427
3240	Footwear	540	207	993	1558	22141	1197	901
3310	Wood	47	38	38	38	38	38	38
3320	Furniture	43	25	25	25	24	13335	25
3410	Paper Products	87	364	472	472	87	87	87
3411	Pulp Paper	43	155	20	20	35	35	35
3420	Printing	424	117	309	307	117	5604	117
3511	Industrial Chemicals	46	75	304	213	1300	311	206
3512	Agricultural Chemicals	127	519	889	341	532	1069	320
3513	Resins	82	562	207	123	435	63	264
3520	Chemical Products	212	681	48	157	29	29	204
3522	Drugs	269	1045	451	173	300	300	300
3530	Refineries	328	165	59	121	2750	2750	2750
3540	Petroleum, Coal	59	1942	77	77	42	42	42
3550	Rubber	219	1107	343	343	1010	1010	1010
3560	Plastics	219	2415	235	235	1132	1132	1132
3610	Pottery	185	106	3792	3792	4709	4709	4709
3620	Glass	186	550	339	339	186	186	186
3690	Non-Metal Products, N.E.C.	20	213	2657	1658	11	11	11
3710	Iron-Steel	182	528	115	1203	779	253	18

ISIC		Particulates	Sulfur Oxides	NO_2, CO_2	Hydrocarbons	Lead	Hazardous Emissions	Other
3720	Non-Ferrous Metals	340	152	49	622	1284	1153	177
3810	Metal Products	343	1563	461	399	161	161	427
3820	Other Machinery	254	855	515	515	138	138	138
3825	Office, Computing Machinery	245	245	864	937	248	17458	245
3830	Other Electrical Machinery	373	483	1559	215	365	166	166
3832	Radio, TV	394	1854	904	1096	738	1491	1138
3840	Transport Equipment	635	1266	468	1006	468	2331	468
3841	Shipbuilding	125	832	2229	2229	84	84	84
3843	Motor Vehicles	350	1523	1155	2441	21483	159	159
3850	Professional Goods	1208	3046	872	1376	995	1634	995
3900	Other Industries	38	26	110	110	26	26	26

The cost estimates are in $1979. These have been inflated to $1993, using an annual compound rate of inflation of 4.6%. The latter was computed using fixed-weight price indices for pollution abatement and control for 1979 and 1989 and was obtained from Survey of Current Business, 1992.

Source: Hartman R., Wheeler D. and Singh M. (1994).

A similar matrix for households and transportation can be worked out. The options come from switching to better fuels, or in the case of transport, to using catalytic converters or fuel-efficient cars. These coefficients have to be worked out, based on the fuel and vehicle mix and the options available to society.

Similar coefficients can be obtained for power generation. However, it is difficult to apply the maintenance cost approach to domestic fuels, which is the major contributor to air pollution in India. This is because alternatives to clean bio-fuels for domestic use are not feasible from an economic point of view. If the new technology costs more, it would not be adopted by the bulk of the poor households.

The maintenance cost approach does not distinguish between emissions in a remote deserted area from a densely populated city. Therefore, in the case of air pollution where local effects are so dominant and where concentrations can vary dramatically over space and time, the impact assessment approach seems more relevant. In part B of the chapter, we present a case study of the impact assessment for the city of Mumbai in India. Such case studies also help in focusing attention on specific problem regions and suggest policy actions.

A Case Study of Mumbai, India

Part – B

2.2 Why a Case Study?

The accounts presented in the preceding section give a national- level picture but fail to capture the impact of high concentrations of pollution on the population. For example, in the urban areas, ambient air pollution levels are much higher than the national average levels and cause adverse impacts on health, property, agriculture and visibility.

The abatement cost method (or the maintenance cost method) that is often used at the national-level by calculating gross emissions from all major activities across the country, is unsatisfactory as a measure of social cost. It assumes that abatement measures are adopted to eliminate all emissions. When pollution levels are below the standard, they overestimate the cost. When they are above the standard, they may grossly underestimate the social costs incurred, due to damage costs caused to health, property and agriculture.

2.3 Case Study for Valuation

For an assessment of the societal impact of pollution, what is important is the ambient concentration and not the gross emissions. Emissions may cumulate in the air and even low levels of emissions from individual devices such as vehicles or stoves, may lead to a high ambient concentration, when the sources are numerous. Particulates concentrated in a few urban and industrial centres have a totally different impact from the same amount dispersed over a wider area. For example, SPM emissions from rail transport are not as serious as similar emissions from a stationary source. The reduction of emissions could entail costs which need to be its benefits. Therefore, case studies are essential in focusing on local problems and understanding potential benefits of policy actions.

At present, such a calculation is possible only with numerous assumptions and many such assumptions may not be scientifically rigorous. However, an attempt in this direction is warranted.

To illustrate the importance of the impact of air pollution, we present a case study of the valuation of health impacts in the city of Mumbai, India. The economic valuation of air quality degradation is not just about the loss of life or an increase in diseases. There are adverse impacts on plants, materials, monuments, even property prices or visibility. A total valuation should take into account all this. However, since our attempt is demonstrative in purpose, we limit our valuation exercise to health and mortality effects. The estimation of health and productivity effects involve three steps (Freeman, 1979a). The first step is to determine the relationship between changes in exposure to environmental pollution and human health as measured by mortality and morbidity rates. The second step is to use this relationship to predict the changes in mortality and morbidity, associated with specific changes in environmental pollution and exposure to pollutants. The third step is to derive monetary measures of changes in the health status.

2.3.1 The dose response relationship

The first task in the physical linkage method is to arrive at a dose-response function from which a suitable damage function can be generated. For human health, this is arrived at through a combination of bio-medical studies and statistical analysis. Damage functions could be either based on mortality or on morbidity. Those specified by Lave and Seskin (1977), Crocker and others (1979), Chappie and Lave (1982), and Lipfert (1984), focused mainly on mortality, while Ostro (1983, 1987), Portney and Mullahy (1986, 1990) and Krupnick and Harrington (1990) concentrated on morbidity effects.

Lave and Seskin (1977) used the multivariate regression technique on US Standard Metropolitan Statistical Area (SMSA) data to investigate the relationship between various air quality indicators and mortality rates. They found no evidence of thresholds for sulphates or sulphur dioxide and concluded that a linear model fits best to the data. They estimated the elasticities between mortality and the degrees of sulphates and particulates pollution. The estimates of elasticities across different data sets, model specifications and degrees of desegregation were substantially similar within the range of 0.09 to 0.12. That means that a one per cent increase in pollutant concentration will increase the mortality rate by about 0.1 per cent.

Ostro (1983, 1987) estimated the effect of air pollutants on morbidity using a damage function. Restricted activity days (RAD) and work loss days (WLD) were regressed to particulates, sulphates and several socio-economic variables. The regression results showed that particulates affected both RAD and WLD significantly. The elasticity was 0.45 for WLD and 0.39 for RAD.

Poor air quality has impact on both morbidity and mortality. Increased mortality is a loss of human resource, whereas, morbidity implies costs to the person affected and a cost in terms of lost production due to restricted activity days and work loss days. The total estimation of the cost of air pollution on human health and productivity would require data to estimate the damage function

The estimation approach used depends on the availability of data. Air quality in Mumbai has been and is being monitored by at least three agencies, for the past many years. The health status of the population has also been monitored from a time when environmental consciousness was not so high.

Air Quality Data: Air quality data is available from at least three sources:

1. The Air Quality Monitoring and Research laboratory of the Municipal Corporation of Greater Mumbai (MCGB).

   The MCGB has been monitoring air quality in Mumbai since 1978. Twenty- four hour samples are taken once every ten days for Suspended Particulate Matter, Sulphur dioxide, nitrogen dioxide and ammonia (the last, only since 1991). Out of 22 monitoring stations, six are in Chembur, a highly polluted suburb. Monthly means as well as maximum values were available.

2. The Maharashtra Pollution Control Board (MPCB)

   The MPCB has been making use of its mobile monitoring vans to take random samples at various locations in Chembur. Air quality values (in terms of SPM, SO_2 and NO_2) at more than 27 locations are available, though not on a regular basis.

3. The National Environmental Engineering Research Institute, (NEERI) Nagpur

NEERI has been conducting air quality monitoring since 1973 under the WHO- sponsored Global Environment Monitoring System (GEMS). There are stations in industrial, residential and commercial areas and monitoring is carried out once every ten days.

Since medical studies are only available from 1978 onwards, we have used air quality data collected by MCGB, which is the only agency maintaining air quality records from that year. This preference is no reflection on the data availability and quality from other agencies.

Exposure levels (pollution): Air quality is measured as concentrations of specific pollutants (SPM, SO_2, NH_2) in specific locations. The underlying assumption is that the monitored value of air quality is representative of the exposure levels of various pollutants to the population. The practical compulsions which dictate such an assumption are understandable as individual monitoring stations cannot be maintained in every household. Moreover, exposure does not depend only on the place where a person lives. A person may live in one place and work in another and during commuting may be exposed to pollution in a third place. Ideally, one would need to put an exposure metre on every individual in the sample. The fact that the ambient air quality monitoring does not represent the whole population has to be kept in mind while conducting epidemiological studies.

In addition to the general sources of air pollution outdoors, there are a number of indoor sources as well. Cooking by kerosene, coal and biofuels, all lead to high levels of indoor pollution which affect women and children more than others. It is therefore important to adjust the values of air quality for various age/gender and income groups. In the present study, the exposure level equivalent was used to calculate True Exposure for each individual. This equivalent value is based on a pilot study of exposure assessment conducted in Mumbai. The worst case scenarios were taken for analysis (Box 2.1).

Morbidity data : Mumbai was fortunate to have had medical research teams with foresight which identified as early as 1978, the importance of epidemiological studies in the area of air quality [The Environmental Pollution Research Centre (EPRC) at King Edward Memorial (KEM) Hospital]. Three locations with different population densities in Mumbai, viz., Chembur (Medium), Parel (High), and Railway Colony (Low) were selected for analysis.

Box 2.1: Calculating true exposure

A pilot study to analyse the level of exposure of different populations was conducted by the BMC, Khar Labs. Personal exposures of fifteen people, along with the ambient air quality indoors, outdoors, and the nearest ambient air quality monitoring site were monitored simultaneously for a period of one year. The subjects were non-smokers, residing in different parts of Bombay, using different modes of transport [car, trains and buses].

The results of the study indicated that personal exposure to concentrations of pollutants is higher than that of air pollution levels prevailing indoors, outdoors and at the nearest monitoring site. There is good correlation between human exposure and air quality indoors and outdoors at monitoring sites during winter and summer seasons but there is a weak correlation during the monsoon season. Indoor air quality is dependent upon the type of fuel used for cooking and is also affected by the nearby sources in the area.

The ratio of air quality measured as Respirable Suspended Particulates (RSP) at different locations with respect to the air quality monitoring station is given below (Ambient Air Quality Monitoring Station = 1.0)

Monitoring Station (M)	1.00
Outdoors (O)	1.07
Indoors (I)	1.15
Personnel (P)	1.27

The comparison of similar households but different cooking fuels revealed that those using kerosene are 1.92 times worse as compared to the ones using LPG.

Some of these relationships are used in the present study to arrive at better numbers of exposure to pollution. The basic assumptions were:

1. People are subjected to higher exposure level indoors than outside (I/M=1.15. O/M = 1.07).
2. Subjects using kerosene are subjected to a higher level of pollution than people using LPG (Kerosene/LPG = 1.92).
3. Housewives, children (< 5) and old people (> 60) spent most of their time indoors (95% time indoors)
4. People engaged in manual dusty jobs are exposed to higher level of pollution than manual non dusty.

Composite exposure values are obtained by taking weighted averages of the exposure time and exposure levels by making some simple assumptions.

Source : WHO EFR/84.66

For the present study, we make use of two sets of studies

1. A cross-sectional study was conducted in 1990 in Chembur. The study involved three middle-class residential localities. In the first locality (Telecom Factory), which is a community near the Rashtriya Chemical and Fertilizers Factory, 409 subjects (161 males and 248

females), were examined. In the locality which is two km away from the factory (Tolaram Colony), 342 subjects (144 males and 198 females) were examined. A residential colony which is distant from the sources of industrial pollution (Collector's Colony) was selected as a control and 341 subjects were examined (167 males and 164 females). The survey results provide details of individual subjects (age, sex, smoking history, type of housing, duration of stay).

The morbidity from this study is collected as discrete entries (for example, a subject having no cough is given 0, dry cough for last one year is given 1, productive cough for one year = 2 and so on). Of this, a sub-sample of 300 subjects was extracted (100 each from each monitoring stations). The samples had the same demographic distribution as the original sample.

2. The time series study conducted on the High, Medium and Low population density locations in Mumbai during 1978-80. The parameters measured were cough, dyspnea(difficulty of breathing), work loss days and hospital admissions.

Based on this data, an econometric analysis was carried out to derive a meaningful correlation between air pollution levels and health damages.

2.4 The Econometrics

2.4.1 Morbidity estimates

The study conducted by the EPRC at KEM hospital, used cross- sectional data for 300 households from the three housing colonies: Telecom factory, Tolaram, and Collector's Colony. The health surveys accounted for morbidity suffered as described earlier. The morbidity variable was discrete in nature, rather than continuous. If the subject was not suffering from cough for three months, the value on the variable was marked 1. If the subject was indeed suffering for a longer period, the value given was 2, and so on, with respect to increasing morbidity.

However, given that the variable was discrete, we could not run a simple Ordinary Least Squares (OLS) estimation. Discrete observations of the health status, such as those obtained in the cross-sectional study,

presents interesting econometric challenges. When the dependent variable is not a continuous function but takes discrete positions, ideally, one should use a multinominal logit model. However, due to limitations of time for data analysis, we aggregated the options into just two choices (having a symptom or not) so that a simple logit formulation can be employed (Box 2.2).

Box 2.2: The logit model

The logit model estimates the probability of a certain event occurring, given a certain set of independent variables. The dependent variable (Y*) is a latent variable and is not observable. What we observe is a qualitative variable y_i defined by

Y_i = 1 if $y^* > 0$

= 0 otherwise

$$y_i^* = \beta_0 + \sum_j^k \beta_j x_{ij} + u_i$$

1. Let P_i be the probability of $y_i = 1$ i.e., in our case, the subject is suffering from cough.
2. The error term is assumed to be logistic and we obtain

$$\log \frac{(P_i)}{(1-P_i)} = \beta_0 + \sum_{j=1}^k \beta_j x_{ij}$$

$$\frac{\partial P_i}{\partial x_i} = \beta_j * P_i(1-P)_i$$

The left hand side of the equation is called a log odds ratio. The log odds ratios is a linear function of the explanatory variables. After estimating the parameter, we can predict the effect of changes of any of the explanatory variables on the probability of the observation belonging to either of the two groups.

The detailed formulation of logit model can be obtained from any of the econometric text books [e.g., Maddala (1990)].

We estimated the following:

logit[DYSPNEA] = f[SMOKING, TOTAL EXPOSURE, SEX]

We arrived at the following:

LOGIT (DYSPNEA) =	0.012 TE +	0.477 SEX +	0.901 SM -	5.682
	(.0069)	(.43)	(.73)	(1.9)
				n=300

where

TE is total exposure calculated as described in Box. 2.1

SEX is dummy variable for sex, equals 1 when male, and 0 when females

SM is dummy variable for smoking, equals 1 when smoker and 0 otherwise

Standard errors are provided in parenthesis. Total exposure, smoking and sex are statistically significant at 10 per cent levels.

Illnesses [their own and those of their friends, neighbours, relatives] impose costs on the individual and the society in many ways. One obvious cost is the bills a patient must pay for a doctor's consultation fee, the medicine itself, the earnings forgone because of a workday lost and the cost of the trip to and from the doctor's. Society too loses out to the extent that its mandays in terms of productivity are lost, more people are ill or "down", others must be found to substitute for the absentee and make-do in his/her absence. Other costs that are not so obvious, are called opportunity costs. Since the government is diverting so many of its resources towards treating diseases caused by air pollution, other sectors like rural development or education could be affected. These opportunity costs are high but difficult to account for.

(1) Morbidity

Using the estimated Log-odds function, we can estimate the change in the probability of getting dyspnea due to unit change in the TE.

CHANGE IN PROB(DYS) = 0.0116 * 0.11 * 0.89
* [Change in True Exposure]

The *entire* population is not exposed to the *average* air pollution concentration. However, it is clear that the entire population is at least exposed to the lowest monitored value. A smaller percentage of the population is exposed to significantly higher pollution values. We will estimate the costs for the 83 per cent of Mumbai's population of 9909544 which is exposed to 200ug/m^3 rather than the average which is exposed to lesser emissions. The following is calculated:

CHANGE IN PROB(DYS) = 0.00114* (200 - 107)
= 0.1056

1. EXCESS DYSPNEA = (0.83 * 9909544) * 0.1056
= 868552

Dyspnea by itself does not imply an economic cost. The following assumptions based on medical judgements are employed to arrive at the cost of increased probability of dyspnea.

1. Fifty per cent of people suffering from dyspnea have either bronchitis or asthma
2. A bronchitis/asthma patient needs medical attention in the following manner
    1. Mild attacks, 100 per cent, once a year
       No doctor visits
       One work day loss
    2. Moderate attacks, 40 per cent, twice in an year
       Two doctor visits per attacks
       Three work days lost
    3 Severe attacks 5 per cent of total cases once in an year
       5 days in hospital
       10 work days lost

The "cost" of such morbidity is therefore borne is several ways. The total can be approximated as detailed in Table 2.12.

Table 2.12 : Data for the cost of calculating morbidity

Morbidity Related Support Sought	Cost in Rs Range	Cost in Rs Average
Medical Consultation (Out Patient)		
Doctors Fee (Per Consultation)	20-200	80
Cost of Diagnostic Tests (Per Case)	50-500	150
Medicines (Per day)	20-100	50
Transport (per visit)	10-100	40
Hospitalisation		
Doctors Fee	300-2000	1000
Diagnostic Tests	1000-3000	2000
Accommodation	2000-3000	500
Food (Two Persons, per day)	50-300	150
Transport (per stay)	200-1000	500
Full Time Assistant (Rupees per day)		51
Work Days Lost (Rupees Per Day)		51

From the data presented above, the economic cost of morbidity can be calculated.

Table 2.13 : Total economic value of increased dyspnea

Severity of Attack	Number of people affected	Loss Suffered	Rupees ('000s)	Total Rs. ('000s)
Mild Attack	434276 (50%)	One Workday loss	36045	36045
Moderate Attack	173710 (40%)	Consultation (80*2)	26309	129011
		Diagnosis (100)	16443	
		Medicine (50* 5)	41107	
		Transport (40*2)	13154	
		Workdays lost (3*51)	25157	
Severe Attack	21701 (5%)	5 Days in Hospital	51385	162877
		Diagnosis Tests	20550	
		Consultation	20550	
		Food	15412	
		Transport	10277	
		Workday loss (Patient)	52402	
		Workday loss (Assistant)	10280	
		Medicine	20550	
TOTAL DAMAGE				223809

Table 2.14 : Expenditure per individual case of dyspnea attack

Severity of Sickness	Expenditure (Rs)	% of Annual Income
Mild Attack	51	0.28
Medium Attack	743	4.00
Severe Attack	7506	40.60

(2) Mortality

Excess mortality has to be first estimated before determining its monetary value. Ideally, one should statistically estimate a relationship between death due to respiratory diseases and exposure to SPM. The data required to separate the effects of income, access to health care, congestion, sanitary conditions of the living environment, nutritional status, period of exposure and

exposure level were not available. To obtain a rough idea and illustrate the method of valuation, we consulted doctors and obtained a rough indication that four deaths from 1000 cases of severe dyspnea attack are likely to occur. Based on this for a 100 unit change in SPM, the number of excess deaths/deaths avoided can be calculated as shown below:

Excess deaths incurred and avoided to 100 units change in SPM	=	0.004 * severe cases of dyspnea attack
	=	0.004 * 21701
	=	86.8 ~ 90 approx.
Estimate of value of life from Human Capital Approach	=	Rs. 2,36,924
Cost of lives lost/saved	=	90 * 2,36,924
	=	Rs. 2,13,23,160

If estimates of only the health impact have to be assessed, then the economic value of damage to health due to unit increase in the ambient concentration of SPM can be obtained by adding up both the mortality and morbidity costs per unit change in SPM. This can further be transformed to the economic value of unit emission of SPM as shown below:

Total Health damages (Mortality & Morbidity)	=	Rs. 245,132,160 /-
Damage per unit (1 ug/cm) increase of SPM	=	Rs 24,51,321 /-

An increase in every tonne of SPM will result in 0.0074 unit increase in ambient concentration, and so an increase by one tonne of SPM will result in a loss of Rs. 18,384. Or in other words, every excess kg of SPM will result in a loss of Rs 18 exclusively due to morbidity and mortality losses. This unit can now be appended to the I-O matrix.

From this computation, it is evident that the economic value of an increase in the ambient concentration of SPM is not only a function of the emission of pollutants or ambient concentration, but also the number of people affected by the increase in ambient concentrations. The economic status of the population also affects the economic value of impacts like mortality and morbidity. The final model should account for all these variations before it can be put into the I-O matrix. It makes sense to conduct such an NRA exercise for a few hotspots rather than for the entire national economy. Alternatively, one could use the economic degradation value of a few cities and average them out for the entire economy.

As explained earlier, the environmental damage constant varies over time because there is an increase in population as time passes. So every unit increase in SPM affected 90 lakh people in Bombay in 1991, whereas it affected only 75 lakhs in 1981. A correction factor to account for population growth needs to be applied to take care of this. Using the average population growth in Bombay (Table 2.15), one could put this constant as 3.5.

Table 2.15 : Population growth in Mumbai

Year	Population	Decenial Growth Rate %
1951	2966902	-
1961	4152056	39.95
1971	5970575	43.80
1981	8243405	38.07
1991	9925891	20.41
Average Annual Growth Rate		**3.56**

Yet another factor which accounts for changes in the constant is the change in economic value consequent to an increase in the economic status of the population, or the cost of medical services. This can also be accounted for by another correction factor, that is the average growth of wages in Bombay (Table 2.16). This factor can be taken as 12 per cent.

Table 2.16 : Annual growth of emoluments of industrial labour (all industries)

Year	Total Emoluments / manday	Annual Growth %
1981	36.17	
1982	40.17	11.11
1983	44.90	17.16
1984	49.78	10.87
1985	57.45	15.59
1986	61.73	7.00
1987	68.71	11.47
1988	75.25	10.29
1989	84.95	12.00
1990	93.79	10.71
1991	105.59	12.90
Average Annual Growth Rate %		**11.91**

The damage function will now have to be multiplied by a combined index, which is (111.91 *103.56)/(100) = 115.89 for updating every year.

2.5 Conclusions

It is clear from the above analysis that the negative externalities of economic activities can be accounted and appended to the System of National Accounts. Obviously, the present study is only a demonstration of the concept. It is not a substitute for a full-scale dose response relationship study. It can be fine- tuned once reliable data on various environmental and health sectors is assured. Till such time, these numbers are at best seen as the order of magnitude indicators of the changes in the quality of natural resources.

Valuing a human life is a difficult task. It is not a specific individual's life but a statistical value of life. It can be estimated either from insurance premia or from compensation to be given or from the wages foregone. Such valuation helps to assess the total magnitude of losses from mortality to compare with losses from morbidity. It can guide local strategy for pollution management. However, these cannot be included in the national accounts as some health expenditures may have already been included. Loss through deaths can be seen as depreciated human capital but it is not included in the capital accounts. The purpose of such an exercise is to emphasise the cost of air-pollution. Moreover, it will not be appropriate to compare these values across the country as valuation is embedded in the socio-cultural value system of a society.

Such case studies are also useful for decision-making at a local level, (e.g., Mumbai city level) where the cost of steps to avoid or mitigate pollution can be compared with the damage costs borne by the society, directly or indirectly. Similar case studies, if conducted for household air pollution, could also give the magnitude of the impact, in relation to the additional expense for clean fuels.

Thus, the SEEA can benefit from local case studies because they provide:

a) Estimates of specific damages due to pollution.

b) Coefficients derived from these estimates which can then be used to arrive at estimates from other places (cities) in the country

c) Coefficients that can be used by cities in other countries (e.g., Manila, Seoul) with suitable modifications till such time as they can carry out analysis specifically suited to their situations.

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APPENDIX A

Model for Air Emission Inventories

SI C#	PROCESS	UNIT (U)	TSP kg/U	SO_2 kg/U	NO_x kg/U	CO kg/U	VOC kg/U	kg/U
MAJOR DIVISION 0. **ACTIVITIES NOT ADEQUATELY DEFINED**								
	Consumer Solvent Use[1]	(Person)*(year)					4.2	
	Surface Coating							
	Painting	t consumed					560	
	Varnish	t consumed					500	
	Lacquer	t consumed					770	
	Enamel	t consumed					420	
	Primer (Zinc Chromate)	t consumed					660	
MAJOR DIVISION 1. **AGRICULTURE, FORESTRY AND FISHING**								
111	**Agricultural and Livestock Production**							
	Open Burning of Agricultural Materials							
	Field Crops	t	11.0			58	9.0	
		1000 m² of land	5.0			26	4.0	
	Vine Crops	t	3.0			26	3.0	
		1000 m² of land	1.7			15	1.7	
	Weeds	t	8.0			42	4.5	
		1000 m² of land	5.8			30	3.2	
	Orchard Crops	t	3.0			26	4.0	
		1000 m² of land	1.0			9	1.4	
	Forest Residues	t	8.0			70	9.0	
		1000 m² of land	12.6			110	14.0	
121	**Forestry**							
	Charcoal Manufacturing							
	Uncontrolled	t	133		12	172	157	
	Afterburners	t	25		12	34	31	
MAJOR DIVISION 2. **MINING AND QUARRYING**								
210	**Coal Mining**							
	Coal Cleaning							
	Coal Drying							
	Fludized Bed Dryer							
	Uncontrolled	t of dried coal	10	0.22	0.07		0.05	
	Cyclone	t of dried coal	6	0.22	0.07		0.05	

t = tonne

1. The listed factor includes evaporation losses from the use of polishes, waxes, deodorants etc. and its value is related to the standard of living of people in the study area. A lower value than the listed one may be more appropriate for areas with low standard of living.

Source: Economopoulos, A. (1993).

3

Solid Waste Management Accounts for India

Part A : Accounting for Solid Waste Management

3.1 Satellite Accounts for Waste Management

Waste management is one of the important aspects of environmental management which needs to be incorporated in the SEEA as a satellite account. The logistics and data requirements for this are extremely demanding, even for the formal sector. For the informal sector, the task is even more complex.

An I-O framework used in the conventional SNA can be used to first include waste management sectors, formal and informal. What needs to be shown is where in the economy waste is produced, where it is consumed, how it moves within sectors, and where it finally ends up[1]. A waste account is defined by Smith, R. [1994] as follows:

" ... A **waste account** is the organisation of data on the production and disposal of waste into a framework that allows their integration with the economic data held in the System of National Accounts ..."

The developed countries may exclude the informal sector in the SEEA. But for developing countries - as the economy and environment is significantly affected by it - the integration of the informal sector into the SEEA becomes imperative.

Conceptually, the integration of the informal sector into the formal SEEA framework poses no difficulty. However, in practice, it raises a number

[1] This exercise can be very useful for a SWM policy that wants to fix responsibility, i.e. make each unit accountable and liable for waste produced. The matrix can be used to assign certain production co-efficients to each industrial sector as being responsible for X per cent of the waste produced in the economy. Similarly each sink for disposal can be highlighted as per the percentage of waste actually absorbed by it. Subsequently, socially desirable taxes and incentives can be structured.

of problems. First, by their very definition, some of the sectors are 'informal' and to that extent, unaccounted and not detailed. Second, their impact on the economy, let alone the environment, is not recorded, or documented by other agencies. Hence the estimation of their contribution to the economy with respect to goods and services is not well-established. Data on emissions and effluents emitted by the informal sector is not easily available. It must be identified and estimated independently.

While some informal sectors contribute towards environmental degradation, others may work to regenerate environmental capacity. It is important to see if the poor can help in environmental regeneration and in the process, obtain their livelihood. Environmental regeneration is needed and can be employment-intensive e.g. afforestation or garbage collection. The informal SWM sector that collects, transports, sorts, re-uses and recycles waste, and moves significant quantities of valuable materials back into the mainstream commercial sector, is one such important contributor.

This chapter explains not only the important task of the waste management sector, including and incorporating informal sectors into environmental accounts, but also provides a case study for a satellite account at a national level and Mumbai city at the local level. The solid waste management sector in Mumbai city that consists of both formal and informal sector contributions, is selected to demonstrate this.

It is true that much of the data required to design complete satellite account is unavailable. To quote from Smith [1994]:

> " ... it almost goes without saying that the data requirements (for) waste accounting are well beyond the scope of the waste statistics available (in Canada). This is not to be lamented however. One of the purposes served in setting out a conceptual framework is the identification of data gaps in existing statistical systems. Once identified, these can be used as a guide to data development ..."

The same holds true in India, and probably in most of the world, not only for SWM sectors, but indeed for many others. Part of the reason for this reality is that it is only recently that governments and people have recognized the need to study and curb development that has undesirable effects on the environment.

The following sections define and describe "waste accounts" and how they fit into the I-O framework.

We define the physical inter-relationships between the environment and the waste management sectors, as the first step needed for an SSNA. Asset boundaries are established and impact highlighted, and wherever possible, a physical quantification of environmental impact is presented. An economic valuation of these impacts is also carried out. The SSNAs are integrated into the SEEA as the final step. In part B we have presented a case study of Mumbai.

3.2 Solid Waste Management: An Overview

Waste management is an important civic activity. When waste is not removed from the streets and public places in time, it poses severe public-health and hygiene hazards. In countries with a tropical, warm and humid climate such as India, decomposition of garbage is especially accelerated. Moreover, waste in Mumbai contains 40 to 60 per cent organic components as compared to 13 per cent in New York (NEERI, 1993).

"Waste" refers to materials that are perceived as having no use or monetary value, and are hence disposed of [Beukering, 1994]. Occupations allied to waste management or recycling too command a low status. In general, municipal authorities also view solid waste as a worthless residue or a by-product of the necessity of consumption and production. Consequently, its management becomes a collection, processing and disposal problem. When the process is disrupted, residents complain of irregular waste collection, non-collection, dirty streets and blocked *nallahs* [open gutters].

This attitude is unfortunate because 'waste' often comprises valuable components and it can actually be considered a potential resource. Not only can it be used as a fuel or as a landfill material but it can be of significant value when its individual components are accounted for.

3.3 Incorporating Waste Sectors in the SNA

Having seen why it is important to account for the SWM sector, let us return to the incorporation of the SWM sector into the SNA.

In building the waste accounts we use the conventional I-O matrix but add to it an extra 'waste' component to show the flow of waste through the economy [Table 3.1]. It is true that solid waste (SW) is made up of several independent components and many materials and that in an I-O framework, different waste types will originate from different sectors, and move differently through the I-O matrix. For the purposes of the present study, however, we do not separate the components of waste, except when we determine the economics of valuable materials in the waste. In extending the NEA to include the waste sector, we conceptually depict the various kinds of waste as Waste 'i' through Waste '**k**' [Table 3.1]. Otherwise, throughout the work, waste is not treated in separate components except in local level case study of valuation.

A detailed waste account will consider two types of waste: the first being the waste produced directly from an economic activity [eg: CO_2 from industrial activity] and the second type being the waste produced as a result of worn-out capital [eg: durable household goods presently discarded]. The latter can be considered as 'other waste' in the waste accounting set-up.

Waste sinks refer to the repository in which the waste is finally discarded for long-term storage or assimilation. In the case of Mumbai, for the non-retrieved waste, the repository happens to be the environment since waste is dumped on land.

Waste inventories are stocks of waste that re-enter the economy even after primary disposal. For example, reserves of plastic, glass, metal and paper recovered from household garbage in Mumbai can be referred to as the waste inventory.

Waste management [WM] industries are those enterprises that collect, treat, dispose and/or recycle wastes produced by other economic agents. Households and governments which are generally consuming sectors in the SNA, become producers of waste.

3.4 Defining Physical Inter-relationships for SSNA for SWM

In the present context, we treat SWM as a service sector. Hence, we amplify the SERVICE column of the conventional SNA for demonstration.

A physical approach to measuring environmental amenities could begin with the immediate influences that economic activities and human intervention have on the natural environment. However, the effects and impact on the environment can be measured only partially by considering major direct impact – such as land degradation due to dumping. It is more difficult to include the secondary impact that results in poor ambient air quality, contamination of water bodies, an imbalance in the ecological make-up, and negative health effects on human beings as a result of this dumping.

A diagrammatic representation of the physical inter-relationships is given below.

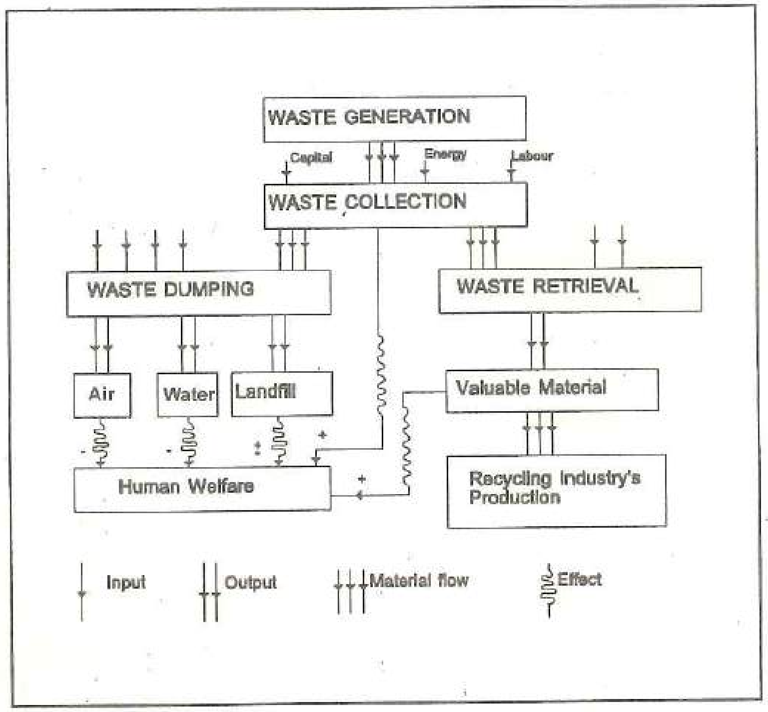


Figure 3.1: A representation of SWM activities and economic-environmental linkages

Table 3.1: Extending the SNA to reflect waste accounts

	Commodities 1,...,m	Waste1... k	Industries		Final Demand	Waste Sinks		Total	
			Non WM	WM		Environment 1,...,z	Inventories 1,...,v	Disposal of commodities	Disposal of waste
Commodities 1,...,m									
Waste 1,...,k									
Primary Inputs									
Industries									
Households									
Government									
Other waste sources									
Total									

Source: Smith, (1994).

Waste collection and disposal entails inputs of capital, energy and labour. Dumping waste needs land, labour, capital and energy. Waste retrieval however, a purely informal sector activity, requires only labour, and minimal capital[2]. Dumping of waste results in air and water pollution. It also blocks land that could have been used for other purposes, and degrades its quality. Retrieval of waste has positive a impact on human welfare as the recycling industry helps society to save valuable resources and postpone the consumption of virgin goods.

3.5 Defining Asset Boundaries

It is true that economic activities affect the environment and the ecology in numerous ways, many of which we can measure only partially, and some of which we are unaware of. Transformations within the economy affect and dictate the output of goods and services, as well as the residuals from production and consumption that affect the natural environment. Transformations within the natural environment, affect material outputs or raw materials and the quality of life in general, that in turn affect the economy.

Given that there are numerous linkages and processes within the natural environment that we have limited information about, we design a narrower framework, which can, however, serve our defined purpose.

An SEEA can focus on that part of the natural environment that is directly or indirectly, actually and potentially affected by human activity. Thus, a limit can be set, within which impacts on the environment will be studied and valued. The definition of such an *asset boundary* may seem incomplete from the point of view of the ecological sphere, but it has advantages when attempting the initial setting-up of the SEEA.

For the SWM sector, we define the asset boundary as the following assets:

Land : When waste is disposed of on land, there are substantial effects on land quality. Impacts are especially harsh when uncontrolled dumping

[2] The only capital that can be considered here is the magnetic metal detectors that some ragpickers use in order to separate small metal components out of waste.

practices are followed. As the quantity of waste to be disposed of increases, especially in a large metropolis such as Mumbai, the supply of additional land for disposal purposes is restricted.

Water : Waste disposal in substantial quantities could lead to leaching and contaminate water tables, adjoining streams, wells, lakes, and creeks. Often, drinking water too could get polluted.

Air : The collection and disposal of waste from streets and public areas in itself has a positive effect on the ambient air quality. But some negative effects also occur when large-scale, uncontrolled dumping takes place. Decomposing waste degrades the quality of ambient air, especially in tropical conditions.

A conceptual matrix showing the activities SWM entails, and their impact on the three resources discussed above [land, water and air] is given below. Only select sectors are presented and impacts on human health and resource quality are depicted. XXs show positive impacts and YYs depict negative ones [although they may attain differing numerical values].

Table 3.2: A Conceptual partial I-O matrix showing linkages for SWM sectors

Sectors	Services connected to SWM				
	Collection + Transport	Dumping	Burning	Sorting + Structuring	Recycling
Transport	YY	YY			
Energy	YY	YY			
Land		YY	XX	XX	
Air	XX YY	YY	YY	XX	
Water		YY		XX	
Value added [wages and salaries]	XX				

The shaded rows 'land', 'water' and 'air' characterised in bold print depict environmental sectors that record *Environmental Joint Products* that result from SWM.

Each activity shown in the table above has important implications for the environment and the economy. We need to quantify wherever possible, environmental joint products and impacts. This forms the second stage in constructing the Satellite Account.

3.6 Integrating Environmental Costs into SEEAs

Having established the economic value of certain costs and benefits connected with SWM and how resources flow and are consumed in this activity, we append the economic values [as 'negatives' or 'positives' if they make profitable contributions towards human welfare] into the SNA.

Solid waste disposal is a major problem mainly for urban areas. A national-level analysis will not reveal the real problems. Therefore, it is important to carry out a case study of an urban area and examine how this can be integrated to the national- level accounts. A case study of Mumbai is presented in Part B.

Part B: A Case Study of Mumbai, India

3.7 Background

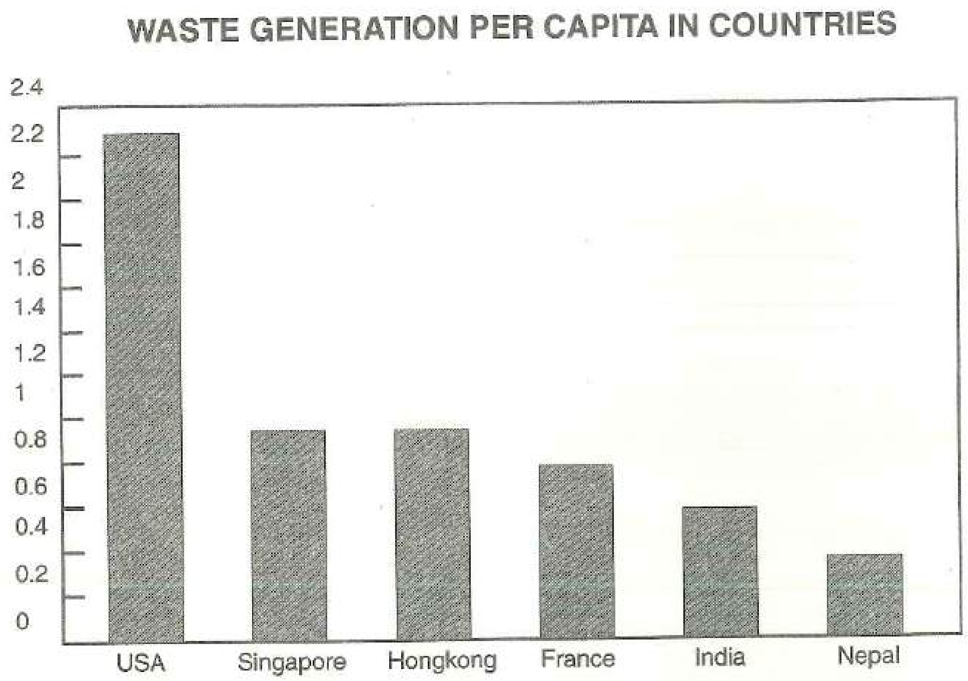
The activities that contribute towards solid waste collection - management, processing, disposal and the retrieval of valuable material from waste, generate important economic, social and environmental benefits. Given these significant benefits of SWM systems, the need to carry out benefit studies is crucial to guide policy and future action.

Working close to and in parallel to the formal SWM sector is the informal sector, which is a major player in the waste management system in Mumbai, and most urban centers in India [Beukering, 1994]. The informal SWM sector is primarily responsible for undertaking the critical job of retrieving valuable materials from waste. It also serves to mobilize a market for recyclable materials. A leading industrialist in Mumbai calls ragpickers " our environmental entrepreneurs". Although retrieval activities are prompted more by economic compulsions, they generate important positive benefits for the environment, and natural resource use, apart from conserving energy. However, despite the significant economic and environmental contribution, it continues to remain an informal, and poorly – rewarded sector.

This chapter describes the case study of the formal as well as the informal waste management system in Mumbai. The concept of a waste account is used within which activities of sectors and subsequent impacts are studied. Joint Environment Products are identified and qualified and an accounting framework is set up. Economic valuation is provided wherever possible. When quantities are not easily available, especially in the case of externalities which are difficult to quantify, attempts are made to provide estimates.

3.8 The Status of Solid Waste Management in Mumbai

Mumbai city with an area of 169 sq km, is inhabited by about 10 million people, excluding its high floating population. It is among the world's most densely populated cities. The city produces more than 5000 tonnes of garbage every day, with 0.5 kg of waste produced per capita per day. This amount is comparable to waste generation figures from other low-income countries, but it is low compared to the developed countries. This can be attributed to the fact that Indians in general re-use and recycle extensively within the household and this life-style results in a greater conservation of resources. Also, the use of packed goods in India is still modest. Figure 3.2 below gives some indication of how much household garbage Indians generate per capita, versus other countries.



Source: Bhide and Sundaresan, (1983).

Figure 3.2: A cross-country comparison of household SW generation

Garbage generation in Mumbai is expected to increase with higher incomes, an expanding population [resident as well as floating], excessive packaging and an emerging 'throw-away' culture. Already, waste generation grows at 6.17 per cent per annum whereas population growth in Mumbai is at 1.62 per cent per annum. The characteristics of the city's refuse are given in Appendix I.

Waste generated by households, commercial establishments and the industry is discharged into street bins. Only a few households have door-to-

door collection services through the informal or formal sector. The garbage in bins usually ends up scattered over pavements and roads. Municipal vans collect the garbage and finally dump it at disposal sites. Ragpickers sort out the garbage and retrieve valuable material from the bins and even at the dumping sites. After collection, this material is sorted out by material type, sometimes cleaned, and then sold to waste dealers or wholesalers who later supply it to other industries.

Figure 3.3 depicts the waste management network, as it prevails in Mumbai today. There is very little data on the *source of the production* of waste, be it the household, industry, or the government.

Some important impacts of each of the activities depicted in the figure need to be mentioned. Garbage on the streets has a direct effect on the health of those who live around the bin. It is not only unhygienic, but can spread disease and cause discomfort due to its bad odour. While residents blame municipal authorities for poor waste management, officials, on the other hand, complain that the sheer volume of waste is increasing exponentially, making it difficult to handle without additional infrastructure. Besides, for a city such as Mumbai, landfill is becoming a poor option for waste disposal as dumpsites are fast reaching their capacity, and land in Mumbai is prohibitively expensive[3].

3.9 The Formal SWM Sector

Mumbai city's SWM is undertaken by the Municipal Corporation of Greater Mumbai(MCGB),[4] under its Solid Waste Management Department [Appendix 1]. The total MCGB budget for SWM has been increasing over the years [to Rs 1230 million in 1993], and was seven per cent of MCGB's total budget of Rs 18,188 million in 1993.

[3] Land may not be prohibitively expensive for the SWM department if all the residents who avail of the SWM services were to pay for the service based on the volume of waste generated per unit/household. At present, the SWM sector does not charge households or other units for its services in proportion to garbage produced, and remains under the auspices of the Municipal Corporation of Greater Mumbai.

[4] All the documents which we have referred to are preceding the change of name of Bombay to Mumbai. Therefore, we have retained the acronym MCGB.

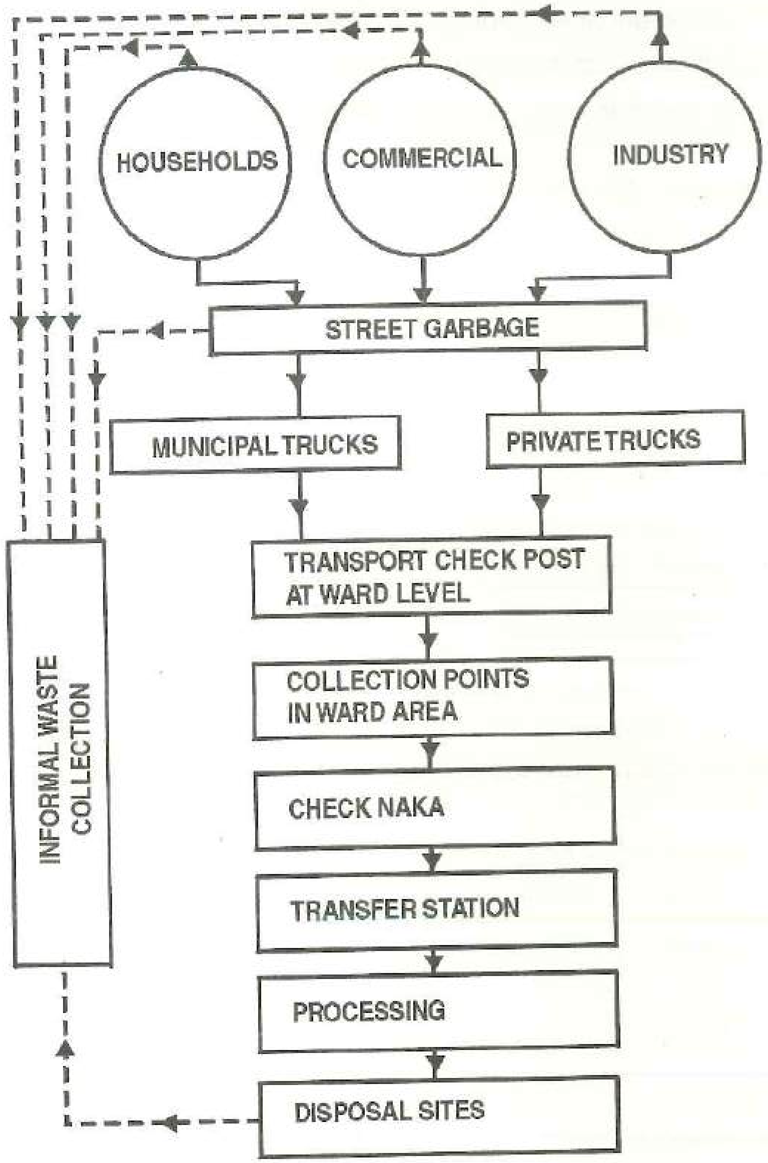


Figure 3.3: Movement of municipal garbage in Mumbai

SWM, as defined by MCGB, consists of services related to the "collection, removal and disposal of garbage and sweepings from public roads, streets, foot-paths and lanes, and maintenance of dumping grounds" and " the removal of night soil and cess-pool from unsewered areas, and the maintenance of public sanitary convenience."

The quantity of refuse and other waste material collected from public areas as well as households, in Mumbai city and its suburbs amounted to 1.66 million tonnes during 1992-93. The collection of debris amounted to 1.18 million tonnes, totaling about 2.85 million tonnes during 1992-93. The details of transport and disposal, including particulars about disposal sites, are given in Appendix I.

The total staff in the SWM department is 26,239. This works out to about *2.5 SWM workers per 1000 residents*, and to *more than five persons per tonne of garbage.*

The SWM Department estimates that the cost of garbage disposal amounts to about Rs 120 per resident per year, or in excess of Rs 400 per tonne of garbage and industry debris. This amounts to about $15 per tonne of garbage and industry debris, and is consistent with the low side of benchmark cost estimates for municipal waste collection and disposal per tonne of $19-38, provided in Pearce [1994] for low- income countries. It is quite probable that people would be willing to pay more than this amount per year if the MCGB were to charge per household by volume.

3.9.1 *Concerns of the formal SWM system*

It is clear that the MCGB contributes significantly to community health and hygiene by cleaning the streets and public areas in the city. The system also generates employment for more than 26,000 people, apart from related and contract work.

However, the department has been criticized for irregular and incomplete waste collection and poor maintenance of dumpsites which pose a threat to community health. Though theoretically, a large amount of garbage is generated and supposedly handled, it is not cleared on time. Studies which have looked at the workers in the SWM department, have described the system as inefficient and questioned the method by which resources are allocated within the system.

No studies have been performed within the MCGB's SWM department to compare the relative costs of incineration, landfill and recycling. Indeed the department undertakes no waste sorting and retrieval at all, leave alone recycling! Nor are provisions made for another department to take on this responsibility.

Solid waste management improves urban environment quality and ensures community health and hygiene. However, employees of the MCGB suffer from occupational hazards due to handling of garbage. Conditions in the dumpsite are damp and warm, and therefore conducive to expedite decay and promote disease.

The other problem with dumpsites is high methane concentrations. Fires errupt due to such concentrations either accidentally or deliberately. Therefore, this system of waste disposal takes a heavy toll on the ambient air quality as well.

The SWM department needs in excess of 26,000 litres of diesel a day to operate about 780 trucks. Each truck covers about 100 km, using up about 9.3 million litres of diesel per year. The implications for environmental quality of so much fossil fuel burnt are significant and are studied in later sections.

Dumpsites are spread over 170 hectares in Mumbai. This aspect gains significance given that the amount of land held for the purpose of dumpsites is considerable, and that the opportunity cost of land in Mumbai is very high.

3.9.2 Contribution of the informal SWM system to waste removal

The formal sector in SWM does not recycle or retrieve materials from waste and it is here that the unorganised sector steps in. Ragpickers in the informal sector collect waste from house to house in certain suburbs, and from all public areas in the city. They retrieve valuable materials from street waste even before the formal sector begins its work and reduce garbage to organic waste. This places less burden on the formal sector and also brings down the volume of uncollected waste, extending the life of landfills.

3.10 Economic Valuation of Retrieved Materials

3.10.1 Value of retrieved materials

An estimated 100,000 ragpickers individually pick approximately 12 kg of waste per day. This amounts to 4,40,000 tonnes a year which is about a quarter of what MCGB collects through its formal set-up (not counting the debris).

Table 3.3 estimates the economic value of waste collected by ragpickers. Column 3 refers to the price ragpickers earn per kilogram of material they collect, and column 4 refers to the price wholesalers charge per kilogram for selling the material.

Table 3.3: Quantity collected and associated earnings

Material	Quantity/day [kgs]	Price received by ragpickers [Rs/kg]	Selling Price of material [Rs/kg]
Paper	4.83	2-5	4-10
Plastic	5.57	5-10	15-30
Metals	0.86	13-20	35-55
Glass	1.29	2-5	4-10

Source: INTERVENTION, [1995]. Column 4 depicts the selling price waste dealers quote as estimated by IGIDR based on Srikanth, [1992].

Ragpickers receive only half the price of what the wholesalers sell the materials for in the market or to small-scale industries. Using estimates of the amount wholesalers acquire for materials and the material composition of the waste, one can estimate the economic value embodied in what is otherwise referred to as "waste". Table 3.4 calculates the economic value of a representative composition of garbage in Mumbai, generated per day.

Effectively, after the wholesalers' mark-up, what the *daily* waste ragpickers inject back into the economy per day can provide about Rs 2 million to Rs 3.7 million of useful materials to the economy. That amounts to an estimated Rs 900 million worth of recyclable material per year (US$ 30m).

According to this accounting, ragpickers who reduce the cost of waste collection and disposal, also return economically valuable resources to society by sorting and recycling valuable materials from waste. Unlike the formal sector, they help conserve virgin resources which would otherwise be necessary for fresh production, and reduce subsequent pollution load.

Table 3.4: Economic value of 'waste'

Material	Quantity as % of total	Low estimate values [Rs/t]	High estimate values [Rs/t]	Total Value using low estimates [Rs/day]	Total Value using high estimates [Rs/day]
Compost-ibles	60%	- -	- -	- -	- -
Glass	7%	80	100	28000	35000
Paper	7%	400	1000	140000	350000
Rags	4%	400	400	80000	80000
Plastic	9%	1500	3000	675000	1350000
Metals	7%	3500	5500	1225000	1925000
Moisture	6%	- -	- -	- -	- -
Total	100%			**2,148,000**	**3,740,000**

Source:Compiled by IGIDR using estimates from NEERI, (1993) and INTERVENTION, (1995).

3.10.2 Employment

The informal waste management system directly occupies 100,000 ragpickers, excluding the secondary employment it may generate. The system also helps to set up a market for recycled materials, usually adjoining dumpsites[5]. The ragpickers who collect waste from house to house, operate with wholesale waste buyers in the same geographical area. Also, they walk from one neighbourhood to the other and do not use any formal transport facilities. So, the informal waste collection system significantly saves on transport and related costs and pollution.

[5] This finding is not uncommon. Yhdego (1991) reports that a range of small-scale industries in Dar es Salaam receive raw materials to the tune of 50 per cent to 65 per cent from ragpickers operating on dumpsites.

The formal sector SWM employees earn salaries that will be reflected in the 'value added' row. The salaries and benefits of the SWM workers amount to Rs 922 million, which is about 75 per cent of the SWM department's budget.

The informal SWM ragpickers do not get paid as such. Their earnings are restricted to how much they can sell from the materials they collect and sort.

3.10.3 Transport

Long-distance transportation of waste is undertaken only by the formal sector. Transportation has important implications for emissions and fossil fuel use. Conveyance leads to a deterioration in the quality of ambient air in the metropolis. The SWM department undertakes 778 trips a day, each truck covering about 100 km, which amounts to 77800 km per day, or in excess of 28 million km per year! This costs the SWM department about Rs 93 million per annum.

At a very pessimistic mileage estimate of the trucks [which are generally old and in poor shape] of 3 kms/litre of fuel, fuel consumption for SWM amounts to about 9.3 million litres. The following emissions from this fuel consumption are calculated per annum at 1938 tonnes of CO, 3663 tonnes of NO_x, 748 tonnes of HC, and 119 tonnes of SPM.

3.10.4 The costs of dumping

Dumping requires labour, vehicles and energy. However, the most significant impact of dumping is felt on the land that is used for landfill and dumping purposes. About 170 ha of land in Mumbai is put aside as dumpsites and at today's rates it can be valued at Rs 1.5 billion. The rent this land could command can be very high given the demand for land in Mumbai. This is a very large amount and several times that of the MCGB's entire yearly budget! This estimate is kept low to reflect the fact that most dumpsite land is low-lying and that it is not suitable for *pucca* construction prior to landfill.

3.10.5 The cost of waste burning

About 100 tonnes of garbage is set on fire by both the formal and informal sectors on 33,145 sq metres of land area, in Deonar each day [NEERI, 1993]. Burning 100 tonnes of garbage per day for the whole year results in 3577 tonnes of SPM, 2664 tonnes of SO_2, 5000 tonnes of VOC, 657 tonnes of NO_2, and 14125 tonnes of CO per annum, significantly polluting ambient air. Comparing ambient pollutant levels with the Central Pollution Control Board standards, NEERI [1993] reports that SO_2 levels are close to the upper bound of permissible pollutant levels for residential areas; SPM levels are twice the standard.

The resulting air quality in the ambient environment is highly deplorable. Even residents living in localities adjacent and close to dumpsites complain of the foul odor. They also complain of eye, skin and throat irritation. Visibility deteriorates to less than 20 ft due to smoke from burning at certain times [Times of India, 1994; Indian Express, 1994]. Dumpsites are located alongside busy highways, and this low visibility has implications for traffic speed and safety. All these need to be technically valued but are difficult in practice.

The findings of one of the health surveys conducted by NEERI (1993) in 25 per cent of the peripheral households adjacent to dumpsites, confirms morbidity due to poor environmental quality. The findings of this study are presented in Table 3.5.

Table 3.5: Morbidity in households around municipal dumpsites

Complaint	% of males suffering	% of females suffering
Breathlessness	61	36GG
Burning of eyes	72	64
Chest pain / burning	11	9
Cough	100	82

Source: NEERI, (1993).

However, there are some positive effects of waste burning. It does reduce the volume of waste, in turn bringing down the need for landfills. But

these benefits are marginal as burning reduces only two per cent of the waste but creates other, more serious problems.

3.10.6 Waste sorting and recycled materials

The sorting and supply of valuable materials by the informal sector ragpickers has important positive effects on both the economy and the environment. This activity reduces waste in general, and hence reduces all subsequent impacts. These spin-off effects are substantial and immediate effects on all sectors are easily visible if an I-O matrix is made. By retrieving material from waste, ragpickers effectively reduce the need for virgin production, and its subsequent economic and environmental impact.

In the SEEA, one will see that sorted waste from the SWM sector acts as an input to the recycling industry production sector. There lies the major benefits of the informal waste collection and retrieval system.

The plight of ragpickers who work on dumpsites is pathetic because they are already very poor and under-nourished. Studies show that almost all of those working on dumpsites suffer from poor health. Even if one assumes that ragpickers suffer from only minor infections, cuts and bruises, the economic value of just the medicine required to relieve them would amount to Rs 72 million per annum for treatment that costs a meagre Rs 2 per day (This may be required but not actually spent due to poverty).

The cost of water pollution due to waste disposal on dumpsites [specially untreated and uncontrolled ones] is also of significant value. Especially so when the damage is substantial enough to pollute water tables, rivers, wells, lakes and other sources of potable water.

On the positive side, the SWM sectors contribute to community health and hygiene, although benefit studies are lacking. *Stated preference measuring* Contingent Valuation (CV) exercises based on the willingness-to-pay (WTP) method can throw light on the benefits of an SWM system. In lieu of the fact that such formal studies are lacking, we can use *revealed preferences* of people. One can study the WTP of residents to domestic servants who carry garbage from the home to the community bin. However, the WTP estimate will be a gross underestimate of the benefits of the SWM system, as residents do not pay the municipality for waste disposal. Assuming that only about 50 per cent of the city's population pays for waste to be transported to community bins, it can be estimated that Mumbai pays to the tune of Rs 30 million per annum on this front[6].

In addition, the informal sector's waste-retrieval activity is contributing Rs 900 million worth of recyclable material per year! Both sectors employ an estimated 1,30,000 people directly, apart from the indirect employment generation.

3.10.7 Expanding the case study

The methodology of case study of Mumbai needs to be applied at an all-India level. Further, the satellite account will have to be integrated with the national-level SEEA.

This could prove to be complicated for a variety of reasons. To mention only a few, firstly, Mumbai's SWM situation may not apply to other metros in the country, and certainly not to towns or rural areas. Secondly, costs and benefits of SWM may differ across the country. Thirdly, it is difficult to aggregate pollutants across the country – they have to be monetised on the basis of local concentrations.

However, having established a framework for doing an SEEA -type analysis of the SWM sector, one can demonstrate many more SWM accounting studies in other parts of the country. Alternatively one can consider Mumbai's situation to be representative and append an SEEA for the entire nation.

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[6] Assuming that households contain 5 members, on average, and that they pay about Rs 25 per month to menial workers for the sole purpose of carrying garbage out of their homes, aggregated WTP works out to Rs 600 million. Assuming that only about 50 per cent of the city avails of this service, the WTP of Bombay to the limited SWM system subsequently works out to Rs 30 million. This is a gross underestimate as it does not measure the benefits from the municipal system that carries waste from the community bins to dumpsites.

3.11 Emerging Policy Conclusions

The SEEA or the satellite account are valuable economic tools as they have the potential to provide an insight into the impact of human activities on the environment, and their subsequent effect on human welfare. This could contribute to major decisions which have to be taken to check the tendency of continuing degradation.

With respect to identifying the 'right' agents, the informal SWM sector gains relevance. Although informal, it is this sector that makes important contributions towards the economy and the environment. Thus its inclusion into the SEEA and into the agenda for policy becomes imperative.

It is now recognized that SWM is an important civic, economic and environmental activity. In the coming years, its role will have to be compatible with the demands of growing cities and sustainable development which lays stress on reuse and recycling materials. Hence, the structure, organization, efficiency and implications of the waste management sector, be it formal or informal, will have to be studied and improved wherever needed.

The SEEA framework shows that the contribution of the informal SWM system has important economic benefits for the economy as a whole, as well as for the environment from subsequent spin-off effects. The satellite account also showed that the environment bore a heavy burden due to waste dumping. As recycling assumes importance, the informal sector will play a significant role and steps must be taken to ensure that this sector gets its due.

Economic measures have to be put in place in the form of recycling credits, deposit-refund schemes and other incentives. Ragpickers should also be provided with specially-designed equipment to protect them from occupational hazards. Further, garbage can be initially treated before being dumped to make it less hazardous. The government needs to find ways to give a just rate for the recycled materials and devise a healthcare system for ragpickers incorporating hygienic working conditions, apart from providing them with social security.

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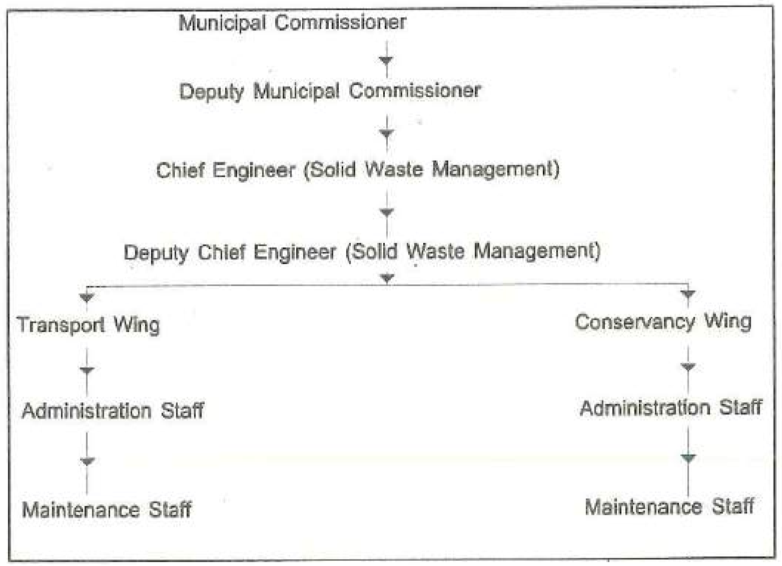
Appendix I

The Formal SWM sector

The SWM department comprises of a Conservancy as well as a Transport Department. The administrative set-up is diagrammatically shown in **Box 1.**

Box 1: The administrative set-up of SWM department in Mumbai: a diagrammatic representation



The SWM department employs supervisory staff, technicians, scavengers, motor loaders, *halalkhores*, and *bigaries*. The latter are menial workers employed to collect and clean street garbage and sewers.

The collection of garbage operates in two shifts each day. Payment to private contractors is made when a "full trip" is made, i.e. 400 cubic feet of waste is transported [i.e. more than six tonnes of garbage].

Appendix Table 1: Details of vehicle pick - ups

Area	Municipal Vehicle Trips p/a	Contract Vehicle Trips p/a	% Contributions by Municipality	% Contribution by Contractors
City	26684	117213	37.67	62.52
Suburbs	37943	71596	31.97	68.03

Source: MCGB, (1993).

More than 90 per cent of the population is served by the community bin system, and others are catered to by a house-to-house collection system. Another estimate, however, suggests that almost 30 per cent of the city's garbage is not collected by the formal system at all [Srikanth, 1992]. If true, this fact could have significant implications for urban health, hygiene and environmental quality.

Table B gives an outline of the attributes of Mumbai's waste.

Appendix Table 2: Composition and characteristics of Mumbai's garbage

Material	% Composition
Compostable Matter	60%
Glass	7%
Paper	7%
Rags	4%
Plastic	9%
Metals	7%
Moisture	6%

Source: NEERI, (1993); INTERVENTION, (1995).

Processing and disposal

Waste is transported to Transfer Stations, discharged directly into refuse bulk carriers which then leave for dumpsites. But only 30 per cent of the trips are routed through transfer stations as the others proceed directly to dumpsites.

The processing of collected garbage is as yet limited to negligible

amounts, although some experimental treatment initiatives on a limited scale are in progress.[7]

Transport

The SWM department carries waste from the streets to the dumping sites. Since it has a limited transport facility, it engages private contractors to collect and transport debris and refuse. The relative contributions of services made by the MCGB and private agents is shown below. Over the years, the MCGB has been increasingly sub-contracting transport services to private parties.

In total, 778 trips are made each day and each covers a route of about 100 kms per day. Each day, 256 [~30%] trips are made by municipal vehicles and 522 [~70%] trips by private contractors.

Disposal

As the garbage is finally dumped on landfills, this entails reclaiming low -lying areas. Four sites cater to this demand for land - Chincholi, Gorai, Deonar and Mulund. The table below indicates their capacity and size.

Appendix Table 3: Details of disposal sites

Site	Area [ha]	Quantity [tonnes/day]	Vehicle Trips/day	Volume filled [cu.m.]	Estimated remainder life of disposal site [years]
Deonar	111.0	3140	526	5283939	10-15
Mulund	19.2	1163	48	411946	10-15
Marve / Malad	14.5	424	227	169851	5-8
Gorai	25.2	275	52	852565	5-8
Total	169.9	5000	853	6718301	

Source: NEERI, [1993].

[7] One such example is that of EXCEL industries that purchases waste from MPCB and makes manure from it. On a capital cost of Rs 38 million, their operating cost works out to Rs 1000/tonne, while their product sells for Rs 1300/tonne. This activity is profitably carried out and there are plans to expand production. Another initiative under the Department of Science and Technology, Government of India, is making fuel pellets from the waste. Other private initiatives use vermi-composting but all these are pilot projects with limited scale.

Disposal sites need bulldozers and labourers to spread and level the waste. Water supply and fire-fighting arrangements are available only at Deonar and Mulund disposal sites, although possibilities of fires breaking out at dumping sites are real and can be extremely hazardous.

Expenditure

The collection costs account for staff salaries, maintenance expenditure and equipment costs. The transport costs incorporate salary spent on staff, fuel, maintenance of vehicles, depreciation and interest charges. The disposal costs include staff salaries, electricity, bulldozers, fuel, civil works, etc. The total expenditure on clearance, transport, and disposal of refuse of 1.6 million tonnes amounted to in excess of Rs 1 billion during 1992-93. About 75 per cent of the SWM department's budget is spent on salaries of staff.

Transport costs vary according to the type of vehicle used, but is estimated (by MCGB) at Rs 135, Rs 40, and Rs 26 for open trucks, compactors, and dumper placers respectively, per cubic meter of waste.

Appendix II

The Informal SWM Sector

At the lowest end of the informal SWM sector, financially as well as socially, are the ragpickers. An estimated 100,000 people worked as ragpickers in Mumbai in 1992 [Panwalkar, 1992]. Ragpickers are usually illiterate young children and women, poor migrants from drought or famine stricken areas of the country.

Ragpickers [or scavengers, or garbage collectors, as they are called] collect items from garbage and sell them for a living. Ragpickers operate at all levels: they pick materials from garbage directly, from households, from street corners, and from municipal disposal sites. They collect valuable materials from waste, such as plastic, paper, newsprint, metals, glass, rags, etc, sort it by material type, and sell them to waste buyers and wholesalers. They also play a central role in developing a secondary market in recylable goods near dumping sites. They retrieve anywhere between five per cent to ten per cent of the refuse either for reuse or recycling, before the formal SWM system collects it.

Problems faced by the informal waste collection system

Although ragpickers effectively help society recycle valuable materials, and to consume its resources carefully, it is unfortunate that they are looked upon with condescension. Although they save millions of rupees worth of material for the community, they remain poor and homeless.

By the very nature of their jobs, however, ragpickers face serious occupational hazards. The environment they work in is full of decomposing and humid waste, yet they have no protective clothing or protective masks. They are exposed to unhygienic surroundings and often suffer from respiratory disorders, skin and eye irritation, and injuries from sharp metals or needles or due to stepping on burning waste. They are prone to plague, diarrhoea, typhoid, dysentery and scabies [Pearce, 1994]. The conditions at dumping sites are particularly adverse during the monsoons.

Even if 50 per cent of the ragpickers suffer from minor infections, cuts and bruises, which is a conservative number, the economic value of only the medicine required to treat them would amount to Rs 36 million per annum for treatment that costs only Rs 2 per day.

Ragpickers are harassed by the police, local muscle men, and are allegedly associated with drug abuse and petty crime. They lack any social standing or social security, and are viewed as undesirable elements by a society that does not appreciate their real value.

4

Water Resources Accounts for Korea

4.1 Introduction

The Korean economy began to face various problems in the 1990s despite the success of the export-led growth policy during the 1970s-80s. Population concentration in some metropolitan and industrial complex areas, and the significant growth of production and export in energy-intensive and pollution-causing industries are some of them. In addition, the Korean environment has deteriorated due to a combination of rapid industrialization, population growth and urbanization.

One of the most pressing environmental issues is inland water pollution. Water pollution has worsened since the 1970s due to increased household and industrial wastewater discharge which has destroyed river ecosystems and polluted drinking water sources. The protection of drinking water sources and the supply of safe drinking water are crucial environmental issues facing Korean society today. On the other hand, the availability of water resources critically affects water quality and that of Korea varies significantly with the seasons. About two- thirds of the annual precipitation is concentrated during summer. Further, local precipitation fluctuates widely and the run off time is short due to the narrow watershed and steep river basin slope. These characteristics create difficulties in efficient water resource management. One way of addressing the issues related to water quality and water resources management is the establishment of an environmental accounting framework.

This study provides the appropriate framework for water resource accounting in Korea and compiles accounts based on the SEEA framework for a specific period, 1985-1992. The main objectives of this study are:

(1) Elaboration of a framework for water resource accounts based on the SEEA for Korea

(2) Identification of flows and stocks of water resources

(3) Valuation of water resource depletion and pollution

(4) Compilation of water resource accounts based on SEEA

(5) Identification of the linkages of water resource accounts to SNA and SEEA

In addition, policies and issues with respect to water resource accounts in the context of SEEA are discussed at the end of this study. The present study, however, emphasizes the above-mentioned objectives since they can be fully achieved only with an agreeable framework and data sets from the related government bodies, research organizations and environmental experts. Although this study identifies data by industry type, based on water pollutant emissions, the uses of water resources, environmental costs, and capital formation for the prevention of water pollution, its details are not reported here. Industry analysis based on this information is not presented since it is beyond the scope of the current study.

The basic approach to constructing a set of water resource accounts for the Republic of Korea is to use existing data for the selected years - 1985-1992 (some data is additionally covered for 1993), and make appropriate adjustments for the depletion and degradation of water resources. The SNA and SEEA are linked by the incorporation of water resource as a non-produced (natural) asset in the SNA. Such consolidation is necessary for integrated environmental-economic analysis and is the basic approach adopted to compile the water resource accounts based on the SEEA in Korea.

4.2 Status of Water Resources in Korea

4.2.1 Supply of water resources

Korea is located within the Asian monsoon zone and has an annual mean precipitation of 1,274 mm which is 1.3 times more than that of the world mean. However, the annual gross precipitation per capita is only one eleventh of the world average (34,000 m^3 per capita) and annual precipitation varies widely from 754 mm to 1,683 mm. The total volume of annual mean

water resources is estimated at 126,700 million m^3, of which 69,700 million m^3 is the surface run off and 57,000 million m^3 is lost in the form of evaporation and infiltration. About 69,700 million m^3 is the available volume of water resources and from the annual precipitation, about 55 per cent runs off through rivers. The natural groundwater resources of Korea is estimated around $32,27 \times 10^8$ m^3. Table 4.1 shows the overall water resource status of Korea. In 1992, only 23 per cent of the total volume of annual mean water resources or 28,600 million m^3 was used. This low rate of utilization is due to the intensive rainfall in the summer rainy season (700 - 900 mm of rainfall between June and September) and short and steep waterways. About 49,700 million m^3 of water is lost due to floods in summer.

The Han, Nakdong, Keum, and Youngsan rivers are four major sources of surface water. About 25 per cent of the total surface water is used for industrial and household purposes. Underground water is estimated at 1,324,000 million m^3, of which 8.8 per cent or 117,000 million m^3 can be used. In 1992, 1,900 million m^3 of underground water was practically used. According to recent statistics, households used 5,100 million m^3 of water, industries, 2,500 million m^3 and agriculture, 14,100 million m^3 in 1991 (Korea, Ministry of Environment (MOE), 1993). Water consumption in Korea is expected to increase significantly, to reach 33,000 million m^3 in 2001. Developing additional water supply sources will be a major task in the future

In Korea, the total amount of water resources available is estimated on the basis of the annual mean precipitation and the quantity estimated does not necessarily reflect the concept of stock. In the estimation, the stock of aquifers is excluded and the amount lost by evapo-transpiration is subtracted from the annual mean precipitation. Table 4.1 shows demand - supply figures assembled from the original data gathered for 1988 by the Korea Water Resources Corporation (KOWACO) (1990). Because this study was conducted for 1988 and is done every ten years, this kind of stock data is available only for 1988.

4.2.2 Uses of water resources

Water uses in Korea are classified into four groups : domestic use, industrial use, agricultural use and river maintenance flow. The total amount of water required, based on the data in 1988, is about 24.8 billion m^3. This demand is met in part with the water supplied through the rivers (14.435 billion m^3), from the underground (1.763 billion m^3), and from the dams and reservoirs (11.219 billion m^3). Although it seems that there is a water surplus of 25.58 billion m^3, many areas, in fact, do not have enough water supply. Only limited areas receive enough water through the wide-range water supply system built around the major dams.

Table 4.1: Status of water demand and supply in Korea(1988) (unit : billion m^3)

Classification		Amount
Demand	Domestic water use	4.216
	Industrial water use	2.396
	Agricultural water use	14.70
	River maintenance flow	3.547
	Sub-total (A)	24.859
Supply	River	14.435
	Underground	1.763
	Dam or Reservoir	11.219
	Sub-total (B)	27.417
Excess (or Deficiency) (B) - (A)		2.558

Source : KOWACO, (1990).

4.2.3 Water pollution and water quality in Korea

Increased household and industrial wastewater discharge has destroyed the river ecosystems and polluted drinking water sources, making drinking water supply a major issue. The household(domestic) waste-water has increased annually by seven per cent and industrial waste-water by 20 per cent. However, the number of treatment facilities for sewage and treatment plants for human excrement are insufficient, and the amount of untreated waste-water discharged into the rivers and oceans is increasing rapidly. In 1992,

only 37 per cent of domestic sewage was treated before being discharged into the rivers.

Water pollution in Korea shows unique variations in different rivers and seasons, according to the distribution characteristics of emission sources and natural seasonal conditions. Water quality standards were set for rivers, lakes and marine waters and vary for different bodies of water. Water quality standards for rivers and lakes are classified into five categories and sea water into three categories. These standards were set for pH, BOD(biochemical oxygen demand), COD(chemical oxygen demand), SS(suspended solids), DO(dissolved oxygen) and the number of E.coli(Escherichia coli) to ensure sufficient water quality for supporting

Table 4.2: Water quality in four major rivers (unit : BOD(mg/l))

Rivers	Points	Water quality Standards	Average in 1991	Average in 1992
Han River	Euiam*	1.0	1.6	1.4
	Chungju*	1.0	0.9	1.1
	Paldang*	1.0	1.1	1.1
	Noryangjin	3.0	3.9	3.6
	Kayang	3.0	4.8	4.3
Nakdong River	Andong*	1.0	1.1	1.1
	Koryung	3.0	5.8	5.4
	Namji	3.0	4.3	3.8
	Moolkeum	3.0	4.0	3.3
	Kupo	3.0	3.7	3.5
Keum River	Okcheon*	1.0	1.6	1.4
	Taecheong*	1.0	1.6	1.6
	Chungwon	1.0	3.1	2.9
	Kongju	3.0	3.1	3.3
	Puyeo	3.0	3.0	3.2
Youngsan River	Tamyang*	1.0	1.1	1.4
	Kwangju	3.0	2.8	3.4
	Naju	3.0	5.6	5.6
	Mooan	3.0	1.5	2.1

Notes

1. Source : MOE, (1995).
2. * indicates that the point is located upstream. BOD - Biochemical Oxygen Demand.

various existing or desired uses of water bodies. The water quality in the upstream and mid-stream of the four major rivers is relatively better (Table 4.2), but it has deteriorated downstream. Water quality in most of the lakes and dams, most of which are the sources of drinking water supply, suffer from eutrophication. The quality is expected to worsen due to the increased inflows of water pollutants in the future (Table 4.3). Therefore, the government is making an effort to improve the water quality of lakes and dams by designating those areas as special protection areas for drinking water supply.

Table 4.3: Status and prospects of eutrophication in major lakes and dams

Lakes	Years			
	1986	1991	1996	2001
Paldang	eutrophic	eutrophic	Eutrophic	eutrophic
Euiam	eutrophic	eutrophic	Eutrophic	eutrophic
Choongju	mesotrophic	meso- and oligotrophic	Eutrophic	eutrophic
Andong	eutrophic	eutrophic	Eutrophic	eutrophic
Hapcheon	eutrophic	eutrophic	Eutrophic	eutrophic
Taecheong	mesotrophic	mesotrophic	meso- and oligotrophic	eutrophic
Okjeong	oligotrophic	oligotrophic	Oligotrophic	oligo- and mesotrophic
Asan	eutrophic	Eutrophic	Eutrophic	eutrophic
Sapkyo	eutrophic	Eutrophic	Eutrophic	eutrophic

Source : Chung Chin-Sung, (1993).

4.3 Accounting for Water Resources

4.3.1 Framework for inland water resource accounts for Korea

The accounting framework for water resources based on the SEEA consists of two major parts. The first is the integrated accounting table to present the analytical data blocks which follows the format of SEEA (Table 4.4). This

table needs to be converted into a format in which integrated economic-environmental data is presented. Alternatively, one can construct it in mixed monetary-physical terms and comprehensive monetary terms, after valuation of degradation, depletion and stocks of natural assets. The second part consists of the individual accounting tables which contains the data supporting the integrated accounting table. Such tables would include the tables for environmental degradation and produced and non-produced(environmental) asset accounts. Based on the data compiled for these accounting tables, analytical measures, such as ratios of capital-output and value added-output, could be derived to show how analyses change when environmental elements are included and/or environmental adjustments are made to the national accounts measures (van Tongeren and others, 1994). The framework of the SEEA for Korea adopted here was originally developed through the regional UNDP project implemented between 1994 to 1996 by the Korea Environment Institute and technically supported by the UN Statistics Division.

The framework for inland water resources accounts in Korea should be applied to both physical and monetary cases and allowed to measure the flow and stock of water resources. Also, the accounting framework should be able to emphasize both the quality and quantity aspects. The accounts for inland water resources, based on the SEEA in Korea, can be composed of two major tables of asset account and emission account.

4.3.2 Asset accounts of water resources

Unfortunately, the SEEA does not provide a detailed description of the physical accounts for water resources. It describes only the general features of natural resources accounts (UNSD, 1993), (van Tongeren and others, 1994). Based on the non-produced asset accounts of the SEEA, the asset accounts for water resources are presented as Table 4.5. To compile this table, data for the various types of water flows, water sources and water uses, the unification of the measuring units, identification of accounting items, and new estimation for indispensable data are required.

Table 4.4 : Framework of integrated environmental-economic accounts

Supply/Use Table							Asset Accounts	
							Produced assets	Non-prod. assets
	Industries/ products	Of which envir. prot. industries					Opening stock produced assets	Opening stock non-produced assets
	Output	Output	Export					
Industries/Products	(-) Intermediate consumption	(-) Intermediate consumption		Imports	Household consumption	Government consumption	(+) Gross capital formation	
	Of which intermediate consumption for envir. Prot.	Of which intermediate consumption for envir. Prot.		Of which imports for envir. prot.	Of which: final household consumption for envir. prot.			(+) Of which gross capital formation for envir. prot.
	(-) Depreciation	Depreciation					(-) Depreciation	
	(-) Degradation emissions caused by industries	(-) Degradation emissions caused by industries			(+) Degradation emissions caused by households		(-) Degradation emissions, effects	(-) Degradation transboundary envir. Impacts, net
	(-) Depletion	(-) Depletion						
	(=) Net value added*	(=) Net value added*						
	(+) Factor incomes & current transfers received from less paid to abroad							
	(-) Degradation trans-boundary envir. Impacts, net						(-) Other vol. changes in prod. assets	(-) Other vol. changes non-prod. assets
	(=) Net disposable income*						(+) Revaluation prod. assets	(+) Revaluation non-prod. assets
							Closing stock produced assets	Closing stock non-prod. assets

* If degradation and depletion are accounted for, net value added and net disposable income refer to environmentally adjusted aggregates (UNSD, 1993).+, -, = refer to columns.

In Table 4.5, a distinction is made between different types of water, i.e. surface water, underground water deposits, dam water, other fresh water (dam water is distinguished from surface water since the data is separately compiled in Korea). In actual compilation, shown in Table 4.6, we have prepared water supply and uses accounts in aggregate terms. Since the stock of water resources, including underground water, has not been surveyed annually, it can be assumed that the water quantity in the long run has not changed, even though there may be periods of drought in which the quantity of water may fall below acceptable levels. Only in one instance, i.e., when water is extracted from the aquifers, could the quantity of water be affected. So, the uses of water can be treated in a water supply/use table and this quantity does not affect the water resource stock in the framework.

Table 4.5 : Format for asset accounts for water resources

	Total Resources	Aquifers	Ground water deposits	Surface water	Dam water	....
Opening stock						
Uses of water						
Drinking water						
Industrial water						
Other water						
Depletion						
Ground water extraction						
Other volume changes						
Natural disasters						
Water replenishment						
Revaluation of assets						
Closing stock						

Table 4.6 : Balance-sheet for water resources (unit : 100 million m^3)

1. Total Precipitation	267
1.1. Outflows	97
1.1.1. By flood	467
1.1.2. Regular	230
1.1.2.1. Used(extracted) (A)	145
1.1.2.2. Non-used	85
* Extraction from outflows by flood and non-used (B)	87
1.2. Losses	70
1.2.1. Evapo-transpiration	365
1.2.2. Accumulation to underground waters	205
* Annual availability of underground waters	143
2. Underground water reserves	32,275
2.1. Available reserves	18,676
2.1.1. Extracted (C)	17
3. Total water resources (= 1 + 2)	,542
4. Total withdrawals and final uses (= A + B + C)	249

Source : KOWACO, (1990).

4.3.3 *Degradation accounts of water resources*

The quality of water resource changes as a consequence of economic activities. So water quality may be affected by emissions from industrial plants and also by the use of water for drinking and industrial purposes. Degradation accounts of water resources can be prepared as a part of environmental assets in a table analogous to Table 4.5. In this, water quality measures are expressed as mg of BOD, COD and SS per unit of water for different sources of water.

For analytical purposes, the quality characteristics need to be correlated to the amount of changes in accumulated degradation. However, the effects of water pollution on natural assets can hardly be identified. Therefore, they are generally captured by monitoring water quality or by estimating the amounts of water pollutants unloaded to water bodies. Judging the water quality of rivers by monitored data and averaging the monitored data to have a representative value for the river's water quality, cannot be

directly used as a measure of the water quality of the whole river. The quality of a river varies extensively according to the location and hydrological conditions at monitoring points.

As a result of the reasons cited above, apart from data deficiency, the overall surface water quality is not accounted for in the suggested framework, though the emissions of wastewater and BOD are provided. That is, the amounts of wastewater and BOD unloaded into rivers are accounted for, instead of the water quality.

4.3.4 Data sources and reliability

Water is one of the natural resources, the stock evaluation of which requires extensive surveys and a large amount of investment. Although some countries such as France, Finland and The Netherlands have compiled physical water resources accounts, most countries do not have this kind of resource accounts or even data. This is also the case for Korea.

Data for physical asset accounts: Data on annual precipitation, the total water resources, internal outflows, gross annual availability and final uses is available in KOWACO*(1991-2011)* and from the old Ministry of Construction(MOC). The former has data on quantities of water resources stock, water utilization and water supply by source for 1988. This data is mainly for surface water based on annual precipitation. For the other years, only the data for water utilization is available. Even if water is not sold in the market, limited data on water rights is available from the Farm Land Improvement Association (FLIA). Information on underground water is available for the years 1988 and 1991. Also, the hydrological data in each of the inland water streams is available, but data does not exist on a yearly basis.

The data on the agricultural and domestic water use in the major river basins is readily available from various sources. For industrial water use, the MOE has some data on daily water use by industry type. However, the survey report does not cover all the plants using industrial water and the data for the operating days is not available. KOWACO (1991-2011) only provides prediction data on the total industrial water use in the future. Limited information on the uses of recycled water by different industry types is available from the MOE.

Data for environmental degradation : *The Korea Environmental Yearbook*, issued every year by the MOE, contains data on water quality in the various water bodies. The National Institute for Environmental Research(NIER) also published a *Study on the Unit Load of Wastewater Discharging Facilities* which included data on unit loads of water pollutants in terms of the amount of sales and products for 134 sub-industries of 26 industries for the years 1987-1989. The industry classification used is not completely consistent with the classification used in 1985 and 1990 I-O tables. Due to this reason, the data obtained cannot be used to estimate the physical and monetary amounts of the emissions by-product as classified in the I-O tables.

The Annual Survey Report on the Industrial Wastewater Discharge, issued by MOE since 1984, is based on survey results performed by six Regional Environment Offices and 15 provinces. It includes statistics of wastewater discharge facilities, emission quantities by industrial types, water uses, wastewater treatment plants, investment expenditures for wastewater treatment, treatment costs by industry and treatment types.

For the degradation accounts of water resources, data from the *Annual Survey Report on the Industrial Wastewater Discharge* is used in the compilation of this study.

Data for monetary valuation: For the monetary valuation of water resources, enough data on market prices and production costs of the various water types does not exist. In most cases, the monetary value of water resources provided in the monetary accounts cannot reflect the net price of water resources. It can only estimate the market value of different uses of water resources. To estimate the environmental costs of degradation (more correctly, pollutants emissions), the unit wastewater treatment costs are available from the internal data of the MOE and the *Annual Survey Report on the Industrial Wastewater Discharge*. The detailed uses of that data are described in the section on environmental costs estimation.

Data availability is limited, especially for water pollution, effects on natural assets and contamination of ground water. In some cases, the data collected is not in the format required by the framework. Therefore, some adjustments and simple estimations are needed to make the data compatible with the accounting system presented in this study. What will be described in the compilation of water resources accounts for Korea in the next sections will not be the physical or monetary accounts which are consistent with the framework provided in SEEA. Instead, the compilation will be a summary of the existing data which tries to resemble the SEEA framework.

4.4 Compilation of Water Resource Accounts

4.4.1 *Scope and criteria of accounting for water resources*

In this section, the method of the ways of constructing accounting tables, the data used and their sources, estimation methods of physical and monetary stocks and flows of water resources are discussed. Asset accounts of water resources, emission tables of water pollutants and their monetary accounts are also presented. Emission tables of water pollutants and their monetary accounts are substituted for water quality degradation accounts since the connections between emission, concentration, and contamination, i.e. the pathways and distribution of water pollutants, cannot be made in this study.

In the SEEA, the estimation for the cost of resource depletion and the environmental asset valuation can be made by the net price method which deducts production cost from the market price. For want of appropriate market prices, the maintenance cost approach is used to estimate cost of the environmental degradation.

The transboundary water pollution of the Yellow Sea and nuclear waste dumping in the East Sea by Russia would reduce the EDI (environmentally adjusted net disposable income) on the framework, if they are accounted for. However, they are not accounted for in this study since no reliable and concrete data is available on these issues.

As in the case of environmental degradation accounts, it is very important to determine a scope of accounting for emission tables and their monetary accounts. In other words, we need to define the relationship between environmental (absorption) capacity and the amount of pollution, to decide a criterion for accounting.

In estimating the environmental cost of degradation, it will be useful to analyze the impact of pollution on the environment, ecology and human health. Since nature has a self-cleaning or absorption capacity, it is necessary to estimate the excess amount of pollution emitted or degradation beyond nature's absorption capacity. To estimate the excess amount of pollution, a standard or criterion to be followed should be given. The standards considered in this study are:

(1) The amount of pollution in excess of the environmental (absorption) capacity

(2) The amount of pollution emitted beyond the environmental standard set by scientific evidence and environmental norms

(3) Pollution emitted under the assumption that the current status of environmental pollution has already exceeded the environmental (absorption) capacity, and

(4) The amount of pollution increase from last year

From a scientific perspective, the first and second methods are reasonable. However, it is very difficult to estimate environmental (absorption) capacity with the first method. With the second method, it is difficult to identify the linkages between emissions and environmental standards. Further, the first and second methods require more detailed information on the amounts of pollution emitted according to regional environmental capacities and standards.

The third method is a kind of radical approach and it tends to overestimate the environmental cost while the physical emissions can be compiled without much difficulty. The fourth method is a very moderate approach and it cannot account for cases where the emissions are decreased by pollution control technology or production processes, while the pollution still deteriorates the environment. Thus, the third approach is adopted in this study by relaxing the assumptions. That is, in this approach,

the amount of water pollutants that are discharged without treatment or after treatment are accounted for in the physical and monetary emission tables.

4.4.2 Physical asset accounts of water resources

As discussed earlier, the estimation of water resources in Korea covers only surface water and it is based on annual precipitation. The estimated amount of water resources cannot be treated as a stock and the physical assets accounts cannot be compiled. One way to overcome this problem is to make an assumption that the water resources stock in the long run is not changed, i.e., the annual precipitation is not changed for a specific period, and to compile the physical assets accounts for water resources.

In this case, the concept of sustainability cannot be applied to the compilation of water resources accounts. However, considering the droughts Korea has experienced in the past, this approach may not be acceptable. More detailed and in-depth survey and studies are required to compile the legitimate water resources accounts.

Keeping in mind these various data problems on water resources, this study replaces the assets accounts for water resources with Table 4.5. The demand and supply table for water resources can be compiled as in Table 4.7, and their outflows and losses table is compiled as Table 4.8.

Table 4.7: Demand and supply of water resources (unit : 100 million m^3)

Year	Demand					Supply				Surplus & Deficit
	Total	Domes. Use	Indus. Use	Agri. use	River maint. flow	Total	Under-Ground Waters	Surface Waters	Dam Waters	
1985	239.7	27.5	20.0	142.2	50.0	225.0	14.0	167.0	44.0	-14.7
1990	262.8	44.7	24.7	143.3	50.1	290.5	18.2	157.6	114.6	27.7
1992	281.9	57.3	25.6	141.6	57.4	309.6	19.1	164.3	126.1	27.6

Note : Data on the demands of domestic and agricultural water uses for the years 1985 to 1991 are the estimates of actual demands by KOWACO in 1993. In 1992, the demand for domestic and agricultural water use was estimated by using the averaged increasing rates of the years 1985 to 1991. Other data is from KOWACO, *('91-2011)*, and *Korea Environmental Yearbook*,(MOE).

Table 4.8: Outflows and losses of water resources in Korea (unit : 100 million m^3)

Year	Outflows		Losses	Total
	by flood	regular		
1985	433.472	42.722	565.806	1,042
1990	406.216	40.036	530.229	976.48
1992	398.266	39.252	519.852	957.37

Notes :

1. Since the data on total precipitation, outflows and losses of water resources is available only for 1988, the data provided here is the backward estimates based on the assumptions that i) total precipitation is not changed over the years; ii) sum of 'outflows' and 'losses' is divided into 'outflows by flood,' 'outflows over regular season,' and 'losses' proportionately according to 1988 ratios suggested in KOWACO,*('91-2011)*, in which the shares of 'outflows by flood', 'outflows over regular season', and 'losses' are 41.6%, 4.1% and 54.3% respectively. It is also assumed that 'outflows by flood and over regular season' to dam is the same.

2. Losses are the sum of 'evapo-transportation' and 'accumulation to underground waters.'

3. 'Total' in the table is the amount of total precipitation – total supply, in which total precipitation is 12.676 billion m^3 estimated for 1988 in KOWACO, *('91-2011)*.

4.4.3 Economic value of water uses

In general, water resources are treated as free goods, but they can have economic value when there is scarcity. However, there are no water markets in Korea and there is no water scarcity in Korea except in unusual drought seasons. Thus, it is very difficult to estimate the economic value of water resources. Although some water rights are sold by FLIA, they are actually user fees for agricultural water use. Also, the user fees for industrial and drinking water do not reflect the production costs as they are subsidized by the government.

Valuing water resources requires identifying the different uses of water resources. For example, water can be used for domestic purposes, irrigation, industry, hydropower, navigation, recreation, aesthetics and river maintenance.

Water for hydropower, navigation, recreation and aesthetics do not change water availability. However, such use may affect water quality and degraded water quality may in turn affect the quality of recreation and aesthetics. This should be taken into account.

4.4.4 Domestic, industrial and agricultural uses

The marginal value of water use in the domestic sector can be obtained by estimating demand functions with variables of income, water prices and other appropriate factors. The price elasticity of domestic water use would be very inelastic since water prices are too low when compared to income (i.e., income effect is almost zero) and there is no substitute other than mineral water which is priced higher than piped-water.

Agriculture uses the maximum amount of water in Korea and in 1992, 50.2 per cent of the total water use was in this sector (Table 4.9). The total cultivated land in 1992 was 2,069,933 hectares (ha) of which paddy fields which needed irrigation, accounted for 1,314,727 ha which is 63.5 per cent of the total cultivated land. Paddy fields are at least partially irrigated in Korea (Table 4.9). Agricultural water use is charged only through FLIA, according to the size of paddy field (Table 4.9). The value of agricultural water use is calculated with the help of water use data from the *Yearbook of Land and Water Development Statistics*(Korea, Ministry of Agriculture, Forestry and Fisheries & Rural Development Agency, 1993) and the water charge collected by FLIA. As shown in Table 4.9, the estimated unit price of agricultural water was 13.5 Won/m^3 in 1985, but it decreased to less than five Won/m^3 since 1988. The price-level of agricultural water is very low compared to the prices of other water uses. It is about two per cent of the average fee of piped-water in 1992. In theory, the value of irrigation water should be estimated, based on the demand function which could be derived from the value of agricultural water use in crop production (Gibbons, 1986). It is impossible to estimate the demand function for water for agriculture since it is supplied almost free and there is no market operating for it in Korea.

As mentioned before, the status of industrial water use has not been surveyed by the ministry concerned in Korea. Also, the *Long-term Integrated Management Plan for Water Resources (KOWACO, 1991-2001)* is not clear about estimating the industrial water demand. However, the MOE provides the *Annual Survey Report on the Industrial Wastewater Discharge, (1985-1992),* which gives details of water supply by source and industry type.

Table 4.9 : Status of irrigation and the prices of irrigation water in Korea

Year			1985	1990	1992	1993
Size of cultivated land (1,000ha)	Total		2,144.4	2,108.8	2,069.9	2,054.8
	Paddy field	sub-total	1,324.9	1,345.3	1,314.7	1,298.3
		Irrigated by FLIA	477.1	512.4	518.2	510.5
		Irrigated by others	476.8	475.1	454.6	445.3
		Partially irrigated	377.0	357.8	341.8	342.5
	Upland		819.5	763.5	755.2	756.5
Water charge collected by FLIA (million Won)			73,205	22,259	25,786	25,346
Agricultural water uses (mill. M^3)	Total		142.2	143.3	141.6	n.a.
	by FLIA*		53.2	57.9	58.6	57.7
	for upland		45.1	42.0	41.5	41.6
Unit price of FLIA water (Won/m^3)			13.8	3.8	4.4	4.4

Note : Water uses by FLIA was estimated by multiplying the unit use factor per paddy field, which was used in KOWACO, (*1991-2001*), to the sizes of irrigated paddy field by the FLIA.

To value industrial water use, it is necessary to have the production function with the amount of water used as an input variable. That is, the marginal value of unit water used should be estimated. If this is not possible, then alternative methods such as valuing the marginal cost required to recycle water can be utilized(Gibbons, 1986).

In Korea, there are three types of water supply which are charged by local governments, KOWACO and FLIA. KOWACO supplies piped-drinking water to provinces and industrial water to industrial complexes. Most local governments have their own piped-water supply system and supply this

water to households and plants. As mentioned earlier, FLIA supplies agricultural water to farmers. The data on prices and quantities of these three types of water supply can be compiled. However, it is not possible to relate the water quality data to water quantity data due to lack of information and research.

Since measuring the economic value of domestic water use is difficult, the monetary value of domestic water use was estimated by the sum of the fee payments of domestic piped-water supply and the monetary estimate of unpaid uses of domestic water. That is, the monetary value of domestic water use is estimated based on the concept of user charges.

For this purpose, the average fee of piped-water is multiplied to the amount of unpaid domestic water use to obtain its monetary value. The amount of unpaid domestic water use is estimated by the quantity of [amount of paid piped-water/(1-supply rate of piped-water)], in which the supply rate of piped-water is the ratio of the population supplied by the piped-water to the population not supplied by piped-water.

These ratios are provided from the *Yearbook of Construction Statistics* by the old MOC. The data on the quantity of domestic water use in the water resources balance-sheet is different from the one used here. In many cases, households are equipped with their own water-extraction systems. For simplicity, it is assumed that this cost is reflected in the average fee of piped-water. Table 4.10 is the estimation result for the monetary value of domestic water use.

Table 4.10 : Monetary value of domestic water uses

Year	Domestic water uses (100 mill. m^3)	Domestic water uses charged (100 mill. m^3)	Domestic water uses unpaid (100 mill. m^3)	Average fee of piped-water (Won/m^3)	Cost of unpaid water uses (100 mill. Won)
1985	26.55	17.79	8.76	165	1,445.4
1990	37.77	29.61	8.16	188	1,534.1
1992	42.13	33.71	8.42	219	1,844.0

The same rule is applied to industrial water use. However, the only data available for the price of industrial water use is the price data provided by KOWACO. As in the case of domestic water use, many firms and plants have their own water-extraction systems. For simplicity, it is also assumed that this cost is reflected in the average fee of industrial water supplied by KOWACO. Table 4.11 shows the monetary value of industrial water use. Table 4.12 shows the total value of domestic, industrial and agricultural water use which is obtained from Tables 4.9, 4.10 and 4.11.

In this study, the economic value of water resources by the net price method has not been estimated due to data limitations. For the estimation of the economic value of water resources in future studies, water use should first be identified and classified. Then, individual estimations for different uses can be made. In doing this, the estimation of demand functions is required for each of the different water uses-- domestic, irrigation, industrial, recreation and aesthetics, and hydropower.

Table 4.11: Monetary value of industrial water uses

Year	Industrial water uses (100 mill. m^3)	Indust. Water uses charged (100 mill. m^3)	Indust. Water uses unpaid (100 mill. m^3)	Ave. fee of KWRC piped-water (Won/m^3)	Cost of unpaid water uses (100 mill. Won)
1985	20	3.27	16.73	35	585.6
1990	25	4.87	20.13	48	966.2
1992	26	5.56	20.44	54	1,103.8

The economic value of domestic (household) water use is often estimated by the Contingent Valuation Method(CVM). A study (Kwak and Russell, 1994) in Korea, estimated the mean willingness-to-pay (WTP) amount for the improvement of drinking water quality to be 2,603 Won a month per household in Seoul in 1992. The aggregated WTP for 2.4 million households in Seoul was 82,944 million Won. However, this study has been conducted only for 1992 and the economic values estimated by the CVM are values from the costs-borne concept.

4.4.5 Water uses for hydropower generation

In the case of water for hydropower generation, the net price method is used, which calculates the rent of water resources by subtracting the electricity generation cost from the revenue earned from selling the generated electricity in the market. The disadvantages of hydropower generation include a high capital cost, degradation of land resources, and destruction of fish and wildlife habitats. Therefore, the value of water use for hydropower generation should subtract the negative value of degradation of land resources and destruction of fish and wildlife habitats if a costs-borne concept is applied to valuing water use for hydropower generation.

Table 4.12 : Total value of domestic, industrial and agricultural water uses (unit : million Won)

Year	Paid domestic uses	Unpaid Domestic Uses	Paid Industrial uses	Unpaid industrial uses	Paid agr. uses	Unpaid agr. uses	Paid water uses	Total value of water uses
1985	2,934.9	1,445.4	328.8	585.6	732.1	1,228.2	3,780.9	7,040.1
1990	5,564.1	1,534.1	691.1	966.2	222.6	324.5	6,018.9	8,843.7
1992	7,398.8	1,844.0	934.9	1,103.8	257.9	365.2	7,957.5	11,270.5

Notes : 1. Paid water uses = Paid domestic water uses + Paid industrial water uses + Paid agricultural uses

2. Total value of water uses = Paid water uses + Unpaid water uses

3. The user fees of piped-water for domestic uses have not reflected the actual unit supply costs. In 1992, the unit supply cost of piped-water for domestic uses was estimated to be 290.9 Won/m3. Thus, about a 32.6% fee increase was required in 1992.

Table 4.13 shows the benefit value of water use for hydropower generation by rivers in Korea. The benefit measures do not reflect the negative value of degradation of land resources and the destruction of fish and wildlife habitats. Table 4.14 shows the applied data for valuation. The price of electricity is the average sale price weighted by sales amounts of different uses for lighting and power. This and production cost data are from *Major Statistics on Electricity* by the Korea Electric Power

Corporation(KEPCO). The data on the amount of hydropower generation by rivers came from the *Information Book on the Operation of Hydropower Plants* by KEPCO.

Table 4.13: Resource rents of water use for hydropower generation (unit : MWH)

Rivers\Year	1985	1990	1992	1993
Han	3,382,650	5,274,074	3,935,657	4,623,288
Nakdong	162,012	2,789,590	2,770,584	2,961,420
Seomjin	244,168	185,965	129,901	196,111
Keum	338,000	287,000	125,000	282,000
Others	3,008	4,444	204,858	233,963
sub-total	4,129,838	8,541,073	7,166,000	8,296,782
small-size hydro plants	19,480	77,945	81,914	93,290
Total generation (MWH)	4,149,318	8,619,018	7,247,914	8,390,072
Unit net rent(Won/KWh)	39.18	29.88	26.59	30.74
Total resource rent (mill.Won)	162,570	257,538	192,722	257,911

Table 4.14: Net prices of water use for hydropower generation (unit : Won/KWh)

Year	Average unit sales price of electricity	Unit production cost	Net unit price
1985	67.92	28.74	39.18
1990	52.94	23.06	29.88
1992	58.09	31.50	26.59
1993	58.90	28.16	30.74

Source : KEPCO, (1995).

4.4.6 Other water uses

For water use in recreation and aesthetics, a demand function analysis for environmental amenities can be used, as this approach helps understand the hypothetical market for an environmental amenity. The effect on the consumer's activity levels of changes in environmental quality, implicit prices and budget, is identified through the analysis of data on that hypothetical market. As can be seen in the demand analysis for a commodity market, the interdependencies among implicit prices, such as travel costs, or alternative sites for an environmental amenity are analyzed, the properties of Hicksian and Marshallian demand functions are tested, and the welfare changes and the cost of living indices are measured in a partial equilibrium framework.

Environmental amenities do not have markets because there is no ownership. Therefore, the general externality problems in public goods holds equivalently in the demand analysis for an environmental amenity. Consequently, one of the main tasks in the valuation of environmental amenities is finding the implicit or hypothetical prices and using these prices to measure the consumer surplus. Further, some information on management issues can be produced by incorporating quality variables into an estimated model.

Three major analytical tools have been developed in the demand analysis for environmental amenities -- the travel cost model(TCM), the hedonic price model(HPM), and the random utility model(RUM). TCM is a variant of the household production function (Mitchell and Carson, 1989) and has been used to value site-specific recreation benefits in the 1960s and 1970s. TCMs cannot account explicitly for quality variables, and the HPM was developed later to overcome this drawback. The RUM explicitly models the choice among substitutes on a given choice occasion where each occasion is independent of the others. The Contingent Valuation Method(CVM) is generally adopted to value environmental benefits and costs in the RUM. This approach can also be applied to estimate the willingness-to-pay method for improving the quality of drinking water.

Water use for navigation in Korea is not significant since many dams limiting the travel distance by navigation, were built in the major rivers. Also, most navigation is for tourism these days. One way of valuing navigation water is by estimating the cost difference between land transportation and river or lake navigation.

4.5 Physical Accounts of Water Quality Degradation

In theory, accounts for physical environmental degradation can estimate all the immediate and indirect long-term effects of environmental degradation on natural resources, environment and human health and welfare. However, sufficient data and studies on such effects are not available in Korea and only limited information exists. So, every aspect of environmental degradation cannot be accounted and only accounting for the amounts of emission, which could be used as a measure of environmental degradation, is feasible in Korea. This is also the case for water resources.

The levels of water pollutants, e.g. for 1993, can be compiled as in Table 4.15 where only the amount of waste-water and BOD discharge are accounted. The data on the amounts of industrial and domestic waste-water emitted were provided from the *Annual Survey Report on the Industrial Waste-water Discharge* and *Data Compendium for Water Quality Policy(1994)* by the MOE. In the same table, the row "Domestic waste-water" indicates the amount of untreated domestic waste-water discharged.

4.6 Monetary Accounting of Water Quality Degradation

The SEEA suggests guidelines for valuing the effects of environmental degradation and natural resource depletion. In principle, the costs related to natural resources or environmental services which can be classified by industry or product classification of the SNA, must be placed in a monetary account based on the market price in the SEEA.

Table 4.15 : Emissions of water pollutants by industry type (1993) (unit : m^3/day, kg/day)

Industry types	No. of Establishment	Waste-water Emitted	Waste-water Discharged	BOD Emitted	
				Before trt.	After trt.
Industry	20,241	6,411,520	2,092,503	2,269,238	85,706
Chemicals	1,270	348,965	338,570	223,851	11,890
Primary metal	408	3,749,375	160,835	377,843	2,501
Fabric. metal	9,212	437,998	215,385	57,638	5,936
Textile	1,149	454,986	435,523	351,345	29,632
Food	1,859	362,531	352,862	687,166	14,409
Fish prod. sale	42	5,590	3,463	4,308	263
Paper & printing	855	674,182	345,894	527,873	17,656
Non-metallic	1,858	255,088	140,399	15,446	1,142
Soc & per serv.	3,334	31,707	29,699	17,213	1,451
Mining	37	39,203	36,592	2,427	304
Social service	0	0	0	0	0
Agriculture	0	0	0	0	0
Electric	28	34,971	22,093	1,402	208
Others(public)	189	16,924	11,188	2,726	314
Dom. Waste wtr.		13,972,000	6,542,000	2,818,000	1,319,000
Livestock w. wtr.		170,138	170,138	470,400	470,400
Total		20,553,658	8,804,641	5,557,638	1,875,106

Environmental costs resulting from economic activity, to which this principle cannot be applied, may be distinguished by costs-caused and costs-borne. The former refers to the costs associated with the immediate effect of the economic activity on the environment at a specific place during a specific period. The latter refers to the costs associated with the direct and indirect effects of environmental degradation, regardless of the question of which economic activities have caused environmental degradation and when. Environmental costs can also be divided into imputed costs and actual costs, depending on whether costs are actually incurred (UN Statistical Division(UNSD), 1993).

Based on this classification, the maintenance cost approach, the hypothetical imputed cost approach, the surrogate market approach, the contingent valuation approach, and the dose-response equation approach, can be applied to estimate the environmental costs of natural resource depletion, and its effects on human welfare and health. In the current study, a net price method has already been applied to the estimation of economic benefits of water uses for hydropower generation. This method could also be applied to the estimation of the economic depletion of water resources if the data is available. Environmental costs caused by water quality degradation can be based on the maintenance cost method using the "costs-caused approach"(UNSD, 1993).

In this section, details on the estimation of environmental degradation costs are discussed. They include the environmental costs of discharging untreated domestic, industrial and animal waste-water, and the costs of degrading potable river water.

4.6.1 Environmental costs of emitting domestic waste-water

One method of estimating the environmental costs of domestic waste-water pollution is to calculate the actual treatment cost of waste-water discharged into water bodies without treatment. That is, the environmental cost of domestic waste-water discharged without treatment estimated as the unrealized maintenance cost, which is required to remove pollutants from the untreated waste-water. Then, the cost can be estimated as the sum of the capital cost for constructing and operating waste-water treatment plants.

Of course, the estimated cost varies extensively according to the size of the treatment plants due to the economies of scale. For this, detailed information on the regional emissions data and the required size of treatment plants and their cost are needed for a more reliable environmental cost estimation.

The capital cost was calculated on the basis of a unit construction cost of 700,000 Won/tonne for domestic waste-water treatment (activated

sludge technique), with a treatment capacity of 20,000-100,000 tonnes/day in 1993. The construction cost data was provided by the MOE. The levelized annual construction cost was calculated by assuming a duration time of 15 years and ten per cent discount rates. The levelized annual construction cost can be obtained from the equation below.

$$\text{Total construction cost at present} = \sum_{t=1}^{n} LAC/(1+i)^t,$$

where LAC denotes the levelized annual construction cost, n duration year. The levelized daily construction cost is obtained by dividing the annual cost by 365 days for simplicity. When the discount rate is ten per cent, the levelized daily construction cost worked out to 252 Won/tonne,day (= 92,032 (Won/ton) / 365 days, where 92,032 Won is the levelized annual construction cost). This levelized daily construction cost was divided into the construction material cost of 170 Won, including design cost and rent, and the wage cost of 82 Won, by applying the composition rates of 67.7 per cent for material cost and 32.4 per cent for wages in the 1993 construction industry. The percentages data is cited from the *1993 Yearbook of Construction Statistics,* (Korea, MOC). Then, the material costs for 1985-1992 were calculated by using the price index of construction material and wages from the daily construction wage index.

The maintenance and operating costs of the domestic waste-water treatment plant for 1985-1992 were also calculated by using the producer price index and internal data of the MOE, 19.5 Won/tonne,day. However, the price indices of construction material for 1992 and 1993 were not available in the *Yearbook of Construction Statistics*. Price indices for 1992 and 1993 were estimated by applying the average increasing rates of the seven years between 1985-1991.

The amount of untreated BOD was calculated in this manner:

Total amount of domestic waste-water untreated *

[(Total amount of BOD emitted)/(Total amount of waste-water emitted)]

The total amount of domestic waste-water untreated was calculated by subtracting the total capacity of the domestic waste-water treatment plant from the total amount of domestic waste-water discharged.

For total environmental costs, the levelized daily cost of BOD was multiplied by the total amount of BOD discharged without treatment. Multiplying the levelized daily cost of waste-water to the amount of waste-water untreated also gives the same cost estimation since the used emission factor of BOD from waste-water is a fixed one. Table 4.16 shows the estimation results with a 10 per cent discount rate.

The environmental cost estimated here does not cover the emissions remaining after treatment due to the removal efficiency of the treatment plant. Also, the cost data applied was for the activated sludge treatment plant where the treatment cost is in general less than that of chemical and physical treatment methods. Further, the cost of installing sewage pipes was not reflected in the cost estimates and as a result, it is an underestimation.

Table 4.16 : Environmental costs of emitting domestic waste-water (with discount rate 10 per cent)

Year	Levelized construction cost (Won / ton, day)			Operation Cost (Won/ T,d)	LC per waste-water (Won/ ton)	LC per BOD (Won/kg)	Dom. waste-water untreated(1000 tons/d)	BOD untrea-ted (ton/ day)	Total env. Cost (mil.Won)
	Mater-ials	Wages	Sub-total						
1985	128.8	28.4	157.2	16.7	173.9	626.0	7,356	2,043	466,839
1990	146.3	52.9	199.2	18.0	217.2	1,079.2	7,226	1,455	573,129
1992	164.2	72.5	236.7	19.2	255.9	1,365.0	7,601	1,434	709,740
1993	170.0	82.0	252.0	19.5	271.5	1,346.1	6,542	1,319	648,296

4.6.2 Environmental costs of untreated industrial waste-water

An estimation of the environmental cost of industrial waste-water discharged can be carried out by the same method applied to domestic waste-water.

The levelized construction cost is calculated based on the 1991 unit construction cost of 320,000 Won/tonne for an industrial waste-water treatment plant Class I, where the waste-water emission level is more than

3,000 tonnes/day. The levelized daily construction cost is 115 Won/tonne by assuming a duration time of 15 years and a 10 per cent discount rate. The estimation results are shown in Table 4.17.

The environmental cost is also underestimated here for the same reason as cited above for domestic waste-water. In addition, the cost data applied was for the activated sludge treatment plant which has lower treatment costs than those with chemical and physical treatment methods. Further, environmental degradation due to hazardous water pollutants such as PCB(polychlorinated biphenyls), cadmium(Cd), arsenic(As), copper(Cu), cyanide(CN) and ABS (alkylbenzene sulfonate), which require a much higher treatment cost than BOD or COD, are not reflected in the cost estimation since data on these have not been compiled in Korea.

Table 4.17 : Environmental costs of industrial waste-water discharged

Year	Levelized construction cost (Won/ton,day)			Operation Cost (Won/T,d)	LC per waste-water (Won/ton)	LC per BOD (Won/ kg)	BOD emitted (ton/day)	BOD unloaded (kg/day)	Total env. Cost (mil.Won)
	materials	wages	sub-total						
1985	62.6	17.2	79.7	106	185.7	501.5	1,221.06	69,571	12,734
1990	71.1	32.0	103.1	319	422.1	820.5	2,276.39	163,161	48,864
1992	79.8	3.8	123.6	264	387.6	1,055.0	2,432.0	84,000	32,344
1993	82.6	49.6	132.2	392	524.2	1,156.9	2,269.0	85,709	36,192

4.6.3 Environmental costs of untreated waste-water from animal husbandry

The same rationale is applied to the estimation of environmental costs of waste-water from livestock discharged into the water streams. While in the past, the regulation of emissions of livestock waste-water was not stringent, it has been tightened after its rising contribution to water quality degradation in the 1990s. Until 1992, there was no livestock waste-water collection treatment plant in Korea, except for the treatment plants operated by the large dairy products companies where the treatment rate was very low.

The environmental cost of untreated livestock waste-water is estimated by assuming that the livestock waste-water discharge in Korea was not treated at all till 1993. Since 1994, only two livestock waste-water collection treatment plants are in operation with an efficiency high enough to meet the effluent standards. Therefore, the entire amount of livestock waste-water emitted is used for the cost estimation.

Table 4.18 : Environmental costs of livestock waste-water discharge

Year	Unit levelized installation cost (Won/m^3,day)	Unit operation cost (Won/m^3,day)	Unit treatment cost (Won/m^3,day)	Waste-water emitted (1,000 m^3/day)	BOD emitted (m^3/day)	Env. Cost (mill. Won)
1985	10,566	11,050	21,616	134.2	378	1,058,817
1990	11,361	11,882	23,243	128.2	354	1,087,610
1992	12,156	12,714	24,870	152.7	422	1,386,142
1993	12,338	12,904	25,242	170.1	471	1,567,187

According to internal data from the MOE and Hyundai Engineering Corporation, the installation cost of a livestock waste-water treatment plant was estimated at 36,870,000 Won/m^3 for a capacity of 100m^3 per day in 1995. This figure gives about 13,281 Won/m^3 day of levelized daily installation cost with a duration time of 15 years and a 10 per cent discount rate. The unit operation cost is estimated at 13,890 Won/m^3 day and the total unit treatment cost of livestock waste-water works out to 27,171 Won/m^3 day in 1995. Deflating this levelized cost by the producer price index to obtain the levelized costs for other years, and multiplying the deflated levelized costs to the amount of livestock waste-water discharged each year, the environmental costs of livestock waste-water can be estimated as in Table 4.18.

In Table 4.18, environmental costs were estimated on the basis of the unit treatment cost of livestock waste-water. The amount of BOD each year was calculated by multiplying the BOD emission factors of cows, pigs, horses and hens to their numbers raised in farming households. The unit treatment cost of livestock waste-water is much higher than that of domestic and industrial waste-water since the water pollutant concentration of livestock waste-water is much higher than that of industrial and domestic waste-water, i.e., the unit BOD loading rate of livestock waste-water is much higher than that of domestic and industrial waste-water.

The treatment capacity of livestock waste-water in Korea cannot exceed 200 m^3/day due to technical limitations and the dispersed locations of livestock-raising farming households. As a result, the advantages of the economies of scale are not secured presently by the for livestock waste-water treatment plants.

4.6.4 Environmental costs of degraded surface water for drinking

Degradation of drinking water leads to additional purification costs which can be considered as the costs induced by degradation of the river or dam used for piped water supply. If data on the average purification cost per water unit and the concentration of water pollutants before and after purification is available, then the unit purification cost and a marginal cost of water purification can be obtained. Then, the unit cost can be multiplied to the amount of purified water to obtain the total cost of purifying drinking water.

The marginal cost of water purification should be estimated on the basis of its cost function. However, the data needed to estimate the cost function is limited. It is assumed for simplicity that the marginal cost of water purification does not change as BOD concentrations of raw water vary. In this case, BOD was chosen as the water pollutant to be used to judge the level of purification. Also, data on the average unit purification cost and the concentrations of BOD before and after purification exist only for 1990. Thus, the cost data for other years was prepared by deflating the 1990 data by the producer price index. Table 4.19 shows that the mentioned data and the (incremental) marginal purification cost was estimated by dividing the unit purification cost by the difference of BOD concentrations before and after purification.

Table 4.19 : Water purification costs of nine major purification plants in Seoul for 1990

Purification	Unit Cost (Won/ton)	BOD concentrations (ppm)		Marginal cost (Won/ton)
Plants	Purification cost won/tonne	Before purification	After purification	won/tonne
Paldang	29.49	1.6	0	18.43
Ku-eui	43.05	2.0	0	21.53
Tukdo	37.39	2.4	0	15.58
Bokwang	39.09	2.3	0	17.00
Noryangjin	95.62	3.7	0	25.84
Youngdeungpo	53.03	3.8	0	13.96
Seonyu	56.70	3.6	0	15.75
Kimpo	101.44	1.7	0	59.67
Amsa	58.29	2.5	0	23.32
Average				18.93

Source : S. R. Na and others, (1992).

In calculating the average value of marginal purification costs, the Kimpo plant was excluded since it was treated as an outlier.

Although the marginal purification cost is for the Seoul area, this value is applied to the nation as an approximation to the cost of degraded raw water. The data on the national production of piped-water is available from the *Statistics on Drinking Water Supply (Korea, MOC)*. The estimation results for the costs of water purification due to quality degradation of raw water are shown in Table 4.20. The total cost of water purification in Table 4.20 assumed that the quality degradation of raw water starts from zero BOD ppm and the related costs cover only the direct costs for purification, i.e., wages and administration costs are not included. Therefore, the costs in Table 4.20 may underestimate the actual costs.

On the other hand, the cost of degraded surface water for drinking is already reflected in the intermediate consumption of the drinking-water

supply industry. These costs cannot affect NDP and are identified as a part of the environmental protection expenditure in the SEEA or water resource accounts. However, if these costs are applied to water quality degradation in rivers, lakes and dams which are not drinking water, then they can be considered as approximated environmental costs due to water quality degradation.

Table 4.20: Costs of water purification

Year	Annual production of piped-water (1,000 ton)	Marginal purification cost (Won/ton)	Total costs (million Won)
1985	2,941,063	16.81	49,439
1990	4,620,433	18.08	83,537
1992	5,084,884	19.35	98,393
1993	5,286,172	19.64	103,820

4.7 Monetary Accounts of Water Use and Water Quality Degradation

Table 4.21 is a summary of individual tables for costs related to water quality degradation and the value-added from hydropower generation in the previous sections.

The bold titles in each cell of the first column indicate the accounting items in the SNA or the SEEA. Intermediate consumption for quality improvement of drinking water in the first column indicates the accounting item of costs induced by the degradation of surface water for drinking. It can be treated as intermediate consumption for improving the quality of drinking water. The environmental degradation cost of domestic wastewater pollution is borne by households and is shifted to the production sector in the SEEA by following the treatment of the SNA. Only the environmental degradation cost is the deduction factor of NDP, which results in Environmentally Adjusted Domestic Product (EADP).

Table 4.21 : Summary of monetary accounting for water uses and quality degradation (unit : billion Won)

Accounting items	1985	1990	1992	1993
Intermediate consumption:	49.4	83.5	98.4	103.8
Interm. consum. for quality. Improv. of				
Drinking water				
Value-added:	162.6	257.5	192.7	257.9
V.A. from hydro-power generation				
Environmental degradation costs:	1,538.4	1,709.6	2,128.2	2,251.7
ind. Wastewater	12.7	48.9	32.3	36.2
livest. waste w.	1,058.8	1,087.6	1,386.1	1,567.2
dom. wastewater	466.8	573.1	709.7	648.3

4.7.1 Linkages of water resource accounts to SNA and SEEA

While compiling the water resource accounts based on the SEEA in the tables compiled in the previous sections, there are nine additional accounting elements which have not been accounted for in the SNA of Korea. This is presented in Table 4.22. The items "3. Income from hydropower generation," "4. Expenditure for degraded surface water for drinking" and "9. Environmental cost of livestock wastewater" were added to the interim outcome of the UNDP project for the present study.

In Table 4.22, the second column indicates the sectors or industries which are responsible for related activities. Emission charges are the penalties(compulsory fines)imposed on the polluters, charged according to the quantity exceeding the effluent limitations and include the Plastic Waste Disposal Charges. Environmental subsidies consist of tax and tariff reduction and exemption policies to support pollution abatement and control activities among private industries in Korea. Incomes from river is the user fees for water extraction from rivers, renting river basin areas for planting, operating boating facilities in rivers or extracting sand and pebbles from rivers. They are collected by local governments.

Table 4.22 : Additional accounting items for SEEA related to water uses and pollution

Additional elements	Related sector	Components in SNA/SEEA	Main accounting item in SNA/SEEA
1. Output for external environmental protection	Industries	Output	Total output
2. Intermediate consumption for ext. & int. envir. Protection	Industries	Intermediate consumption	Intermediate consumption
3. Income from hydro-power generation	Electricity generation industry	Value-added	V.A. of electri. Generation ind.
4. Expenditure for degraded surface water for drinking	Government/ Industries/ Households	Intermediate consumption	Intermed. consump. by water supply ind.
5. Emission charges	Government/ Industries	Value-added	Operating surplus
6. Environmental subsidies	Government/ Industries	Value-added	Operating surplus
7. Income from rivers and streams	Government/ Industries	Value-added	Operating surplus
8. Non-refunded deposit	Government/ Industries	Value-added	Operating surplus
9. Water quality degradation	Households	Environmental cost	Environmental degradation cost
domestic wastewater	Industries	Environmental cost	
industrial wastewater	Agriculture	Environmental cost	
livestock wastewater			

Non-refunded deposit indicates the wastes deposit that is not refunded by consumers or producers. All items except "9. Water quality degradation", do not affect the aggregates of GDP or NDP and they are identified as parts of each related main accounting item for environmental purposes. Since it was assumed in this study that there is no depletion of water resource in Korea, its environmental cost is not accounted for in the

SEEA. Only the environmental cost of water pollution lowers the NDP in water resources accounts and the SEEA.

If the nationally aggregated WTP for safer drinking water supply is included by multiplying the mean WTP in Seoul to the number of national households, the aggregate WTP can be recorded after EADP as a deductible portion of EADP, since the WTP reflects the unrealized(or negative) benefit of degraded drinking water quality. However, this treatment requires caution as the WTP varies according to regions and the regional quality of drinking water supplied and income levels. Integrating these items into the SNA by following the SEEA, Table 4.23 can be compiled.

The linkage of water resources accounts to the SEEA and that of the SEEA to the SNA can be explained by Table 4.23. The accounting items written in bold letters are the main components of the supply/use table in the national accounts of Korea, those written in bold italic letters are the ones added to the SEEA, and those written in plain italic letters are the ones identified in the water resource accounts of the present study.

The figures for water pollution of "Shift of Environmental Cost by Households" in Table 4.23 are for environmental costs induced by untreated domestic wastewater estimated earlier. The figures for water pollution for "Environmental Degradation" are for environmental costs for untreated industrial and livestock wastewater. "Shift of Environmental Costs by Households" is, (by following the 1993 SNA), to record the shift of environmental costs by environmental degradation from the household sector to the production sector. The figure of WTP for safer drinking water supply was calculated from the study by Kwak and Russell (1994). The aggregated WTP for safer drinking water supply was 356,090 million Won in 1992 for 11.4 million households in the country.

At this stage, the share of the environmental cost of wastewater in the total environmental costs or in the NDP cannot be correctly assessed since the cited figures of E.V.A., environmental degradation and natural resource depletion in Table 4.23 were estimated based on the existing data sets which do not cover all aspects of resource depletion and environmental degradation. With the national determination of the agreeable coverage of

the SEEA and cost estimation methods for resource depletion and environmental degradation, the figures in Table 4.23 can be assessed or analyzed across industries and the country.

4.9 Conclusions and Future Research Orientation

4.9.1 Summary of the major outputs

The Republic of Korea, is not deficient in water resources except during drought seasons and in some areas. However, it is expected that the amount of water use, especially domestic water use, will increase significantly in the future. Until now, the sources of water supply have been limited to surface and dam water and additional sources of water supply will come from the construction of dams and reservoirs and the development of underground water resources.

The stock of underground water has not been systematically surveyed in Korea and its development poses another water pollution problem. The demand side management of water use may be the most cost-effective and best measure to reduce water use. Another important aspect of the efficient management of water resources is utilizing the market mechanism for water trade. Although agricultural water use accounts for more than half of the total water uses, it is practically free (Table 4.9).

Domestic and industrial water use is being subsidized by the government (see the notes in Table 4.12). Since the economic values of different water uses, except for hydropower generation, have not been estimated due to data deficiency in this study, it is not possible to propose the optimal levels of water prices for different water uses. A water market is recommended for the efficient management of water use in the future and for this more detailed studies would be required.

The compilation results of water quality degradation accounts, more correctly, monetary emission accounts, are summarized in Table 4.24. The contribution of domestic wastewater to the degradation of water quality in inland water streams, in terms of the amount of BOD unloaded into water streams, is the highest. Its resulting environmental cost is also the highest among the three major pollutants from domestic, industrial and livestock wastewater.

Table 4.23 : Linkage of water resource accounts to SNA and SEEA (unit : billion Won)

Supply/Use	1992	1989	1985
Total Output(T.O.)	531,469.6	348,111.6	97,870.3
of which :	3,634.9	1,616.2	905.5
T. O. for Ext. Env. Prot.	946.8	534.8	438.7
of which :			
T. O. for Water Pollution Prev.			
Intermediate Consumption(I.C.)	291,077.4	198,946.6	115,807.9
of which :	1,592.8	690.6	390.1
I.C. for External Env. Prot.	528.8	364.6	242.7
of which :	98.4	72.0	49.4
I.C. for Water Pollution Prev.	974.4	504.8	163.3
I.C. for Quality Improvement of Drinking Water	346.0	205.2	55.8
of which :			
I.C. for Internal Env. Prot.			
of which :			
I. C. for Int. Water Pollution Prev.			
Gross Value Added(G.V.A.)	240,392.2	149,165.0	82,062.4
of which :	2,042.1	925.6	515.3
G.V.A. for Ext. Env. Prot.	192.7	178.5	162.6
of which :			
Value-added from Hydropower Generation			
Consumption of Fixed Capital	23,925.9	15,687.7	8,205.6
Net Value Added(N.V.A.)	216,466.3	133,477.3	73,856.8
Compensation of Employees	113,876.0	66,367.9	32,904.2
Operating Surplus	75,247.8	50,977.6	31,545.4
of which :	10.4	103.9	1.7
Emission Charges	9.0	7.8	1.3
of which :	24.2	10.7	18.3
Emission Charges for Water Pollution	94.0	56.9	101.9
of which :	27.1	n.a.	n.a.
Environmental Subsides			
Income from Rivers and Streams			
Non-refunded Deposit			
Indirect Taxes	27,342.4	16,131.8	9,407.3
Statistical Discrepancy between G.V.A. and Expenditures	-988.2	295.4	401.1
Natural Resources Depletion(Mineral Resource)	123.5	227.3	224.3
Environmental Degradation	5,723.9	3,927.4	2,998.1
of which :	1,418.3	1,067.6	1,071.8
Water Pollution			
Shift of Environmental Cost by Households	1,261.8	893.4	832.6
of which :	709.7	425.7	466.8
Water Pollution			
Environmentally Adjusted Value-added(E.V.A.)	209,357.1	128,629.2	69,801.8
National Disposable Income	215,367.8	132,775.7	72,052.8
WTP for safer drinking water supply	356.1	n.a.	n.a.
Environmentally Adjusted Disposable Income(E.D.I.)	207,902.5	n.a.	n.a.

Table 4.24 : Comparison of environmental costs estimated by pollution sources

Year	BOD unloaded w/o treatment (tonnes/day)				Environmental costs(million Won)			
	Dom. Waste w.	Ind. waste w.	Livest. waste w.	Total	Dom. waste w.	Ind. Waste w.	Livest. Waste w.	Total
1985	2,043	69.57	378	2,490.57	466,839	12,734	1,058,817	1,538,390
1986	2,061	61.11	381	2,503.11	500,454	11,403	1,058,027	1,569,884
1987	1,296	76.63	370	1,742.63	344,984	13,658	1,043,110	1,401,752
1988	1,293	66.26	356	1,715.26	381,278	17,911	1,035,305	1,434,494
1989	1,315	69.37	356	1,740.37	425,691	16,220	1,051,422	1,493,333
1990	1,455	163.16	354	1,972.16	573,129	48,865	1,087,610	1,709,604
1991	1,481	79.24	397	1,957.24	667,163	27,318	1,235,524	1,930,005
1992	1,434	84.0	422	1,940.0	709,740	32,344	1,386,142	2,128,226
1993	1,319	85.71	471	1,875.71	648,296	36,192	1,567,187	2,251,675

Notes : 1. The amounts of BOD unloaded to water streams by livestock wastewater were obtained from *Data Compendium for Water Quality Policy*(MOE, 1994).

2. The amounts of BOD unloaded to water streams by livestock wastewater are the data emitted, not discharged into water bodies. Some portion of livestock wastewater emitted is treated through livestock wastewater treatment plants or facilities. However, this portion is small. Thus, it was assumed for environmental costs estimation that livestock wastewater emitted is not treated at all.

As mentioned earlier, compared to domestic and livestock wastewater, the amount of BOD discharged into water streams by industries is not so high since most of the industrial wastewater is treated to meet the emission standards set by the government. This fact is also supported by the size and increasing trend of expenditure for the prevention of water pollution by the private sector, i.e., industries (Table 4.25).

The intermediate consumption and capital formation for the prevention of water pollution by industries was about 124.1 billion Won in 1985 and 659.8 billion Won in 1992. There has been an increase of 432 per cent in the past eight years. Of course, the emissions of hazardous water pollutants, such as cadmium(Cd), cyanide(CN), polychlorinated biphenyls (PCB) and arsenic(As), in industrial wastewater are not covered in this study.

Table 4.25: Expenditures for the prevention of water pollution by industries (unit : billion Won)

Year	1985	1986	1987	1988	1989	1990	1991	1992
Intermediate consumption for internal environmental protection								
total by industries	163.3	221.9	264.6	405.9	504.8	583.5	806.4	974.4
of which: prevention of water pollution	55.8	58.5	79.8	146.3	205.2	201.5	278.6	346.0
Capital formation for environmental protection								
Total by industries	160.8	200.7	244.2	311.7	464.3	553.3	814.3	974.5
of which: prevention of water pollution	68.3	66.2	89.3	93.4	147.1	200.6	271.2	313.8
total by government	424.0	381.8	452.4	471.1	475.1	640.7	753.0	1,022.0
of which: prevention of water pollution	405.8	353.6	424.5	428.7	439.2	520.6	660.6	768.5

* Data source : Korea Environmental Technology Research Institute(1995), Interim report for the UNDP regional project Research on Integrated Environmental and Economic Accounting (Pilot Compilation of Environmental-Economic Accounts for Korea).

In Table 4.24, the amount of BOD unloaded by domestic wastewater is 2.8 times that of livestock wastewater in 1993, but the environmental cost of livestock wastewater is about 2.4 times that of domestic wastewater. While the contribution of livestock wastewater to the total BOD discharge is not that high, the environmental cost of BOD from livestock wastewater is higher than domestic wastewater. This is mainly due to the high treatment cost of water pollutants in livestock wastewater. Therefore, the government should put a higher priority on developing more cost-effective methods for livestock wastewater treatment to improve the water quality of inland water streams.

Subtracting the environmental cost induced by the emissions of livestock wastewater from the value-added of the agricultural sector, the environmentally adjusted net domestic product of the agricultural sector will be much lower and this could create a political debate on the competitiveness of the agricultural sector.

A comparison between the emissions of industrial and livestock wastewater reveals that the amount of BOD from livestock wastewater is much higher than that of industrial wastewater. This large difference of BOD between industrial and livestock wastewater is due to the fact that most firms or plants emitting water pollutants have their own wastewater treatment plants or get it treated by others. That is, the individual firms or plants are paying for the necessary costs to meet the effluent standards of water pollutants set by the government. However, the emissions of specific hazardous wastewater pollutants such as CN, CD, Pb, Hg and As are not covered for the environmental costs imputed in this study. This cost may be much larger than the cost of untreated BOD.

4.9.2 Suggestions for future studies

The purpose of this study was to develop an environmental accounting system for water resources in Korea and to compile the related accounts. The basic framework adopted was the SEEA which can be linked to the SNA. For these objectives, some aspects of uses and supplies of water resources and water quality are described and the appropriate framework for Korea, based on the SEEA, is suggested. The results and methods of the compilation of water resources accounts are also explored.

However, compilation of the water resource accounts does not yet provide a true picture of the connection between economic activities and uses of water resources for two reasons. The first one being the coverage of water resources and data. That is, the exact stock of various water resources have not been surveyed in Korea and as a result, some rough estimations are made for the use and supply of water resources.

The second reason is related to the estimation of the stock value of water resources and environmental costs related to water quality degradation. Since there is not enough data on the market price and production costs of water resources for the estimation method, the stock value of water was not estimated. Also, environmental costs of hazardous water pollutants emitted and water pollution by non-point sources were not estimated either, due to the unavailability of physical emission data.

Another major drawback of this study is that the effects of water quality degradation on human health, aquatic life, recreation activities in waterfront areas, and property values have not been assessed due to data deficiency. These effects can be measured in physical and monetary terms. In monetary terms, these effects can be assessed by the costs-borne concept according to SEEA. In future studies, this cost estimation based on the costs-borne concept would be required for a welfare- oriented analysis of environmental degradation.

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5

Forest Resources of the Philippines

5.1 Introduction

The Philippines has a total land area of 30,000,000 hectares(ha), around 50 per cent of which is characterized as forest land. As of 1994, only 5,686,055 ha are stocked with forest trees. This is only about half of what was existing 20 years ago. To conserve and protect the forest, the old growth dipterocarp forest areas have been placed under the National Integrated Protected Areas Systems (NIPAS) since January 1, 1992. Logging in these areas has been prohibited since then.

With the log ban enforced, the Gross Value Added (GVA) of the forestry sector continuously declined. In 1994, the GVA of forestry amounted to only 2.971 billion pesos or 0.39 per cent of the total Gross Domestic Product (GDP) at constant prices. The level is 15 per cent lower than that registered in 1993. Still, more than 100,000 persons continue to depend on the forestry and hunting sector for their main source of income, and wood-based products contributed around 3.5 per cent of the country's total export earnings. The forest also continues to serve as a source of fuelwood, especially for rural dwellers.

Ecologically, the forest gives invaluable environmental benefits to the country by providing watersheds for rivers. It protects the soil, regulates water flows and carbon cycles, and provides habitats for a multitude of animal and plant life. Destruction of forests will result in the depletion of the potential resource of wood and habitats and threaten the capacity of the biosphere to regulate atmospheric and hydrospheric cycles. It can also lead to a loss of species, soil erosion, siltation and flooding. Deforestation, along with the burning of hydrocarbons, also contributes to the CO_2 build-up in the atmosphere.

The objective here is to account for the stock of forest resources from 1988 to 1994 and to trace the factors that contribute to the changes in the stock. The sources and methods of estimation are discussed and the results

of the estimates are presented. These initial estimates will subsequently form part of the inputs in constructing the adjusted production accounts, which will provide a measure of sustainable development.

The System of Integrated Environmental and Economic Accounting (SEEA) framework calls for the compilation of the asset accounts for produced and non-produced assets of forest resources. In this study, no distinction is made between economic and environmental non-produced assets. The complexity of the data requirements and the rigidity of sourcing them have set this limitation. The asset accounts for forest resources presented here will include only forest trees on forest land.

Philippine forests are classified into different types, viz., dipterocarps, pine, sub-marginal, mossy and mangrove. The dipterocarps make up roughly two-thirds of the total forest cover. For the current exercise, only the dipterocarp and pine forests will be included in the accounting process, primarily because of their economic and ecological significance, and also because of data availability considerations. In addition, rattan, a non-timber forest product, was also included because of its contribution to the economy.

5.2 Description of Forest Resources

Dipterocarps are forest stands dominated by trees of the dipterocarp species such as red and white lauan, tanguile, tiaong, almon, bagtikan and mayapis of the Philippine mahogany group, as well as apitong and yakal. These species are located in places with high elevations, particularly in regions where precipitation is high.

Dipterocarp forests are further classified as either old growth or second growth. Old growth dipterocarp forests are virgin forests with no traces of commercial logging, while second growth dipterocarp forests are those with traces of logging. The dipterocarp forest has been the major source for the wood industry for its raw material supply of lumber, veneer, plywood, pulp and paper, furniture wood and other wood-based products. The harvest of these species generate revenues for the government through forest charges, property taxes, license fees and income tax from concessionaires.

Pinewood is a fast-growing species and excellent construction material. In the mining areas of Benguet, pine is used as a mine prop for mine shafts and tunnels. It is also used for piles, posts, Christmas trees, and as raw material for pulp and paper manufacturing. Wood from pine trees is a good fuel source, both for cooking and heating purposes. In watershed areas, pine trees provide an ideal vegetative cover for soil and water conservation. The pine needle is also a source of the toxic ingredients used for insect repellents such as mosquito coils. Pine bark is a potential source of tannin for the country's leather industry, and sawmill wastes like pine sawdust are sources of tan and pitch. Oleoresin and derivatives like turpentine and rosin from pine trees also generates income for many inhabitants in the pine region.

Rattan is one of the several types of palm, its distinguishing characteristic being that it can climb. Rattan is distributed throughout the country, from Batanes to the Tawi-tawi Islands.

Rattan is mostly found in the interior of the old growth forests, though some are located at the edge of the forest where the area is more open. Its life is coterminous with the dipterocarp forest and is dependent upon bigger trees for survival. This is also the reason why there are no exclusive plantations of rattan. Rattan plantations can be found within dipterocarp forests and some are integrated within an agro-forestry system. The long and flexible rattan stem is shaped, polished and processed to create many beautiful products for the furniture and handicraft industries. Rattan products have been internationally accepted in the market since the seventies, after improvements were made on their design, workmanship and finishing. Rattan is also used in the manufacture of fish traps, hammocks, sleeping mats, carpet beaters, hats and walking sticks, among others objects. Employment in the rattan industry has grown since then and the industry contributes to the country's income and foreign exchange generation.

Table 5.1 : Morphological differences between Benguet pine and Mindoro pine

FEATURE	BENGUET PINE	MINDORO PINE
Occurrence	Grows in high elevations between 500 and 2700 m.	Grows in lower elevations 150 and 300 m.
Seed	Oval, dark brown in color	Ovoid, pale reddish brown in color
Bark	Flaky	Deeply fissured
Leaves	Needle-like and in bundles of three per fascicle	Needle-like and in bundles of two per per fascicle
Crown	Conical when young and dome-shaped when mature	Pyramidal with large and spreading branches when mature

However, the existing supply and demand situation may not be reflective of the policy's objectives because

(a) the demand for rattan canes increases as the years go by

(b) The industry estimates of harvested rattan poles for 1991 is between 200 to 250 million lineal meters(lm). The remaining rattan resources in the natural forests indicate that the sustainable annual yield of cane greater than two cm. in diameter, is 50 million lm. At the current annual cut of 70 million lm, the supply will be exhausted in five years

Among the many non-timber forest resources, rattan is being prioritized in this accounting effort in view of its shrinking availability. Unlike bamboo, rattan is not so prolific and since it is coterminous with dipterocarp forests, it is subject to the damages caused by the logging of its tree hosts.

Although rattan is found in natural stands in dipterocarp, sub-marginal and mossy forests, only rattan in dipterocarp forests is considered in these accounts because of data availability problems and because of the assumption that rattan in dipterocarp forests is of good quality, thus having an economic value.

5.3 Conceptual Framework

5.3.1 Framework for the asset account

The *Asset Accounts*, in physical and in monetary terms, adopt the format presented on the next page. The *opening stock* represents the stock of resources at the beginning of the accounting period. Within the period, several factors account for changes in the stocks of the resource. These are *changes due to economic activities*, *other accumulation* or changes due to economic decisions, and *other volume changes* representing the changes due to non-economic factors. Other changes under *other volume changes* denote the *statistical discrepancy* equivalent to the difference between the computed *closing stock* (taking into account the framework's identified factors) and the *opening stock* in the succeeding year taken from official sources. The *closing stock* for a year is equal to the *opening stock* of the succeeding year.

Changes due to the economic activity refer to human production activities as they affect the stock of resources. *Depletion* is caused by harvest, logging damage and illegal logging. The item identified as *other accumulation* covers forest conversions which mainly refers to the clearing of forest to convert it to other uses such as residential or industrial purposes. Under *other volume changes*, additions to the stocks include natural growth and regeneration while *reductions* cover stand mortality, insect infestation, forest fires and natural calamities.

In the monetary accounts, there is an item called *revaluation* which is equivalent to the differences due to changes in prices between the opening and closing periods.

OPENING STOCK

Changes due to Economic Activity
- Depletion
  - Logging/harvest
  - Logging damage
  - Illegal logging

Other Accumulation(+/-)
- Forest conversion to other forest use
- Forest conversion to non-forest use

Other Volume Changes
- Additions
  - Natural growth
  - Regeneration
- Reductions
- Stand mortality
  - Insect infestation
  - Forest fires
  - Natural calamities
  - Other changes (statistical discrepancy)

Revaluation*

Changes in Stocks

CLOSING STOCK

**Only for monetary accounts*

Figure 5.1 : Asset accounts framework adopted under the SEEA.

5.4 Operationalizing the Framework

5.4.1 Sources of data

Physical Account: The base information on the stock of forest resources was available for the year 1988 from the RP-German Forest Inventory Project.[1] The project paved the way for the preparation of new forest maps for the whole country based on aerial photographs and satellite imagery, the inventory of standing volume, the generation of data on forest regeneration

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[1] The RP-German Forest Inventory is a joint project of the Government of the Republic of the Philippines and the Federal Republic of Germany.

and minor forest products, and the compilation of forest statistics by region and by province. From the 1988 base information, the Forest Management Bureau (FMB) of the DENR extrapolates the value of forest resources stock for the succeeding years.

For old growth dipterocarp forests, data for depletion due to logging was taken from the Master Plan for Forestry Development (MPFD), 1990. For second growth forests, data for forest area converted to non-forest use from 1991 onwards was also taken from the MPFD while data from 1989 to 1990 was derived from the study of Balangue (1991).

For pine and rattan forest resources, the basic data came from: (1) the Philippine Forestry Statistics (PFS), 1988-1994 of FMB, DENR; (2) the 1990 MPFD; (3) the RP-German Forest Resource Inventory Project Report; (4) the Natural Resources Accounting Project (NRAP) I Report on Forest Accounting; (5) the Philippine Council for Agriculture Forestry and Natural Resources Research and Development (PCARRD); and (6) the Philippine Lumberman, April 1988.

Monetary Accounts : Parameters used in the computation of stumpage value for dipterocarp forests were taken from Pio Bote's study for pine forests, from NRAP I; for rattan, from the 1988 study conducted by Rivera and others (1976). The Consumer Price Index (CPI) was taken from the National Statistics Office (NSO) and the Implicit Price Index (IPIN) for Forestry was taken from the National Statistical Coordination Board (NSCB).

5.4.2 Estimation methodology

The compilation of asset accounts for forest resources begins with the physical accounts. These are then valued to arrive at the monetary accounts. In terms of physical accounts, both area and volume accounts are compiled for dipterocarp and pine forests, while only volume accounts are compiled for rattan. In monetary terms, the asset accounts for the three resources are all expressed both at current and constant 1985 prices. The accounts cover the years 1988 to 1994.

5.4.3 Physical asset accounts - area

Dipterocarp Forest

In the compilation of the physical asset accounts, the forest stocks in area terms, as reflected in the PFS, were taken to be the closing stock for a given year. This then becomes the opening stock for the succeeding year.

Logging in old growth forests was allowed only up to 1991, so, beginning 1992, there was no reduction in the area due to logging. For second growth forests, the damage due to logging is equivalent to 15 per cent of the logged area in old growth forests in the previous year. The area converted from old growth to second growth is equal to the area logged in old growth forests in the previous year, less 15 per cent for log landings, roads and skidding/yarding trails. It is further assumed that there is no additional area for old growth forests.

Other changes under *other volume changes* represent the statistical discrepancy (s.d.) or the unaccounted factors in the changes in area. It is derived as the reported closing area during the year, taken from official sources, less the computed closing area, derived by summing up the opening area, changes due to economic activity, changes due to *other accumulation* and the identified *other volume changes.*

Pine Forest

The framework of physical accounts for pine forests is similar to that of the dipterocarp forest and so it followed the same estimation process/formula viz.:

Closing Stock = Opening Stock - Depletion ± Other Accumulation

± Other Volume Changes

Depletion refers to the area harvested during the accounting period. Other accumulation accounts for forest conversions during the period. *Other volume changes* include the stock addition which refers to the increase in stock through time as attributed to growth and increase in the forest area through natural means. Stock reduction in pine forests, which may be due to forest fires and stand mortality due to pests or diseases, also forms part of *other volume changes*. The change in stock is the difference between the ending stock and the beginning stock for a given period.

Rattan

No separate area accounts for rattan were compiled since rattan thrives in the same area as the dipterocarp forest.

5.4.4 Physical asset accounts- volume

Dipterocarp Forest

The opening volume of dipterocarp forests in a given year is based on the volume in the preceding year as reported in the PFS. Due to the extensive depletion of forests in the Philippines, it was assumed that logging has exceeded the sustainable cut. Therefore, all the logging, together with damages from logging, were counted as depletion. The damage due to logging was estimated as a fixed proportion of the area logged. Forest conversion data was taken from projection data from the MPFD. The volume of forest depleted through logging, damage due to logging, and forest conversion was derived by multiplying the area covered by the corresponding assumed harvestable volume per unit of area: 248.22 cu.m./ha for old growth and 67.0 cu.m./ha for second growth. For old growth forests, it was assumed that the net stand growth is equal to zero, that is, tree growth is equal to tree mortality. For second growth forests, the net stand growth is equal to the opening volume multiplied by the annual growth rate, taken from a study by Revilla (1976). Other changes (s.d.) were computed as in the area accounts.

Pine Forest

The following assumptions were used in estimating the volume accounts for pine forests: a) 68 per cent of the total volume of pine forest comes from closed forests[2] while the remaining 32 per cent comes from the open forests;[3] b) under the other volume changes, additions were based on an annual growth rate of 3.4 cu.m./ha/year (RP-German Inventory Project);

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[2] Closed forest -- pure stands of Benguet or Mindanao pine with a crown cover above 30%.

[3] Open forest -- pure stands of Benguet or Mindanao pine with a crown cover of 10% to 30%.

c) reductions in volume due to stand mortality assumes a mortality rate of 1.75 and 2.95 cu.m./ha/yr., respectively, for open and closed forests; d) destruction due to forest fires is 45,000 cu.m/year (MPFD, 1990); and e) forest conversion is estimated to be 1,200 ha per year for the period 1988 to 1989 based on the MPFD.

Rattan

Data on rattan show the average rattan occurrence in primary and secondary-growth dipterocarp forests. The opening volume of stock of rattan in 1988 was derived from the 1987 closing stock, estimated by NRAP. Separate estimates were prepared for small-diameter rattan and for large-diameter rattan.

The changes in stock are due to : (1) depletion due to harvest, (2) other (negative) accumulation due to conversion of forest to other land-use, and (3) *other volume changes*, composed of positive changes due to natural growth (increase in the length of a stand), and negative changes due to stand mortality. The *closing stock* is thus computed as the *opening stock* plus the changes due to the three factors mentioned. The *closing stock* is then carried over as the opening stock for the succeeding period. Also included in *other volume changes* is the statistical discrepancy (s.d.) between the reported closing stock from official sources and the computed *closing stock* based on the other factors in this framework. It should be noted that this item, instead of *closing stock*, is the last item to be computed in these accounts. Moreover, the reported *closing stock* taken from official sources would still remain as the official *closing stock* for these accounts, inspite of any statistical discrepancies that may arise.

Growth is one of the important measures in determining the stock of rattan in the forest. In this accounting, the growth rates adopted were based on those used by NRAP (1991) which in turn were derived from Rivera and others, (1988). The growth rates were applied only to the stock density of rattan in the residual forest, on the assumption that there is zero growth in the primary forest. For stock reduction, it was assumed that the rate of stand mortality is five per cent, based on a Malaysian study.

The data on harvest for split and unsplit rattan derived from the PFS, was assumed understated by 488 per cent, according to a study by NRAP, taking into consideration the data from PFS and the Silviconsult-ADB report. Out of the harvest, 50 per cent of the merchantable lengths felled were deducted to represent the portion which goes to waste. For forest conversion, the data was based on projections made by MPFD.

5.4.5 Monetary asset accounts

Dipterocarp Forest

The net price method was used in valuing forest resources. The economic or monetary accounts were derived by multiplying the volume accounts by the stumpage value of the forest. The opening stock was multiplied by the stumpage value of the preceding year. All the other items in the asset accounts for a given year were multiplied by the stumpage values of the current year. The stumpage value is the value of the standing timber and it is equal to the price of the product less the cost of harvesting, transport and a margin for normal return to capital (which is assumed to be 30 per cent of the logging cost). This represents an allowance for normal profit and risk associated with the production activity and is approximated by the opportunity cost of capital or the operator's estimated earnings from an alternative investment. The stumpage value represents the potential economic rent accruing to operators.

The sales value of a log is equal to the weighted selling price of the products. The cost items include logging cost, pre-logging cost, post-logging cost, road construction cost, transportation cost and overhead costs. The logging cost represents felling and bucking costs and the cost of pulling the logs from the felling site to the log landing. The costs are classified by terrain type, by extractable log volume, and by logging methods. Pre-logging cost represents the cost of pre-logging activities such as pre-logging inventory and tree marking. Post-logging cost is the cost of post logging residual stand inventory, and enrichment planting conducted by the private forest users or the concessionaires. Road construction cost is the cost incurred in road construction in peso/kilometer/cubic meter of harvest. The transportation cost involves the cost of transporting a cubic meter of log from the forest landing to the processing mill or log pond, in peso/km/cu.m. It includes the depreciation value of trucks and loaders used, the wages of drivers and helpers and fuel

and oil used in operation. Overhead costs cover representation or relevant administrative expenses.

The base information for stumpage value was taken from Pio Bote's study for 1990 with adjustments for margin for profit and risk (MPR). For years other than 1990, the corresponding stumpage value was derived by adjusting the 1990 value by the corresponding changes in weighted prices of logs by species. Attempts were made to update the stumpage value not only by the changes in prices of logs but also by the changes in the corresponding costs of harvesting. Updated cost structures were derived from the financial statements of logging companies from the Securities and Exchange Commission (SEC) of the Philippines. However, the financial statements culled from the SEC were limited to just a few companies and the results derived from them are not satisfactory. Hence, the stumpage values were updated only by the changes in the log price. Stumpage values at constant prices were derived by dividing the stumpage value at current prices by the consumer price index base year 1985. Revaluation is equivalent to the differences due to the changes in prices between the opening and closing periods.

Pine forest

The net price method is adopted in valuing pine timbers. The value of opening and closing stocks was derived by multiplying the volume accounts by the stumpage value, which is the value of timber as it stands in the forest. The stumpage value is estimated by deducting the production cost (PC) and MPR from the market price of timber. The production cost includes all expenses incurred in getting timber out of the pine forests, log preparation and the related cost associated with sale. The stumpage value represents the potential economic rent accruing to operators. The actual rent retained by the operator is obtained after deducting all forms of taxes and payments from the potential economic rent.

In this study, the source of basic data for the 1989 stumpage value of pine forest at current prices was the report of NRAP-Phase I. For the other years, the given stumpage values were extrapolated using the Implicit Price Index of Forestry taken from the Philippine National Accounts published by the NSCB. Stumpage values at constant prices were estimated by deflating the stumpage values at current prices by the Consumer Price Index base year 1985. These stumpage values at constant prices are then multiplied with the volume accounts to arrive at the asset accounts in monetary terms at constant prices.

Rattan

The monetary account for rattan is computed as stumpage value multiplied by the physical units. The net price or stumpage value is equal to the market price of rattan at the manufacturer's (factory) level less production/extraction cost (equal to the price paid to the cutter/harvester), less marketing/handling cost (which includes the cost of transport, bundling, classifying, scraping, chemical treatment), and less MPR. This procedure of the net price method valuation, adopted from NRAP, considers the concept of economic rent (or profit) for natural resource valuation.

The stumpage value of rattan for 1988 was derived from the study conducted by Rivera and others. The study provides prices and costs by the location and diameter class of rattan. The stumpage value is equated to the rent defined as market price less the total cost less MPR which is 30 per cent of the total cost. The total cost comprises the production cost and marketing cost. The stumpage value is derived as the weighted average of the stumpage values by location and diameter class, for small and large diameter rattans. The resulting stumpage values are P0.57/lm and P1.24/lm for small and large diameter rattans, respectively, for 1988. The stumpage values for the other years were derived by adjusting the 1988 level by the changes in the Implicit Price Index of Forestry. Values, at constant prices, were derived by deflating the stumpage values at current prices by the consumer price index.

5.5 Analysis, Results and Discussions

Appendix tables 1 to 20 at the end of this report contain the estimated asset accounts for forest resources. Physical asset accounts are shown in appendix tables 1 to 9 for both old growth and second growth dipterocarp forests, appendix tables 10 to 14 for pine forests, and appendix tables 15 to 18 for rattan. A summary of the monetary asset accounts is presented in appendix tables 19 and 20.

Dipterocarp

The area of old growth forests steadily declined from 1988 to 1991 and has remained unchanged since 1992 when the logging ban was imposed. By 1994, only a total of 805,000 ha remained of the old growth dipterocarp forest areas. Likewise, areas planted with second growth dipterocarp forests also decreased form 3,413,000 ha to 2,963,000 ha, registering a negative annual growth rate of 2.3 per cent. Forest conversion was identified as one of the major causes of this decrease in forest area.

At current prices, the value of stock of both old growth and second growth dipterocarp forests grew as the prices of logs continuously surged. Valued at constant 1985 prices, however, the stock of forest resources diminished through the years. For old growth forest resources, the value shrank from 213 billion pesos at the end of 1988, to 156 billion pesos at the end of 1994, recording an annual decline of 5.1 per cent. Similarly, second-growth forest resources dwindled, although at a slower rate of 4.1 per cent, from 209 billion pesos in 1988, to 162 billion pesos at the end of 1994. Table 5.2 and Figure 5.2 and 5.3 further illustrate the situation of old growth and second growth dipterocarp forests for the period 1988 to 1994.

Table 5.2: Summary table of the monetary estimate of the closing stocks of old growth and second growth dipterocarp forests, at current and constant prices, 1988-1994.

Year	Old Growth					Second Growth				
		Depletion		Value of closing stock			Depletion		Value of closing stock	
	Closing stock (in '000 ha.)	Current Prices	Constant prices	Current Prices	Constant prices	Closing stock (in '000 ha.)	Current Prices	Constant prices	Current Prices	Constant prices
		(in million pesos)		(in million pesos)			(in million pesos)		(in million pesos)	
1988	988	23,650	21,167	238,054	213,058	3,413	523	468	233,050	208,580
1989	922	13,953	11,130	255,351	203,689	3,351	550	438	262,591	209,464
1990	861	9,939	6,944	243,004	169,780	3,228	287	201	262,054	183,090
1991	805	11,224	6,609	256,840	151,231	3,224	227	134	290,158	170,850
1992	805	-	-	296,838	160,429	3,132	263	142	325,292	175,807
1993	805	-	-	325,778	163,620	3,042	-	-	346,998	174,278
1994	805	-	-	338,617	155,977	2,963	-	-	351,259	161,800

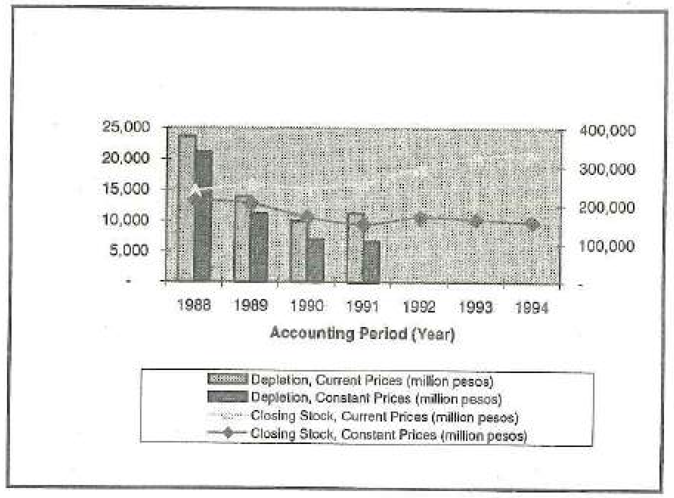

Figure 5.2 Monetary Valuation of the Closing Stock and Depletion of Old Growth Dipterocarp Forest, 1988-1994

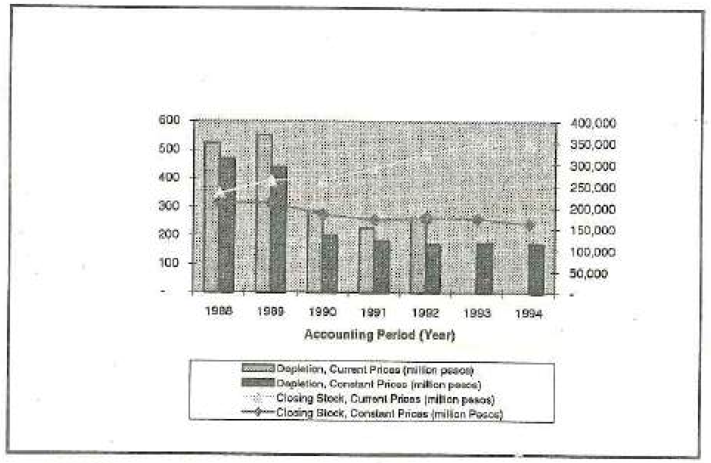

Figure 5.3 Monetary Valuation of the Closing Stock and Depletion of Second Growth Dipterocarp Forest, 1988-1994

Pine

In 1988, the total area of pine forests was 238,890 ha, with a volume of 25,098,000 cubic meters. Sixty- eight per cent can be found in closed forests while the rest are in open forests. Both the area of open forests planted with pine stands is lesser than in closed forests because the latter is more prone to forest fires. The area and volume of pine forest slightly decreased at an annual rate of 0.5 per cent within the six-year period. By the end of 1994, only 231,500 ha remained of the country's pine forests, with a volume of

24,252,000 cubic meters. Table 5.3 indicates that the country's pine resources are being reduced at the rate of 120,833 cubic meters per year during the period covered, not due to economic activity but mainly because of stand mortality and forest fires.

Table 5.3: Value of the closing stock and depletion of pine forest resources, at current and constant prices, 1988-1994

Year	Closing stock		Value of depletion (in million pesos)		Value of closing stock (in million pesos)	
	Area in 000 ha.	Vol. In mil. Cu.m.	Currentprice	Constant price	Currentprice	Constant price
1988	238.9	25.0	52	47	46,582	41,680
1989	237.6	24.9	44	35	48,133	38,396
1990	236.4	24.8	-	-	48,478	33,870
1991	235.2	24.6	-	-	54,768	32,249
1992	233.9	24.5	-	-	63,700	34,427
1993	232.7	24.4	-	-	62,478	31,379
1994	231.5	24.2	-	-	62,667	28,867

Due to the increase in the estimated stumpage value of pine forests, the value of its closing stock at current price grew at an annual rate of 5.1 per cent, despite the reduction in terms of cubic meters. At constant prices, however, the value of the stock of pine forest resources declined from 41,680 million pesos in 1988 to 28,867 million pesos in 1994.

Rattan

The results of the physical accounts show that the volume of stock of rattan shrank at a diminishing rate over the period 1988 to 1994, from 4,112 million lm in 1988 to 3,236 lm in 1994.

At current prices, the depletion due to harvest and waste dropped from 304 million pesos in 1988 to 271 million pesos in 1994, registering an annual decline of 1.9 per cent. At constant prices, depletion was reduced from 273 million pesos in 1988 to 125 million pesos in 1994, manifesting an annual negative growth of 12.2 per cent.

Despite the decrease in the volume of stock of rattan, the value of its closing stock at current prices slightly rose from 3,290 million pesos in 1988 to 3,305 million pesos in 1994, as a result of the increasing stumpage values. However, at constant 1985 prices, the real value declined from 2,945 million pesos in 1988 to 1,522 million pesos in 1994, recording an annual decline of 10.4 per cent. Table 5.4 and Figure 5.4 summarize the situation of rattan resources in the country for the period 1988 to 1994.

Table 5.4: Value of the closing stock and depletion of rattan resources, at current and constant prices, 1988-1994

Year	Closing stock	Value of depletion (in million pesos)		Value of closing stock (in million pesos)	
	Area in mil. Lm.	Current price	Constant price	Current price	Constant price
1988	4,112	304	272	3,290	2,945
1989	3,894	304	243	3,188	2,543
1990	3,821	178	125	3,129	2,187
1991	3,627	315	185	3,329	1,960
1992	3,511	279	151	3,713	2,007
1993	3,371	300	151	3,456	1,736
1994	3,236	271	125	3,305	1,522

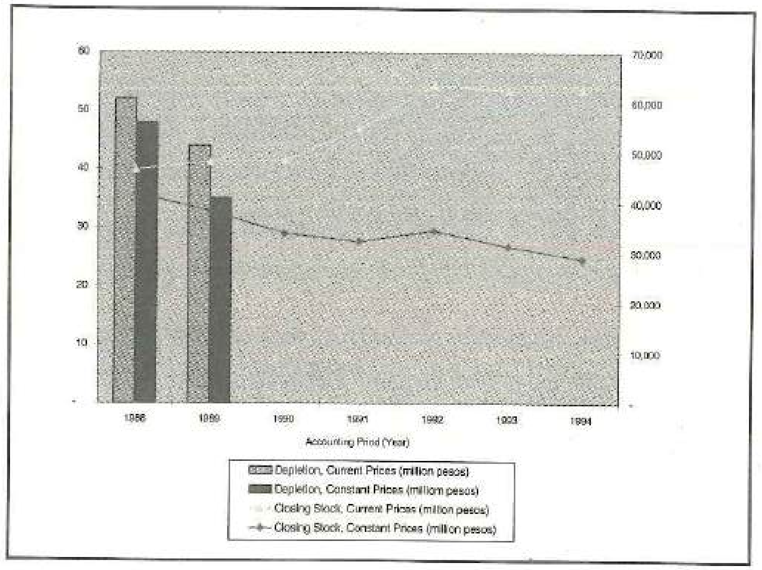

Figure 5.4 : Monetary Valuation of the closing stocks and depletion of the forest, 1988-1994

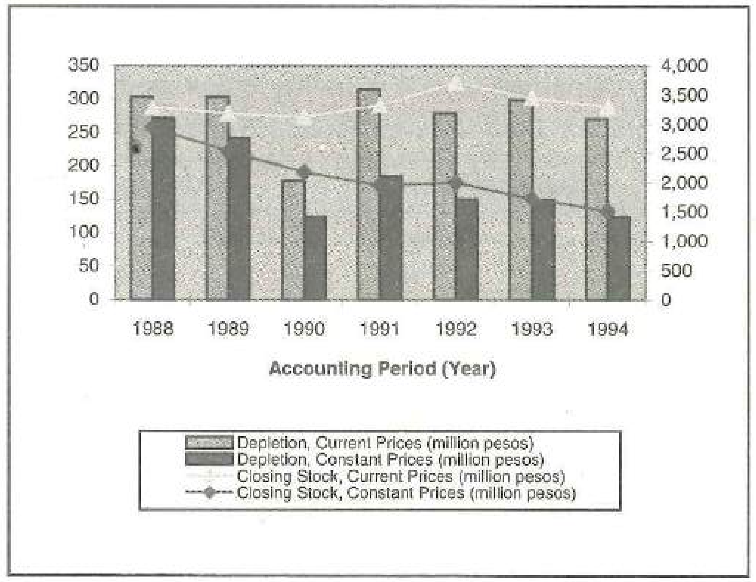

Figure 5.5 : Monetary valuation of closing stock and depletion of rattan forest resource, 1988-1994

5.5.1 Summary of economic accounts

At current prices, the closing stock of forest resources displayed an increasing trend, mainly brought about by the increase in prices of timber. At constant prices, despite the continuous decrease in depletion, forest conversion and other volume changes, the value of the closing stock of forest resources showed a declining trend between 1988 and 1994.

At current prices, depletion decreased from P 25 billion in 1988 to 271 million pesos in 1994, at an average rate of 52.8 per cent per annum. At constant prices, the rate of decline was 58 per cent per year, from a high of P 22 billion in 1988 to P 125 million in 1994. Though the significant decrease in depletion can be chiefly attributed to the selective log ban which was imposed in 1992, the reductions due to economic activity have been steadily decreasing even before 1992.

The closing stock at current prices rose from P 521 billion in 1988 to P 756 billion in 1994. Removing the effects of the increase in prices, the closing stock of forest resources in real terms diminished from P 466 billion in 1988 to P 348 billion in 1994.

Table 5.5: Monetary valuation of the closing stock and depletion of forest resources, in current and constant prices, 1988-1994 (10^6 Pesos)

Year	Depletion		Closing stock	
	Current prices	Constant prices	Current prices	Constant prices
1988	24,529	21,954	520,976	466,263
1989	14,852	11,847	569,263	454,093
1990	10,404	7,269	556,666	388,927
1991	11,766	6,928	605,096	356,290
1992	542	293	689,543	372,669
1993	300	150	738,710	371,013
1994	271	125	755,848	348,166

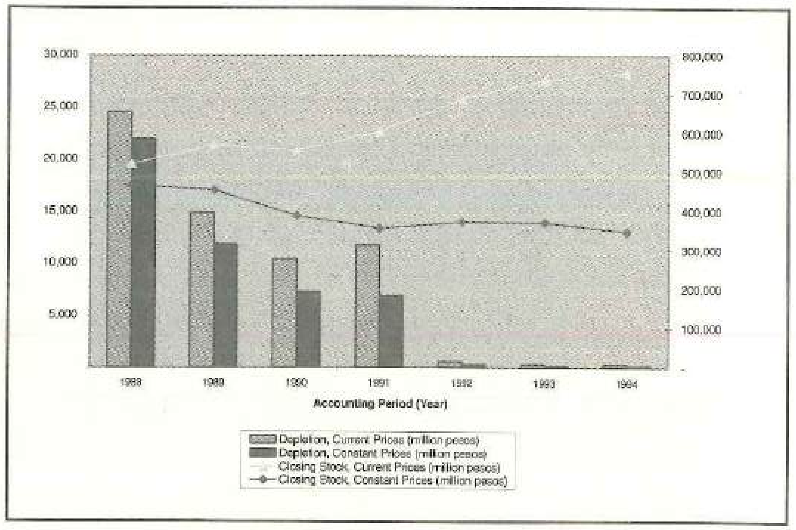

Figure 5.6 : Monetary Valuation of forest resources, 1988-1994

Percentage Share of Depletion and Closing Stock : In terms of the percentage share of the depletion of forest by the type of forest, there was a reversal of roles between dipterocarp and rattan from the period 1988 to 1994

in both current and constant prices. From 1988 to 1991, the dipterocarp forest accounted for most of the depletion, registering a percentage share of more than 95 per cent. In 1992, rattan resources became the major contributor to the depletion of forest resources, accounting for 51 per cent of the total depletion for that year, which increased to a 100 per cent for the period 1993 to 1994. Meanwhile, the depletion of pine forest accounted for a very negligible share for the whole period(Table 5.6 and Figure 5.6).

On the other hand, the percentage shares of the closing stock of forest by the type of forest almost remained the same for the period 1988 to 1994. For both current and constant prices, the dipterocarp forest accounted for around 90-91 per cent, with pine accounting for around eight to nine per cent. Rattan resources, however, reduced its share from around 0.6 per cent in 1988 to around 0.4 per cent in 1994. Table 5.7 illustrates the percentage shares of the closing stock of the different types of forest resources.

Table 5.6: Per cent share of the values of forest depletion for dipterocarp, pine, and rattan, at current and constant prices, 1988-1994.

Year	At current prices				At constant price			
	Total	Diptero carp	Pine	Rattan	Total	Dipter ocarp	Pine	Rattan
1988	100.00	98.55	0.21	1.24	100.00	98.54	0.22	1.24
1989	100.00	97.65	0.30	2.05	100.00	97.66	0.30	2.05
1990	100.00	98.29	0.00	1.71	100.00	98.29	0.00	1.71
1991	100.00	97.33	0.00	2.67	100.00	97.33	0.00	2.67
1992	100.00	48.51	0.00	51.49	100.00	48.48	0.00	51.52
1993	100.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00
1994	100.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00

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6

Marine Fishery Resources of the Philippines

6.1 Introduction

The Philippines consists of 7,100 islands and islets with a coastline of about 18,000 km. Its territorial waters cover about 2.2 million square km, 12 per cent of which is coastal while 88 per cent is oceanic, including the Exclusive Economic Zone (EEZ). The Philippine coastal ecosystem comprises biologically productive habitats such as mangroves, sea grasses and coral reefs that support the country's marine fisheries. The country is also endowed with 569,600 hectares(ha) of a freshwater ecosystem that includes lakes, major rivers, reservoirs, swamplands and fishponds. The diverse aquatic resources favor the development of various interrelated but distinct components of the coastal zone.

During the past decade, the Philippine coastal zone has been under intense pressure from overfishing.[1] The fishing capacity for demersal and small pelagic fisheries exceeded the levels allowed to ensure maximum productivity of fish stocks. The nearshore fish stock is believed to have been fished most heavily. Overfishing has resulted in small and juvenile fish being caught along with the bigger fish, further slowing down the natural recovery of the fish stock. The country's increasing population aggravates the situation as it causes a corresponding increase in the demand for fish.

Fishing is the major source of livelihood in coastal zones. The absence of alternative sources of income in the area results in an increasingly conflicting situation in the use of fishery resources. Cases of illegal fishing among commercial and municipal fisherfolk have been plaguing the industry. The laws prohibit commercial fishing vessels (vessels which exceed the three gross tonne capacity limit) from fishing within 15 km from the shore. Yet, many commercial fishing vessels compete with municipal fishing vessels in nearshore fishing grounds.

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[1] Philippine Fisheries Sector Program, 1993

Commercial fishing vessels have bigger storage space and nets with bigger fishing capacities than those of municipal fishing boats, and they effectively crowd out the municipal fisherfolk in the area. This renders the municipal fishing grounds unproductive and lowers their capacity to replenish fish stocks.

Other environmental damages due to human activities also contribute to the degradation of the coastal zone resources. Such activities include destructive fishing practices, which destroy the coral reefs, inland logging, which causes siltation, and industrialization, which causes pollution. Not to be discounted are the wastes produced by the consumption activities of a growing population.

It is believed that fishing has not been maximized in the offshore and EEZ waters, which constitute 88 per cent of the area of marine waters. Some foreign commercial fishing companies with modern technology and equipment have been illegally fishing in the EEZ waters of the country to maximize catch. Philippine commercial fisherfolk are deterred from venturing into these areas because of high fuel costs, inadequate information on the availability of resources in offshore waters, lack of technical expertise on post-harvest handling and an obsolete fishing fleet.[2]

The importance of fishery in the Philippine economy cannot be understated. It is the country's second staple food after rice. For the period 1988-1993 at constant 1985 prices, the contribution of the fishery sector to the country's gross domestic product (GDP) averaged 4.5 per cent (The Philippines, National Statistical Coordination Board, (NSCB), 1994). The fishing industry also provides employment to around 1.4 million Filipinos, equivalent to six per cent of the country's total labor force (Philippines Fishery Sector Program, (PFSP), 1993).

In 1990, the Philippines ranked eleventh in the world in terms of total fish production, yielding a total of 2.27 million metric tonnes. The country also ranked third in tuna production and was the top producer of cultivated seaweed (carageenan) in the world (Padilla, 1994).

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[2] Ibid.

Because of its importance, concern for the fishery sector has been incorporated into the government's Medium Term Development Plan (MTDP) 1978-1982. It was during this time that the country's growing environmental problems began to be accorded a higher priority. The current MTDP (1992-1998) emphasizes the following policies on fisheries and aquatic resource management:

1. Intensifying the implementation of resource management and conservation programs by protecting and rehabilitating traditional fishing grounds, coral reefs, mangrove and other habitats of marine life, and designating coastal resources for the exclusive use of subsistence municipal fisherfolk in consultation with the local government units (LGUs)
2. Conducting an inventory of the remaining mangrove areas and prohibiting their conversion
3. Formulating a framework for coastal research and providing means for its implementation
4. Establishing more marine nature reserves
5. Conducting more baseline studies on the ecological characteristics and dynamics of corals and marine ecosystem diversity productivity
6. Expanding deep-sea fishing to non-traditional fishing grounds in the Philippine EEZ

However, the information necessary for the formulation of policies and plans for the fishery sector in accordance with the concept of sustainable development is still lacking. Nevertheless, there are several macro-economic indicators relating to the performance of the fishery sector, as well as biological and environmental information on this resource and related ecosystems. Attempts to develop a common framework that consistently addresses both economic and natural resource/environmental problems have been initiated, although they are mostly fragmented and still in their initial stages.

Natural resources have always been considered as free goods, and conventional national accounts do not value the use of these resources. So, the medium and long-term plans for the economy, which use these macroeconomic aggregates, do not link up with the policies concerning natural resources.

This study demonstrates the accounting and valuation of the use of these natural resources, specifically the fishery resource as an input to fishing activity, and the monitoring of the corresponding stocks. This paper is organized as follows: 1) the conceptual framework; 2) operationalizing the framework which includes sources of data and estimation methodology; 3) results and discussions; and 4) recommendations for the improvement of fishery resource accounting.

6.2 The Conceptual Framework

6.2.1 Scope and coverage

Fishery resource accounts cover the cultivated fish stock and stock of other aquatic animals in fishponds and farms, as well as non-cultivated fish stocks and other aquatic animals in the ocean and in the inland and coastal waters. Specifically, cultivated fishery resources cover aquaculture and mariculture, while the non-cultivated fishery resources include marine and freshwater fisheries. Due to data limitations, this initial study is confined only to marine fisheries.

6.2.2 Framework for the asset account

Guided by the proposed consolidated SEEA framework for Non-Financial Asset Account, the following framework for the Asset Account of the Fishery Resource was prepared:

OPENING STOCK

Changes due to economic activity
- Depletion
- Total catch
- Sustainable Yield

Other Accumulation
- +/- Conversion of fish stockx to economic control

Other Volume Changes due to natural or multiple causes
- \+ Natural Growth
- \- Natural mortality
- +/- Net migration
- \- Mortality due to natural disasters or due to the destruction of natural habitats

Changes in Stocks

Revaluation

CLOSING STOCK

• depletion is only true if total catch is greater than sustainable catch.

Figure 6.1: Asset account framework for fishery resources

This asset account framework is followed for the physical as well as the monetary asset accounts for fishery resources, with the exception of revaluation which is only used for monetary asset accounting.

For non-cultivated fishery, which constitutes marine and fresh water resources, changes in stocks are due to depletion, other accumulation and other volume changes. Depletion is accounted for when the fish catch exceeds the sustainable yield, that is, when harvest exceeds natural growth. Since fish is a renewable resource, the stock of fish can be increased only if it is allowed to regenerate. But fish can only regenerate to a level allowed by the carrying capacity of the ecosystem. Given the capacity of the fish to regenerate and its natural life span, the use of this resource when provided for by its natural growth, is not considered depletion. Other accumulation is the conversion of non-cultivated fish stocks to economic control, considered as "economic appearance" in the 1993 SNA.

Natural growth, natural mortality, net migration and mortality due to natural disasters or due to the destruction of natural habitats make up other volume changes which affect the closing stock of non-cultivated fishery resources.

6.3 Operationalizing the Framework

The study recognizes the complexity of fishery resource accounting, taking into consideration the highly mobile nature of fishery resources. Fish stocks can only be measured indirectly, using biological modeling. Through the Fox model (FAO, 1989), a clear relationship between decreases in stock and increases in fishing effort, with all other factors remaining constant, may be established. However, available data on fishing effort is lacking. For the purposes of this study, the fishing effort had to be estimated indirectly using other available parameters and indicators. These will be discussed in further detail later in the estimation methodology.

As for fish stocks, the Resource Ecological Assessment Study conducted by the Bureau of Fisheries and Aquatic Resources(BFAR) in 1993, which covered twelve major fishing grounds, can provide estimates of biomass for the areas covered and other parameters relevant to the compilation of the asset accounts. The level of fish stocks for the entire country, however, is required in this study and the limited data available cannot be statistically raised to arrive at an estimate for all fishing grounds.

Depletion, as earlier mentioned, is the extraction of fishery resource beyond the rate of natural growth, measured as a positive difference between the catch and sustainable yield. Sustainable yield is likewise dependent on fishing effort data, the monitoring of which has been stopped since 1981. However, special studies and administrative-based data are available which could provide indicators to estimate this variable, but only at the national level and limited to marine fishery resources.

As an initial exercise in operationalizing the concepts of natural resource accounting for the fishery resource, depletion will be the only indicator included in the asset account framework to be computed. The estimates on depletion are measured at the national level for total marine fishery resources. Variables on fish catch and sustainable catch serve as critical input variables in the estimation of depletion.

6.3.1 Sources of data

Data used for the fishery study was sourced from agricultural censuses, current surveys on fisheries, administrative reports and results of special studies of research institutions. Data on fish production and prices was provided by the Bureau of Agricultural Studies (BAS) from Surveys of Commercial and Municipal Fish Landing Centres. Prior to 1980, this data was generated by BFAR, based on regional monitoring reports of licensed fishing vessels.

The cost of production data for commercial fishing was obtained from various sources such as the Annual Survey of Establishments (ASE) of the National Statistics Office (NSO), the Input-Output Tables of the NSCB and the results of special studies on the cost of production conducted by research institutions like the International Center for Living Aquatic Resources Management (ICLARM) and the College of Fisheries, University of the Philippines, Visayas.

Results of fishery studies conducted by the Environment and Natural Resources Accounting Project (ENRAP) Phase II, also provided the parameters for the estimation of fishing effort.

6.3.2 Estimation methodology

The discussions below include the methodologies for estimating depletion in physical and in monetary terms, and also include the estimation of the different input variables necessary, given the limited data available.

Fish Stock : Data on fishery stock is not available at present. However, an indirect estimation of this variable can be carried out as soon as the complete results of the 1993 Resource Ecological Assessment Study (REA) of the BFAR, covering twelve major fishing grounds, become available. This study provides estimates of biomass for areas covered and tackles other parameters relevant in the construction of the asset account. Stock assessment can only be meaningful, however, if estimated according to fishing grounds. With an incomplete set of data, the study cannot arrive at an estimate for all fishing grounds.

Fish Catch : Fish catch is one of the variables used in estimating depletion and sustainable catch. Catch data was classified into commercial and municipal fish production. Municipal production data was further classified into marine and inland fish production. For this study, however, the total marine fish catch refers to commercial and municipal marine fish.

To derive the variable on sustainable catch, a longer series on fish catch was required. This was obtained by extrapolating the BAS data on fish catch, using trends of the BFAR data from 1980 backwards. Fish catch data is likewise used to estimate the fishing effort. To be consistent with the national accounts, a correction factor of 20.0 per cent was applied to the reported fish production to account for the under coverage (Appendix Table 1). This ratio was obtained as the percentage difference between the survey data and the estimated actual production, using the commodity flow method.

Fishing Effort : Data on the fishing effort is necessary to compute sustainable catch. Current production surveys do not produce data on fishing effort.[3] However, special studies and administrative-based data are available which can provide indicators to estimate this variable at the national level, which is limited to marine fishery resources. As such, the fishing effort was

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[3] Fishing effort and fish catch were generated by BFAR prior to 1980. This was not however continued by the BAS, which took over data collection from BFAR.

indirectly estimated by using available parameters on the horsepower for commercial and municipal fishing vessels.

For commercial fishing effort expressed in horsepower (hp), the horsepower equivalent was obtained on the basis of the computed catch per unit effort (CPUE). The CPUE for each major fishing gear was computed based on the actual fish catch data divided by the estimated parameters on horsepower[4] (Appendix Table 2). The CPUE was computed by major fishing gear: purse seine, bagnet, ringnet, trawl, muro-ami and beach seine. The computation assumes that the fishing effort is understated by the same percentage as catch. The total commercial fishing effort was derived by applying the computed CPUE to the corrected commercial fish catch in metric tonnes, by major fishing gear (Appendix Table 3).

To standardize the catching efficiency of the various fishing gears used over a certain period of time, each of the horsepower of other fishing gears was converted to purse seine equivalent (PS)[5] using the ratio of CPUE of each fishing gear to CPUE of purse seine (Appendix Table 4).

For the municipal fishing effort, the available benchmark estimates on the horsepower of municipal fishing vessels and the total municipal fisherfolk by type were obtained from the results of the 1980 Census of Fisheries. Both sets of data were extrapolated using ENRAP estimates[6] on the horsepower of municipal fishing vessels and the number of fisherfolk. To translate the number of fisherfolk to fishing power (hp equivalent), the following conversion factors[7] were applied:

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[4] The relationship between horsepower and vessel tonnage by fishing gear was estimated by ENRAP based on data from BFAR. 1 hp = 0.74 kilowatt.

[5] Purse seine equivalent is used to standardize fishing efficiency for the different gears because purse seine accounts for a large proportion of marine fish landed.

[6] ENRAP series on horsepower of municipal fishing vessels and number of fisherfolk were estimated using time series analysis.

[7] The constant factors used are based on available studies. The horsepower equivalent of a full-time fisher is placed at 0.18 hp per day (Southeast Asia average), based on a study by Karim (1985) on Energy Expenditure of a Group of Students. Six hours is assumed to be the number of hours worked by a fisher per day (full-time fishing). Forty per cent is the mean percentage of days of actual part-time fishing with respect to full-time fishing and 11 per cent is the mean percentage of actual occasional fishing with respect to full-time fishing.

(a) hp of full-time fishermen = number of full-time fishermen x 0.18 Hp x 6/24 hours;

(b) hp of part-time fisherman = hp of full-time x 40%; and

(c) hp of occasional fishermen = hp of full-time x 11%.

The above constant factors were applied throughout the series. The total horsepower equivalent for municipal fisherfolk is equal to (a) + (b) + (c).

To arrive at the total fishing effort in hp equivalent for municipal fishing, the fishing effort for municipal fishing vessels was added to the fishing effort of fisherfolk, after which a two-year average was computed to obtain a smoother set of time series data. This was then translated to PS equivalent following the same methodology used for commercial fishing effort in PS equivalent. Results of the above estimates are presented in Appendix Table 5. The total fishing effort in PS equivalent for marine fishery is the sum of the estimated commercial fishing effort and the municipal fishing effort, both in PS equivalent (Appendix Table 6).

Sustainable Yield (Catch) : The level of sustainable catch was estimated using the Fox Model. This model shows that the catch decreases as the fishing effort increases, with all the other factors remaining constant. The following equation was used:

$$Y = E^{\exp(a + b E)}$$

Where:

	Y	=	catch or yield from the resource
	E	=	fishing effort per unit time
	a	=	constant
	b	=	regression coefficient

The regression coefficient was derived by establishing the relationship between time series data on the fish catch and the fishing efforts estimated[8] earlier, with an R-square of 0.7960 (Appendix Table 7). The sustainable catch level estimated using the above equation is presented in Appendix Table 8 with the sustainable yield curve in Appendix Chart 1.

Depletion : Fish is a renewable biological resource that will eventually die if not harvested. When the harvest of fish exceeds natural growth, depletion occurs. Depletion was computed as follows:

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[8] Time series of the fishing effort was smoothened using the two-year moving average.

Depletion = Actual Catch less Sustainable Catch

In monetary terms, the value of depletion, expressed as net rent, was estimated using the Net Price Method, that is,

Net Rent = Net Price per Unit x Depletion

Appendix Tables 8 and 9 present the results of these formulas.

The ASE of the NSO provided the basis for arriving at the net rent. To arrive at the net rent, costs of intermediate inputs (fuel, compensation to employees, indirect taxes, depreciation, and a 15.0 per cent opportunity cost - based on experts' opinion - for holding fixed assets) were subtracted from the gross output valued at producer's price (gross revenue). Based on the above computations, the ratio of net rent to gross output was derived.

The net price at market prices was estimated from the net price at producer's price. Since ASE data does not provide information on the corresponding catch, the net price at producer's price was obtained by applying the ratio of net rent to gross output, which is 12.2 per cent, to the producer's price[9] of fish. The trend of producer's price was applied to derive the estimates of net price.

Environmentally Adjusted Net Value Added (EVA) : The net value added (NVA) includes factor payments to production, namely, compensation, indirect taxes less subsidies, and the net operating surplus (excluding the cost of depreciation of fixed assets). From the computed NVA, the resulting net rent was deducted to arrive at an estimate for environmentally adjusted NVA. However, only depletion of fish stock, as a component of the asset account that effects the changes in the closing stock, was computed in this study. All other factors have yet to be included in the preliminary estimate of environmentally adjusted NVA.

Available data from the National Accounts covers estimates of gross value added (GVA) of the fishery sector by factor shares. The GVA estimates at current prices for fishery were derived using the formula:

[9] Producers Price for fish was generated from the BAS Survey of fish landing centers.

GVAt = Qt x (1+UNC) x Pt x GVAR

where :
- Qt = quantity of production
- UNC = undercoverage ratio
- Pt = current producer's price
- GVAR = gross value added ratio

Separate estimations were carried out for commercial and municipal marine fishing to generate total GVA for marine fishery. However, since the breakdown of GVA by factor share is not available separately for commercial and marine municipal fishing, the same structure as the total fishery sector was used. The NVA was estimated by deducting the depreciation cost of fixed assets from the computed GVA.

6.4 Analysis, Results and Discussions

The importance of fishery rests heavily on its ability to support the population's food requirements. An increasing population demands increased fish production. Between the period 1985 to 1993, the total fish production continued to increase. Per capita fish consumption also showed an increasing trend from 32.5 kg in 1985 to 40.9 in 1991. In 1992, however, this declined to 40.2 kg, further decreasing to 40.1 kg in 1993. Table 6.1 presents the complete data.

Table 6.1 : Per capita consumption, fish production, and population in The Philippines, 1985-1993

Year	Per capita consumption (kg)	Fish production ('000 mt)	Population ('000)
1985	32.5	2,052	54,668
1986	37.3	2,089	56,004
1987	38.9	2,213	56,764
1988	38.1	2,270	58,112
1989	39.6	2,356	59,470
1990	40.3	2,503	62,049
1991	40.8	2,597	63,692
1992	40.2	2,624	65,339
1993	40.1	2,648	65,982

In 1985, the GVA of total fishery at constant 1985 prices accounted for 19.0 per cent of the total GVA for agriculture, forestry and fishery. On the other hand, the aggregate GVA for fishery constituted 5.0 per cent of the total domestic product (GDP). The GVA of the fishery sector has steadily grown during the period 1985 to 1993 as shown in Table 6.2.

Table 6.2: Contribution of fishery GVA to AFF GVA and GDP 1985-1993

Year	Fishery GVA	% to agriculture, Fishery and forestry	% GDP
1985	27,058	19.25	4.73
1986	29,246	20.07	4.94
1987	30,920	20.56	5.01
1988	28,581	18.40	4.34
1989	29,628	18.52	4.24
1990	30,783	19.15	4.27
1991	32,001	18.89	4.47
1992	32,375	19.79	4.51
1993	32,820	19.65	4.47

Source: NSCB.

Fishery resources are important to the economy and they must be managed properly to ensure sustainability. An idea of the level of stocks available is essential to the management of this resource. However, given the nature of the resource and data limitations, computations for this indicator could not be covered by this study.

Inspite of data constraints, the study was able to come up with a measure of sustainability of fish production. If depletion goes beyond sustainability, the cost of depletion or net rent is computed. A positive value for net rent indicates that we are over-exploiting our fish stocks. If the fish resource is to be valued as nature's input, the net rent should be netted out of the value added of the fishery industry to determine the true contribution of this activity to the economy.

From the resulting sustainable yield curve *Y= E exp (2.138495808 - 1.88251E-06)*, the maximum sustainable yield (MSY) was estimated at an effort of 531,206 hp and a catch of 1,658,461 metric tonnes. By harvesting at

MSY, the regenerative capacity is maximized. Although this point serves as the optimum physical point of resource use, it is not the economically optimal management policy. The point where harvesting is rewarding is where the marginal revenue (MR) is equal to the marginal cost (MC).

Table 6.3: Estimated value of marine fishery resource depletion, 1985-1993

Year	Fishing effort (Hp)	Sustainable catch (m.t.)	Actual catch (m.t.)	Depletion * (m.t.)	Net price (P/m.t.)	Net rent ('000 Pesos)
1985	649,477	1,622,976	1,556,542	0	0	0
1986	650,655	1,622,318	1,624,206	1,888	2,391	4,513
1987	653,145	1,620,911	1,688,926	68,015	2,159	146,845
1988	611,119	1,641,475	1,726,033	84,558	2,223	187,939
1989	561,349	1,655,890	1,823,409	167,518	2,183	365,741
1990	548,115	1,657,639	1,914,725	257,086	2,230	573,224
1991	455,734	1,640,049	2,008,007	367,957	2,543	935,700
1992	380,379	1,577,501	1,991,463	413,963	2,671	1,105,772
1993	405,231	1,603,754	1,978,350	374,596	2,866	1,073,460

* Actual catch less sustainable catch.

An examination of catch data from Table 6.3 above reveals that the period 1986-1993 witnessed higher harvest rates than the natural growth rates. The catch was highest in 1991 where it peaked prior to tapering off in 1992-1993. The slowdown could be attributed in part to the decrease in fishing effort. It was during this time that the government started introducing interventions to curb overfishing. It formulated and implemented the Fisheries Sector Program after realizing the adverse effects of over-exploitation of the resource.

The use of the resource will only be valued at points where production activities put pressure on the environment, that is, when harvesting is greater than the volume of natural growth. For the country's fishery resources, depletion was recorded starting 1986 but was most evident when it grew by a hefty 98.1 per cent, from 84,558 metric tonnes in 1988 to 167,518 metric tonnes in 1989. Up to this point, though depletion was occurring, it was at a decelerating rate. From a high of 1.106 billion Pesos in 1992, the value of depletion started to decrease slightly to 1.073 billion Pesos the following year due to an appreciation in the net price of fish during the period. For the period 1986 to 1992, the estimated net rent continued to increase.

Measures have been initiated by government to curb over-fishing. One measure that promotes the regeneration of fish stocks was the government's campaign to shift fishing activities to less- exploited fishing grounds. Fisherfolk were encouraged to tap fishery resources in the identified EEZ.

Another measure was to regulate fishing by traditional commercial fisherfolk as well as new fishing vessels, in both the ocean and coastal waters. In 1990, a five-year loan package program from the Asian Development Bank (ADB) was introduced in the Philippines to regulate fishing in twelve priority bays. Included in the program is the Coastal Resource Management (CRM) Component which aims to rehabilitate and regenerate damaged and depleted marine resources. The Credit Component aims at assisting municipal fisherfolk to engage in other non-fishing livelihood programs. With a continuing decrease in the fishing effort from 1992-1993, it is expected that the government's intervention to regulate the fishing industry will lead to a decrease in the depletion of fishery resources. Finally, an effective fishery licensing system can be a means of controlling the fishing effort to achieve the twin objectives of resource conservation and economic efficiency.

During the period 1985 to 1993, as the GVA continued to increase, the NVA which represents the GVA less the cost of depreciation of fixed asset, also increased. Deducting resource depletion from the NVA, the resulting environmentally adjusted net value added (EVA) showed a general increasing trend from 1985 to 1991, but at a slower rate compared to the conventional NVA. Growth in EVA picked up thereafter, growing at a rate that is faster than the NVA, reflecting a slowing down of the depletion rate. The computations for EVA of fishery resources, taking into consideration the depletion of marine fisheries from 1985 to 1993 in million pesos at current prices, are shown in Table 6.4.

Table 6.4: Estimated value of marine fishery resource depletion, 1985-1993

Year	Gross Value added* (in million P)	Net value added** (in million P)	Growth rate (%)	Net rent (in million P)	EVA*** (in million P)	Growth rate (%)
1985	15,297	15,177	-	0	15,177	-
1986	18,269	18,126	19.43	5	18,121	19.40
1987	17,492	17,399	(4.01)	147	17,252	(4.80)
1988	21,371	21,266	22.23	188	21,078	22.18
1989	26,214	23,111	8.68	366	22,745	7.91
1990	24,376	24,261	4.98	573	23,688	4.14
1991	27,057	29,927	10.99	936	28,991	9.72
1992	29,409	29,264	8.68	1,106	28,158	8.34
1993	30,645	30,382	3.82	1,073	29,309	4.09

* Gross value added = compensation + depreciation + (indirect taxes – subsidies) + net operating surplus.
** Net value added = gross value added – depreciation of fixed assets.
*** EVA = net value added – resource depletion.

6.5 Recommendations

A lot has to be done to fully operationalize the fishery resource accounting in the Philippines. The following recommendations were drawn from the basis of data problems encountered during the study:

1. Data set on fishing effort is considered as one of the most critical variables in the study. Therefore, regular surveys on fisheries of the BAS should incorporate this data set. Other factors that affect the fishing effort, like the number of hauling, fishing days, number of crew, likewise, should be included. The current available data on production is estimated with a 20.0 per cent under-coverage ratio and there is a need to improve this data to further refine the estimates on sustainable catch.

2. Available data from the 1991 Census of Fisheries failed to include relevant information on the characteristics of fishing units, particularly on the inventory of fishing boats and their corresponding tonnage and horsepower. These variables need to be looked into in succeeding censuses.

3. Data on the cost of production for both commercial and municipal fishing is inadequate and limited only to the results of special studies. A nation-wide survey for commercial and municipal fishing should be pursued separately.

4. The study also showed that although there is available data from BFAR studies on stock assessment, the coverage is limited only to selected fishing grounds. To be able to derive accurate estimates of fish stock at the national level, an expansion of the coverage of these studies should include the remaining fishing grounds.

5. Finally, more venues for discussions and exchange of experiences in operationalizing the concepts in fishery resource accounting should be made available, given the complexity of the bioeconomics of the resource.

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APPENDICES

Appendix Table 1 :
Total Marine fish catch [1/], 1976-1993
in metric tonnes

Year	Commercial	Municipal (marine)	Total Marine Fish Catch
1976	609,836	640,185	1,250,021
1977	621,798	736,727	1,358,525
1978	607,008	802,300	1,409,308
1979	600,896	762,652	1,363,548
1980	586,174	776,741	1,362,915
1981	593,722	851,987	1,445,709
1982	631,648	849,619	1,481,267
1983	623,179	925,186	1,548,365
1984	616,002	947,970	1,563,972
1985	614,384	942,158	1,556,542
1986	655,476	968,730	1,624,206
1987	709,430	979,496	1,688,926
1988	719,994	1,006,039	1,726,033
1989	764,566	1,058,843	1,823,409
1990	840,677	1,074,048	1,914,725
1991	911,778	1,096,229	2,008,007
1992	965,839	1,025,624	1,991,463
1993	1,014,517	963,833	1,978,350

Source : Bureau of Agricultural Statistics (BAS)

Note: 1/ Marine fish catch corrected with 20% undercoverage

Appendix Table 2: Actual estimates: Horsepower and marine fish catch and the computed CPUE of commercial fishing vessels by type of gear, 1976-1993

YEAR	PURSE SEINE			BAG NET			MURO-AMI			RING NET			TRAWL			BEACH SEINE		
	Hp	CATCH	CPUE	Hp	CATCH	CPUE	Hp	CATCH	CPUE	Hp	CATCH	CPUE	Hp	CATCH	CPUE	Hp	CATCH	CPUE
1976	50,253	211,417	4.21	133,366	42,012	0.32	7,976	13,800	1.73	7,151	22,647	3.17	189,690	206,205	1.09	189,690	727	0.00
1977	45,298	190,607	4.21	85,260	71,524	0.84	7,786	10,523	1.35	5,357	32,777	6.12	162,824	204,468	1.26	162,824	479	0.00
1978	62,754	186,073	2.97	96,920	69,823	0.72	974	10,273	10.55	12,855	31,997	2.49	156,035	199,605	1.28	156,035	468	0.00
1979	80,564	174,029	2.16	100,154	97,799	0.98	11,736	11,677	0.99	20,223	32,950	1.63	188,977	176,739	0.94	188,977	780	0.00
1980	35,844	163,153	4.55	62,179	106,254	1.71	636	11,553	18.17	16,810	33,913	2.02	150,633	164,287	1.09	150,633	664	0.00
1981	98,587	168,918	1.71	81,536	107,229	1.32	5,705	10,058	1.76	28,951	39,774	1.37	162,119	151,674	0.94	162,119	510	0.00
1982	105,602	198,178	1.88	84,469	114,624	1.36	11,437	10,367	0.91	28,729	40,862	1.42	174,682	151,837	0.87	174,682	801	0.00
1983	95,186	212,979	2.24	80,397	84,958	1.06	11,985	8,694	0.73	29,498	50,283	1.70	199,949	152,106	0.76	199,949	669	0.00
1984	81,530	193,054	2.37	90,186	93,990	1.04	8,732	9,748	1.12	45,857	58,360	1.27	159,854	151,053	0.94	159,854	486	0.00
1985	80,202	183,414	2.29	90,325	102,879	1.14	10,098	10,284	1.02	48,944	75,406	1.54	162,472	129,327	0.80	162,472	2,260	0.01
1986	91,677	224,730	2.45	87,438	91,053	1.04	12,648	10,002	0.79	47,924	72,958	1.52	171,906	136,604	0.79	171,906	3,657	0.02
1987	97,182	239,663	2.47	91,717	92,413	1.01	11,362	11,491	1.01	62,440	86,175	1.38	184,112	147,317	0.80	184,112	7,241	0.04
1988	87,826	263,439	3.00	89,958	95,474	1.06	11,362	11,646	1.02	37,047	87,965	2.37	179,035	117,932	0.66	179,035	9,940	0.06
1989	89,328	279,747	3.13	91,489	101,384	1.11	11,362	12,367	1.09	37,681	93,411	2.48	182,100	125,233	0.69	182,100	10,555	0.06
1990	87,954	307,596	3.50	90,090	111,477	1.24	11,362	13,598	1.20	37,101	102,709	2.77	179,298	137,699	0.77	179,298	11,606	0.06
1991	88,368	453,807	5.14	90,513	53,506	0.59	11,362	0	0.00	37,280	90,012	2.41	180,142	90,173	0.50	180,142	1,106	0.01
1992	91,196	467,438	5.13	91,484	53,396	0.58	11,362	7	0.00	33,691	109,418	3.25	193,731	90,547	0.47	193,731	2,087	0.01
1993	94,114	425,261	4.52	92,465	53,889	0.58	11,362	0	0.00	30,447	159,270	5.23	208,345	86,965	0.42	208,345	1,040	0.00

Notes:
1. Catch data refers to actual catch from BAS.
2. Hp data is based on parameters used by the ENCAP study.
3. CPUE = Actual fish catch divided by Hp.

Appendix Table 3: Corrected estimates: Horsepower and marine fish catch of commercial fishing vessels by type of gear, 1976-1993

YEAR	GEAR TYPE												TOTAL	
	PURSE SEINE		BAG NET		RING NET		TRAWL		MURO-AMI		BEACH SEINE		UNADJUSTED	
	Hp	CATCH	Hp	CATCH	Hp	CATCH	Hp	CATCH	Hp	CATCH	Hp	CATCH	Hp	CATCH
1976	61,686	259,516	163,708	51,570	8,778	27,799	232,846	253,118	9,791	16,940	232,846	892	709,655	609,836
1977	55,187	232,218	103,873	87,138	6,526	39,933	198,370	249,105	9,486	12,820	198,370	584	571,812	621,798
1978	76,454	226,695	118,078	85,066	15,661	38,983	190,099	243,180	1,187	12,515	190,099	570	591,578	607,008
1979	98,002	211,698	121,833	118,968	24,600	40,082	229,882	214,995	14,276	14,205	229,882	949	718,475	600,896
1980	43,789	199,315	75,961	129,805	20,536	41,430	184,020	200,700	777	14,114	184,020	811	509,102	586,174
1981	122,413	209,741	101,241	133,143	35,948	49,386	201,299	188,329	7,084	12,489	201,299	633	669,283	593,722
1982	129,103	242,280	103,267	140,132	35,122	49,955	213,556	185,627	13,982	12,674	213,556	979	708,585	631,648
1983	116,381	260,402	98,299	103,875	36,066	61,479	244,471	185,975	14,654	10,630	244,471	818	754,340	623,179
1984	99,119	234,703	109,642	114,267	55,750	70,950	194,340	183,640	10,616	11,851	194,340	591	663,807	616,002
1985	97,851	223,775	110,202	125,518	59,714	92,000	198,225	157,786	12,320	12,547	198,225	2,757	676,537	614,384
1986	111,487	273,291	106,332	110,728	58,280	88,723	209,053	166,122	15,381	12,163	209,053	4,447	709,586	655,476
1987	117,994	290,988	111,359	112,204	75,812	104,630	223,540	178,865	13,795	13,952	223,540	8,792	766,040	709,430
1988	107,836	323,458	110,453	117,226	45,488	108,006	219,824	144,800	13,951	14,299	219,824	12,205	717,375	719,994
1989	109,680	343,482	112,333	124,483	46,265	114,692	223,588	153,764	13,951	15,185	223,588	12,960	729,405	764,566
1990	107,993	377,675	110,615	136,875	45,554	126,110	220,147	169,071	13,951	16,696	220,147	14,250	718,407	840,677
1991	117,008	600,884	119,847	70,847	49,363	119,185	238,525	119,398	0	0	238,525	1,464	763,268	911,778
1992	121,844	624,532	122,229	71,341	45,013	146,191	258,839	120,978	15,180	9	258,839	2,788	821,945	965,839
1993	131,438	593,915	129,136	75,261	42,521	222,435	290,972	121,454	0	0	290,972	1,452	885,040	1,014,517

Notes:

1. Corrected Hp = corrected marine fish catch x computed CPUE in Table 2
2. Corrected Catch = actual marine fish catch x 20% undercoverage

Appendix Table 4: Commercial and municipal horsepower adjusted to purse seine equivalent, 1976-1993

YEAR	COMMERCIAL FISHING VESSELS							TOTAL MUNICIPAL Hp ADJUSTED to PS EQUIV.	TOTAL MARINE FISHERY Hp ADJUSTED to PURSE SEINE EQUIVALENT
	PURSE SEINE	BAG NET	MURO AMI	RING NET	TRAWL	BEACH SEINE	TOTAL COMM'L Hp ADJUSTED to PS EQUIV		
1976	61,686	12,258	4,026	6,608	60,165	212	144,956	152,169	297,125
1977	55,187	20,709	3,047	9,490	59,200	139	147,771	185,223	332,994
1978	76,454	28,689	4,221	13,147	82,013	192	204,716	232,688	437,404
1979	98,002	55,074	6,576	18,555	99,528	439	278,175	334,742	612,918
1980	43,789	28,517	3,101	9,102	44,093	178	128,780	164,681	293,461
1981	122,413	77,708	7,289	28,824	109,916	370	346,519	463,338	809,857
1982	129,103	74,672	6,754	26,619	98,914	522	336,583	429,236	765,819
1983	116,381	46,425	4,751	27,477	83,117	366	278,515	392,028	670,543
1984	99,119	48,257	5,005	29,964	77,554	250	260,148	379,561	639,709
1985	97,851	54,886	5,486	40,229	68,996	1,206	268,654	390,592	659,246
1986	111,487	45,171	4,962	36,194	67,768	1,814	267,397	374,668	642,065
1987	117,994	45,498	5,657	42,427	72,529	3,565	287,670	376,554	664,224
1988	107,836	39,081	4,767	36,008	48,274	4,069	240,035	317,978	558,013
1989	109,680	39,750	4,849	36,623	49,100	4,138	244,139	320,545	564,684
1990	107,993	39,138	4,774	36,060	48,345	4,075	240,385	291,161	531,546
1991	117,008	13,796	0	23,208	23,250	285	177,547	202,374	379,921
1992	121,844	13,918	2	28,521	23,602	544	188,432	192,404	380,836
1993	131,438	16,656	0	49,227	26,879	321	224,521	205,105	429,626

Appendix Table 5: Number of fishers and horsepower equivalent adjusted to purse seine equivalent, 1976-1993

YEAR	NUMBER OF FISHERS				FISHING EFFORT			2-YEAR AVERAGE of TOTAL Hp	ADJUSTMENT FACTOR to PS EQUIVALENT	ADJUSTED Hp to PS EQUIVALENT
	FULL TIME	PART TIME	Occasional	SUB-TOTAL	FISHER HP	MUNICIPAL VESSEL Hp	TOTAL HP			
1976	230,960	157,945	72,333	461,238	13,572	1,030,959	1,044,531	1,044,531	0.1457	152,169
1977	197,310	109,616	58,462	365,388	11,121	924,994	936,115	990,323	0.1870	185,223
1978	266,199	181,317	84,881	532,397	15,636	1,284,654	1,300,290	1,118,203	0.2081	232,688
1979	285,786	194,269	91,950	572,005	16,784	1,434,031	1,450,815	1,375,553	0.2434	334,742
1980	369,126	284,574	143,671	797,371	22,408	1,537,462	1,559,870	1,505,343	0.1094	164,681
1981	329,391	223,016	107,904	660,311	19,339	1,786,913	1,806,252	1,683,061	0.2753	463,338
1982	353,628	238,948	116,891	709,467	20,757	1,994,692	2,015,449	1,910,851	0.2246	429,236
1983	379,648	256,017	126,627	762,292	22,281	2,226,630	2,248,911	2,132,180	0.1839	392,028
1984	407,583	274,306	137,173	819,062	23,918	2,485,539	2,509,457	2,379,184	0.1595	379,561
1985	437,192	293,902	148,598	879,692	25,656	2,774,552	2,800,208	2,654,833	0.1471	390,592
1986	469,259	314,897	160,974	945,131	27,505	3,097,171	3,124,676	2,962,442	0.1265	374,668
1987	503,677	337,393	174,382	1,015,451	29,519	3,457,304	3,486,824	3,305,750	0.1139	376,554
1988	540,621	361,495	188,905	1,091,022	31,682	3,859,313	3,890,994	3,688,909	0.0862	317,978
1989	580,274	387,319	204,639	1,172,232	34,002	4,308,066	4,342,068	4,116,531	0.0779	320,545
1990	622,835	414,988	221,683	1,259,506	36,493	4,808,999	4,845,492	4,593,780	0.0634	291,161
1991	668,518	444,634	240,146	1,353,298	39,166	5,368,180	5,407,346	5,126,419	0.0395	202,374
1992	717,552	476,397	260,148	1,454,096	42,428	5,815,284	5,857,712	5,632,529	0.0342	192,404
1993	770,182	510,429	281,815	1,562,426	45,962	6,299,626	6,345,588	6,101,650	0.0336	205,105

Appendix Table 6: Total fishing effort in purse seine equivalent, 1976-1993

YEAR	MUNICIPAL HORSEPOWER	COMMERCIAL HORSEPOWER	TOTALHp (2-YEAR AVERAGE)
1976	152,169	144,956	297,125
1977	185,223	147,771	315,059
1978	232,688	204,716	385,199
1979	334,742	278,175	525,161
1980	164,681	128,780	453,190
1981	463,338	346,519	551,659
1982	429,236	336,583	787,838
1983	392,028	278,515	718,181
1984	379,561	260,148	655,126
1985	390,592	268,654	649,477
1986	374,668	267,397	650,655
1987	376,554	287,670	653,145
1988	317,978	240,035	611,119
1989	320,545	244,139	561,349
1990	291,161	240,385	548,115
1991	202,374	177,547	455,734
1992	192,404	188,432	380,379
1993	205,105	224,521	405,231

Appendix Table 7: Summary output of regression

Regression Statistics	
Multiple R	0.892168288
R Square	0.795964254
Adjusted R Square	0.78321202
Standard Error	0.139034696
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.20657318	1.20657318	62.4176318	6.5208E-07
Residual	16	0.309290345	0.019330647		
Total	17	1.515863525			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.000%*	*Upper 95.000%*
Intercept	2.138495808	0.131286743	16.28874139	2.2064E-11	1.860180408	2.416811208	1.860180408	2.416811208
X Variable 1	-1.88251E-06	2.38278E-07	-7.900483009	6.5208E-07	-2.38764E-06	-1.37738E-06	-2.38764E-06	-1.37738E-06

Appendix Table 8: Estimated marine fishery resource depletion, 1976-1993

YEAR	EFFORT (Hp) (1)	ACTUAL CATCH (m.t.) (2)	SUSTAINABLE CATCH (m.t.) (3)	DEPLETION (m.t.) (4)
1976	297,125	1,250,021	1,441,311	0
1977	315,059	1,358,525	1,477,571	0
1978	385,199	1,409,308	1,583,061	0
1979	525,161	1,363,548	1,658,353	0
1980	453,190	1,362,915	1,638,723	0
1981	551,659	1,445,709	1,657,263	0
1982	787,838	1,481,267	1,517,283	0
1983	718,181	1,548,365	1,576,930	0
1984	655,126	1,563,972	1,619,775	0
1985	649,477	1,556,542	1,622,976	0
1986	650,655	1,624,206	1,622,318	1,888
1987	653,145	1,688,926	1,620,911	68,015
1988	611,119	1,726,033	1,641,475	84,558
1989	561,349	1,823,409	1,655,890	167,518
1990	548,115	1,914,725	1,657,639	257,086
1991	455,734	2,008,007	1,640,049	367,957
1992	380,379	1,991,463	1,577,501	413,963
1993	405,231	1,978,350	1,603,754	374,596

Note:

Estimated Maximum Sustainable Yield (MSY) 1,658,461 m.t.

Estimated Maximum Fishing Effort (EMSY) 531,206 Hp

Appendix Table 9: Estimated net rent for philippine marine fishery resources, 1985-1993

YEAR	DEPLETION (m.t.)	NET PRICE (P/m.t.)	NET RENT ('000 P)
1985	0	0	0
1986	1,888	2,391	4,513
1987	68,015	2,159	146,845
1988	84,558	2,223	187,939
1989	167,518	2,183	365,741
1990	257,086	2,230	573,224
1991	367,957	2,543	935,700
1992	413,963	2,671	1,105,772
1993	374,596	2,866	1,073,460

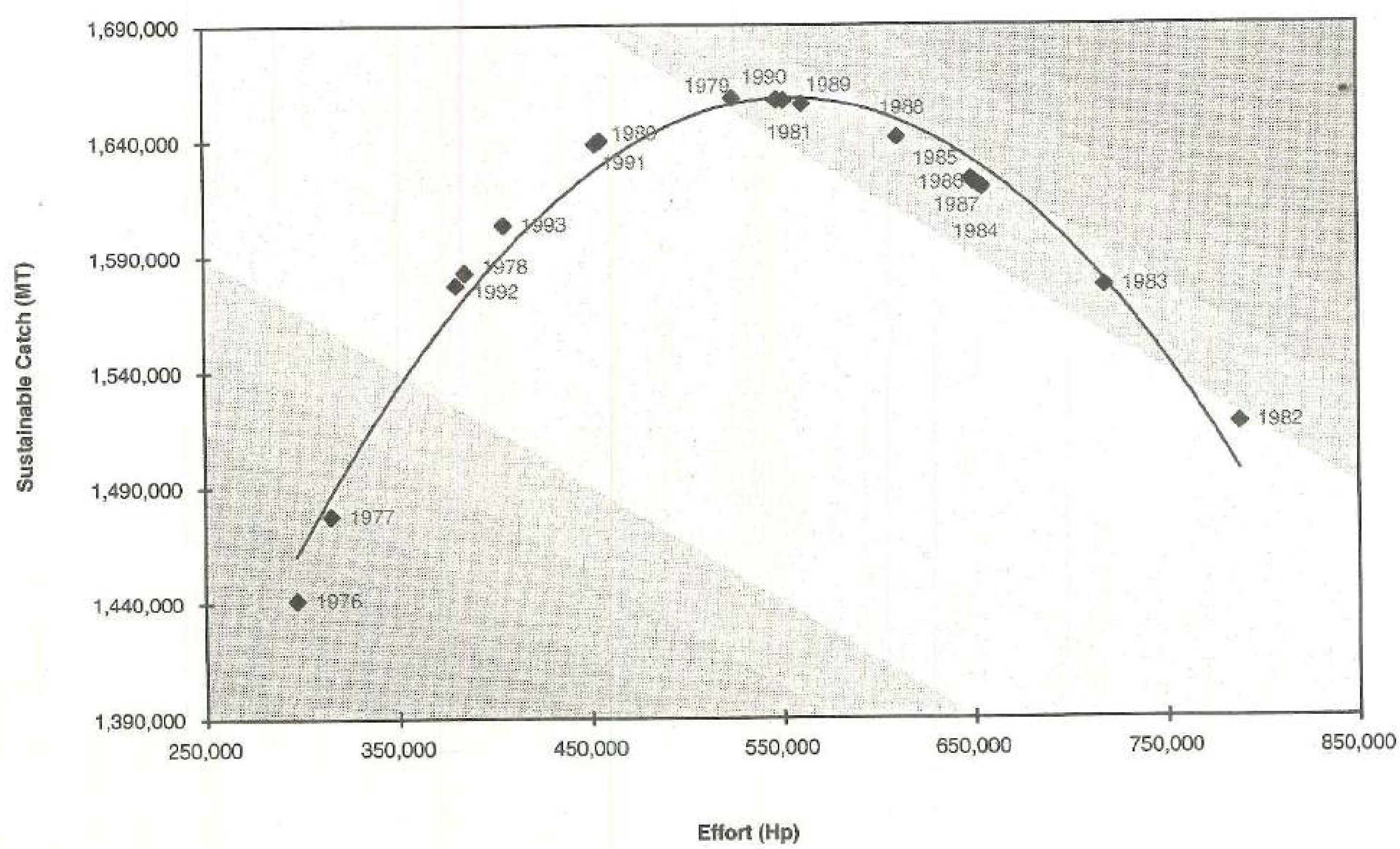
Notes:

(1) Net price was derived by using the 1989 ASE. Series was generated by applying the change in producers price to the derived Net Price of 1989.

(2) To translate the Net Price at purchaser's price, the trade and transport margin was added to NP at producer's price.

(3) Net rent is the value of resource depletion.

APPENDIX FIGURE 1. SUSTAINABLE YIELD-EFFORT CURVE FOR MARINE FISHERY RESOURCES



7

An Environmental Assessment of Guam

7.1 Introduction

Guam is a relatively small oceanic island, 550 square km east of the Philippines and south of Japan. It is a territory of the United States of America (USA) with a military base and a per capita income of US$18,000.

Overall, Guam has a high quality environment. The US Environmental Protection Agency's (EPA) regulations apply to Guam or in some cases, Guam laws are more stringent than those of the USA. On this small high island, the marine environment is vulnerable to the impact of activities on land. The Guam Environmental Protection Agency conducts monitoring programs that document water quality on a regular basis.

No permanent fresh water streams exist on this plateau because of the permeability of the limestone soil. A Ghyben-Herzberg ground-water lens exists in this area which forms the main source of potable water for the island populace. The southern portion of the island has rugged terrain which is dissected by numerous streams. This area has clay soil of volcanic origin. The western slope is short and steep while the eastern slope is gentle, with wide valley flats. The entire island is surrounded by coral reefs that form barrier reefs.

The quality of the reef is found to be generally good. All monitoring stations showed elevated levels of turbidity consistent with ambient conditions for reef flat environments. However, all stations violate acceptable fecal bacteria levels periodically, with some sites showing chronic levels above the acceptable point.

The quality of the surface water network has been found to be generally good, but numerous problem areas have been identified with specific river systems. The violation of water quality standards occur due to elevated fecal coliform levels. In addition, elevated nutrient loading readings are chronic for certain river systems.

Air quality is very high with the prevailing winds removing air

contaminants (e.g., sulphur dioxide) which are mainly associated with point sources using fossil fuel for the Guam Power Authority electrical generators. The use of high-sulphur fuel is allowed under a waiver of the EPA of the USA.

Despite the highly-regulated environment, some problems do occur. For example, the erosion of soil is associated with construction activities and natural erosion in poorly vegetated areas in southern Guam. Occasional grass fires lead to increased erosion. A general area of concern is the sedimentation impact on the reef in areas where the rivers discharge into the ocean in southern Guam. As a result, the coral reefs and associated organisms are dying in the areas adjacent to river mouths.

Landfills with solid waste is a matter of concern in Guam, with its limited land area. The amount of solid waste continues to rise each year. These problems are magnified as the standard of living rises, along with increases in population and industrial activity which bring more goods and commodities into the island. An increase in waste poses a threat of contamination to the aquifer system as well. The possibility of co-generation from garbage (i.e., to generate heat and electricity) is being explored to reduce the volume of garbage going into a landfill.

Hazardous and toxic wastes may lead to a severe impact on the environment of Guam. This danger has increased as is evident in the growth of major hazardous waste generators and on-island treatment, storage and disposal facilities. Significant quantities of hazardous materials are imported in the commercial sector. However, the military continues to be the largest importer and user of hazardous materials. As hazardous materials become waste, disposal requires special handling in accordance with Guam's Hazardous Waste Management Regulations. The cost of packaging, transporting and disposing of hazardous waste to an EPA approved site continues to rise.

7.2 An Analysis of the Environmental Problems of Guam

In Guam, limited land and fresh water resources make it a highly vulnerable system and because of the coral reefs, marine pollution is an important concern. However, air quality does not appear to be a major issue.

7.2.1 *Impact on water resources*

An increase in waste generation threatens ground water aquifers through seepage. Moreover, excess water from the aquifer naturally flows to the ocean from above sea level (springs, etc.) and at sea level.

Nearshore Marine Pollution : The quality of marine waters is found to be generally excellent across all parameters. No major areas of concern were identified in the various sampling programs. However, at the confluence of one of the major river systems (Pago River) and the receiving marine waters, a high percentage of violation of nitrate levels was detected. This is attributed to nutrient loading by leaching from the major landfill on the island (Ordot).

The specific data for fecal levels from the sample sites around the island are taken on a weekly basis. Based on this count, the recommendation for closure of the beach is made by the GEPA. The actual implementation of the closure is issued by the Department of Parks and Recreation.

The following are the areas to be incorporated into the Satellite System for Integrated Environmental and Economic Accounting (SEEA). Two of the resource areas are selected for actual incorporation into the SEEA. Data currently being collected for the specific parameters is noted in the Appendix. These resources can be separated by their measurement in two ways : 1) measuring the use of a resource, and 2) measuring the impact of human activities on that resource. A description of some of the key environmental areas is provided below.

Ground Water: In addition to the marine environment, ground water is an area of concern. The aquifer represents Guam's main source of potable water. Currently, there are 106 wells in operation in northern Guam. These wells draw nearly 11 billion gallons of water per year from the major aquifer system. In addition, there are eight wells in southern Guam. Groundwater is a renewable resource that is dependent on the percolation of the amount of rainfall. Excess water resources percolate through springs at various points above and at sea level. This resource is sensitive to potential groundwater pollution from agriculture, use of pesticides and fertilizers, household sewage (septic tanks), solid and hazardous waste storage or disposal, and general

pollution associated with the run off from developed areas.

If the water pumped from the aquifer is overused, salt water will intrude into the fresh water lens system. According to a study by Mink (1976), the sustainable pumping capacity of the aquifer is estimated at 60 million gal/day (21 billion gal/year). There is a program currently being implemented that will provide a continuous evaluation of the sustainable capacity. Once the sustainable capacity of the resource has been determined, it should not be exceeded, and other sources need to be explored.

In order to stay within an "environmentally sustainable standard", the degradation in water quality can be used as a proxy to reflect the cost of the use of this natural resource to society : for example, the cost of water treatment to remove the pollutants and restore its original quality. Or returning it to an acceptable level for discharge with no negative impact (within its absorption capacity).

Sewage Waters: There are eight sewage treatment plants in Guam. The total treated sewage pumped from these plants amounts to 5.1 billion gallons per year. The discharge is mainly into the marine waters through a pipeline offshore. There are some discharges into rivers and land as well. The measurement of sewage entering the plants could be considered a reflection of the level of activities and responses. Some increases represent the expansion of the sewer line system so as to serve houses and business areas, previously under septic tank use.

7.2.2 Land resources

Land on a relatively small island, represents one of the scarcest resources. Constructive use as well as protection of environmentally sensitive areas are essential elements for sustainable management of the resource. Soil erosion is one of the parameters that measures the potential detrimental impact on the surface and marine water environments.

Soil erosion is accelerated due to development projects in Guam. The Forestry and Soil Resources Division of the Department of Agriculture plays an important role in reducing soil erosion, especially in the southern part of the island. It has developed programs which enhance the development of forested areas. One of these is tree planting which protects the soil from erosion, improves soil quality and converts flammable ground vegetation into useful tree stands which do not easily burn. The estimated value of lost yield due to loss in the top soil from 9,481 acres consumed by fire in 1992, is nearly $ 3,936,400 (1993-1,693 acres valued at $ 785,200). This figure does not include the lost value of the resource, the loss of wildlife or the cost of fighting the fires. Landfills reflect a negative impact of development with possibilities of pollution as well as the use of a valuable resource to dispose of solid wastes.

It is estimated that a little over a cubic foot of solid waste per day is generated for each person on Guam. This figure is expected to eventually increase by about 0.5 to 1.0 pounds per person per day as current trends continue. The option of co-generation is being examined to reduce the quantity of solid waste entering landfills and to generate electrical power.

7.2.3 Air quality

With the economic boom in Guam, construction activities have increased. Although some of the construction activities are short-term in nature, they nonetheless contribute to air quality. Most of Guam's air pollutants come from emissions from the electrical power plants, wind erosion, sandblasting, spray painting, vehicle and stand-by generators.

7.3 Forecasting Aquifer Demand and Sustainable Capacity

For a good free trade, an increase in demand places pressure on the market, as the amount currently supplied is less than the amount demanded, causing prices to rise. This adjustment in price brings the market into equilibrium. It must be pointed out that the market for the aquifer resource differs from a free market good, as in Guam, the price is set by the Public Utilities Commission (PUC) rather than by market forces, and the supply function is based on a government monopoly and not on the competitive market. The difference in the cost of production is absorbed by the government.

An empirical model was constructed to predict the time schedule when the demand for groundwater will exceed the sustainable capacity of the

aquifer. The demand model for groundwater can be specified as follows :

$$AQF = a_1 POP + a_2 NDVST + a_3 INCP + a_4 P + U$$

This model states that the volume of the water demand from the aquifer in thousand gallons during a given year, AQF, is a linear function of the population, POP, per capita income INCP in US$ (Per capita income was collected from the 1994 annual report on Household and Per Capita Income published by the Bureau of Labor Statistics, Guam Department of Labor) and number of visitor days, NDVST. The variable U is the residual or disturbance term reflecting the influences of random elements. The terms a_2, a_2, a_3 and a_4 are the parameters of the demand function. Since price, P, was constant in the time period we tested, it was omitted from the regression equation. The data we used for the model was annual data from 1981 - 1994 (See table 7.1).

Since the coefficient for income was insignificant, it was dropped and a regression without the INCM variable was estimated. The regression results are as follows :

Excluding the one significant variable does improve the predictive performance of the regression equation.

After running the model, we get the parameters for the demand function, as shown in the following equation:

$$AQF = 42.65\ POP + .99875\ NDVST$$

The equation states that for every person added to the population and for every day added to the number of visitor days to the island, aquifer demand increases by approximately 42,650 and 998 gallons respectively.

To derive an estimate of the industry demand in any given year, each parameter is multiplied by the value of the related variable. Table 7.1 illustrates this process showing that the estimated aquifer demand will be 22,711,125 gallons in the year 2010, which exceeds the sustainable capacity estimated by Mink in 1976 of 21,900,000 gallons. When the sustainable capacity is surpassed, water quality begins to deteriorate.

Table 7.1: Guam's aquifer capacity use and a related variables

Year of Observation	Aquifer Usage (in thousand gallons)	Population	Visitor Arrivals	Number of Visitor Days	Per Capita (Income (US Dollar)
1981	5,447,396	108,343	321,766	1,126,181	4,496
1982	6,368,388	110,759	326,342	1,142,197	4,789
1983	6,261,328	113,230	351,087	1,228,805	5,087
1984	6,283,063	115,756	358,520	1,290,170	5,412
1985	6,825,012	118,338	377,941	1,322,794	5,709
1986	7,093,988	120,977	407,061	1,424,714	5,912
1987	6,849,690	123,675	483,956	1,693,846	7,049
1988	7,109,048	126,434	585,799	2,050,297	7,174
1989	6,874,341	129,254	668,827	2,340,895	8,399
1990	8,277,747	132,137	780,404	2,731,414	9,885
1991	9,016,426	136,226	737,260	2,580,410	10,152
1992	9,226,462	139,371	876,742	3,068,597	11,589
1993	8,995,307	142,589	784,018	2,744,063	10,834
1994	9,994,209	145,881	1,086,720	3,803,520	11,306
1995	11,125,679	149,249	1,361,830	4,766,405	11,962
1996	11,929,984	152,695	1,549,884	5,424,594	12,656
1997	12,817,127	156,220	1,760,673	6,162,356	13,390
1998	13,629,914	159,827	1,949,189	6,822,162	14,166
1999	14,522,162	163,517	2,159,425	7,557,988	14,988
2000	15,332,687	167,292	2,345,244	8,208,354	15,857
2001	16,175,132	171,106	2,539,719	8,889,017	16,777
2002	16,785,382	175,007	2,666,705	9,333,467	17,750
2003	17,421,685	178,998	2,800,040	9,800,141	18,779
2004	18,085,090	183,079	2,940,042	10,290,148	19,869
2005	18,776,950	187,253	3,087,044	10,804,655	21,021
2006	19,498,553	191,522	3,241,397	11,344,888	22,240
2007	20,251,312	195,889	3,403,466	11,912,132	23,530
2008	21,036,620	200,355	3,573,640	12,507,739	24,895
2009	21,856,019	204,923	3,752,322	13,133,126	26,339
2010	22,711,125	209,596	3,939,938	13,789,782	27,866
2011	23,603,499	214,374	4,136,935	14,479,271	29,483
2012	24,534,995	219,262	4,343,781	15,203,235	31,193
2013	25,507,376	224,261	4,560,970	15,963,397	33,002
2014	26,522,620	229,375	4,789.019	16,761,566	34,916
2015	27,582,626	234,604	5,028,470	17,599,645	36,941
2016	28,689,599	239,953	5,279,893	18,479,627	39,084
2017	29,845,717	245,424	5,543,888	19,403,608	41,350
2018	31,053,306	251,020	5,821,082	20,373,789	43,749
2019	32,314,757	256,743	6,112,137	21,392,478	46,286
2020	33,632,663	262,597	6,417,743	22,462,102	48,971

ASSUMPTION:

1) Population projected growth at 2.28% per year:
2) Aquifer sustainable capacity at 21,900,000 gallons per year.
3) Forecasting visitor arrivals numbers are based on "Vision 2001" Economic Plan by the Govt. Guam and number of visitor days are based on the Economic and Development Planning Division of the Guam Department of Commerce.
4) Annual growth rate per capita income at 5.8%.

The above results have an assumption that the price is constant. However, if the price rises due to an increased demand as a result of population growth, several phenomena may occur. For example, as the price increases, it becomes economically feasible to repair the distribution system. Estimates indicate that approximately 40 per cent of the water pumped from the aquifer is unaccounted for, with much of this loss attributed to leaking water. At a higher price, there will be a financial incentive to invest in the repair and maintenance of the system, resulting in increasing available water from the aquifer. All of these responses to a price increase would lead to a shifting outward of the supply curve for water.

An increase in the price of water is also expected to generate a response from the consumer. The higher price creates an incentive for the consumer to invest in conservation techniques, such as constructing catchments, or investing in new water saving technologies (such as water conserving shower heads or commodes or simply encouraging water-saving behavior or lifestyle). Similarly, in response to an increase in the air pollutants, unpaved roads, quarry operations, incinerators, and boilers are controlled. Because of Guam's remote geographical location and size, trade winds play a vital role in reducing air pollution. Frequent rains also help in diluting air contaminants.

7.4 Water Supply And Environmental Accounting For Guam

7.4.1 Guam aquifer resources and theoretical models

We first examine Guam's existing water supply. Potable water on Guam is derived from two general sources: surface-water sources in Southern Guam, including the Navy's Fena Reservoir and the Ugum River project of the Public Utility Agency of Guam (PUAG), and groundwater in Northern Guam. Approximately 65 per cent of the total water production is derived from wells, four per cent from springs, and 31 per cent from surface sources. Currently, there are 117 production wells on Guam. Of these wells, 96 belong to PUAG, nine to the Air Force, three to the Navy, and the remainder to private parties. All but 16 of the wells are located in the north. Figure 7.1 shows the existing water-supply sites on Guam. The Northern Guam Lens Aquifer is the primary potable-water source for Guam.

In standard economic theory, markets are evaluated by the relationship between the demand for a particular good or service and market supply of the particular commodity. This relationship is typically viewed graphically with the price of the commodity being listed on the vertical axis and the quantity, either demanded or supplied, on the horizontal axis. In a static model of supply and demand equations, all variables such as income, population, preferences and levels of productivity are held constant. Changes in these factors result in a shifting or/of either the demand curve or the supply curve depending on the variable in question. Changes in price do not lead to a shift in the supply or demand curves but rather cause movement between both the existing curves. In a free market economy, changes in price (delta price) is the adjustment mechanism which is free to fluctuate, resulting in the market adjusting mechanism guided by Adam Smith's "Invisible Hand" theory.

7.4.2 Guam's new income accounting with national resources depreciation adjustments

Guam's aquifer resource depreciation can be calculated using models that estimate changes in the "sustainable yield" based on the volume of water pumped from the aquifer. "Sustainable Yield" measures, productive potential at a certain level of effort.

Traditionally, there are four valuation methods for natural resource accounting. The Present Value Method, the Net Price Method, The User Cost Method and The Replacement Cost Method. If the resources in question enter directly into the market and current prices are available, then it may be possible to employ the net price method. If not, the replacement cost method can be used to measure the cost of restoring the resource to its previous state - not the actual change in present value terms.

Since Guam does not have a market price for aquifer water resources, it is appropriate to use the replacement cost method.

Currently, Guam's Forecasting Model consolidates the income accounts of Guam which are represented by the Gross Island Product (GIP) and Personal Income (PI) (Table 7.2).

Table 7.2: Guam gross island product, personal income

	Actual						Estimate		Forecast	
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Gross Island Product ($ Million)	1,729	1,898	2,312	2,667	2,902	2,917	3,057	3,128	3,256	3,425
Personal Income ($ Million)	1,327	1,421	1,672	1,987	2,203	2,240	2,314	2,412	2,525	2,671

Personal Income reflects the flow of purchasing power to the residents of Guam. It excludes returns to capital and business organizations which are not distributed to persons, and it includes social security and other transfer payments to the residents of Guam.

The estimates of GIP are presented for six sectors or groups of industries: services, trade (including retail and wholesale), construction, other private industries, the government of Guam, and the Federal government. The services sector, including tourism, trade (retail and wholesale), and construction are three major model elements as sources of demand, generating growth directly and indirectly. They are three key sectors of the Guam economic model.

Using the replacement cost method, we can reconstruct Guam's Income Accounting.

The regression model shows that the estimated aquifer water demand will be 22,711,126 thousand gallons/year in 2010, which exceeds the current sustainable capacity estimated by Mink in 1976 of 21,900,000 thousand gallons. It is the amount of the aquifer water that can be utilized at a sustainable level, without salt water intrusion. When the "sustainable" capacity is surpassed, the over-pumping stage is reached when the chloride levels start to exceed 250 parts per million (ppm). This is a serious condition, because as the amount of water in the lens reaches a critically low level, there is salt water intrusion, as the water at the bottom of the lens contains more of the settled sediments and other contaminants. The thickness of the lens is also lessened.

It is hard to accurately determine the recharge rates in terms of rainfall as some of the rainwater percolates, some of it evaporates, or is absorbed by the vegetation, and so forth. The important fact in the light of this is to monitor the amount of production and chloride levels to guard against over-pumping of water.

In the new Accounting System, natural resource depreciation - aquifer over-pumping - is deducted from "conventional" Gross Island Product. To calculate the deduction, we use the water price which will gradually increase with the decrease in the water table to multiply the forecasted over-pumping aquifer usage. An adjusted Gross Island Product is calculated and presented in Table 7.3.

7.5 Water Quality and Pollution Assessment

The case study here deals with marine water pollution and aquifer pollution. In Guam, people have different opinions about what is the primary cause of pollution. Some believe that pollution is the side- effect of economic development, while some argue that pollution is more often attributed to natural weather conditions and there is no correlation to economic development.

Here, we want to test the relationship between pollution, general economic activity and natural weather conditions between the years 1985 - 1994.

In the end, we may use the results to try and decide if increased pollution can be explained by economic events, including construction, agriculture, and households or if weather conditions have to be brought into the explanation.

7.5.1 Nearshore marine water pollution

Data review : There is a common indicator, Fecal Coliform, to show the quality of nearshore water pollution.

Fecal Coliform (FC) is an organism in the waters that thrives in the presence of waste material from the intestines of warm-blooded animals such as humans, dogs, cats or birds. Fecal coliform is a non-pathogenic organism, which means it is not harmful to humans. But its presence in high numbers indicates a possible risk of pathogenic organisms being present, which is the primary concern.

Table 7.3: Guam's new income accounting

Year	Conventional Gross Island Product (US Dollar)	Aquifer Use Over Sustainable Volume (21,900,000)	Natural Resources Description	Adjusted Gross Island Product (US$)	Natural Resources Depreciation as % of GIP
	A	B	C=BXWater Price(E.)	A – C	C/A
1988	1,729,470,000	0	0	0	0
1989	1,897,5000,000	0	0	0	0
1990	2,312,480,000	0	0	0	0
1991	2,687,380,000	0	0	0	0
1992	2,902,000,000	0	0	0	0
1993	2,916,770,000	0	0	0	0
1994	3,057,010,000	0	0	0	0
1995	3,128,090,000	0	0	0	0
1996	3,256,110,000	0	0	0	0
1997	3,425,180,000	0	0	0	0
1998	3,608,420,000	0	0	0	0
1999	3,817,980,000	0	0	0	0
2000	4,024,130,000	0	0	0	0
2001	4,241,433,020	0	0	0	0
2002	4,470,470,403	0	0	0	0
2003	4,711,875,805	0	0	0	0
2004	4,966,317,098	0	0	0	0
2005	5,234,498,222	0	0	0	0
2006	5,517,161,126	0	0	0	0
2007	5,815,087,826	0	0	0	0
2008	6,129,102,589	0	0	0	0
2009	6,460,074,108	0	0	0	0
2010	6,808,918,110	811,125	31,147	6,808,888,962	4 57447E-08
2011	7,176,599,687	1,703,499	78,497	7,178,521,190	1 09379E-05
2012	7,564,136,071	2,634,995	121,421	7,564,014,650	1 60521E-05
2013	7,972,599,418	3,607,376	168,228	7,972,433,191	2 08499E-05
2014	8,403,119,787	4,622,620	213,010	8,402,908,777	2 5349E-05
2015	8,856,888,255	5,682,628	·261,855	8,858,626,400	2 95652E-05
2016	9,335,160,221	6,789,599	312,865	9,334,847,357	3 35147E-05
2017	9,839,258,873	7,945,717	368,139	9,838,892,735	3 7212E-05
2018	10,370,578,852	9,153,306	421,784	10,370,157,088	4 06712E-05
2019	10,930,590,110	10,414,757	479,912	10,930,110,198	4 39054E-05
2020	11,520,841,976	11,732,663	540,641	11,520,301,335	4 69272E-05

Note : Annual growth rate in conventional GIP at 5.4 per cent (based on guam Economic Forecasting Model's empirical data).

If there are high amounts of bacteria found off the island's shores, it would indicate that there has been a sewage effluent break, water run off from roads or sewers, or something similar, involving an input of waste materials.

Each week, the Guam Environmental Protection Agency (GEPA) puts out a list of beaches that are polluted above the accepted bacteriological standard at the time of testing. Our quarterly data was compiled from the GEPA weekly Marine Recreational Water reports.

Other data used in the model is as follows (on a quarterly basis).

RAIN Rainfall

RST Residential Construction Value (in US dollars)

NDVST Number of Visitor Days

FC Number of days Fecal Coliform count exceeded standard and beach closure was ordered. There are shown in Table 7.4.

RAINFALL data was collected from Guam's local newspaper, the "Pacific Daily News" which sources its figures from the National Oceanic and Atmospheric Administration (NOAA), an agency of the United States Federal Government.

RESIDENTIAL CONSTRUCTION VALUES and NUMBER OF VISITOR DAYS were collected from the "Guam Quarterly Economic Review" by the Department of Commerce, 1984Q1-1993Q3.

Major causes of pollution : To test the relationship between ocean water pollution and general economic activity and natural conditions, we construct the following model.

$$\text{Ocean Pollution} = a_1 \text{ RAIN} + a_2 \text{ NDVST} + a_3\text{RST}$$

The regression results show that the t-statistic for RST is insignificant - there is weak evidence that residential construction is a determinant of ocean water pollution. The variable RST is omitted from the next regression because it adds almost nothing to the quality of the predictions. The results are shown in Table 7.5.

Table 7.4 : Guam's water pollution and related variables

OBSERVATIONS (Year/Quarter)	FECAL COLIFORM [Frequency of Excedences (> 199FC/100 ml)**]	AVERAGE LEVEL OF CHLORIDES (84 WELLS) (acceptable level: 250 ppm)*	CONSTRUCTION RESIDENTIAL Value in U.S. Dollars (Thousands)	NUMBER OF DAYS	RAINFALL (INCHES)	VISITOR ARR. Total Visitors (Number)
1985Q1	N/A	91.53	6,320	374.749	10.25	107,071
1985Q2	N/A	91.24	7,919	305.109	26.04	87,174
1985Q3	N/A	103.24	3,770	357,595	41.29	102,170
1985Q4	N/A	101.71	2,823	285.341	17.84	81,526
1986Q1	41	90.36	5,558	360,465	10.22	102,990
1986Q2	29	88.96	4,526	312,914	12.24	89,404
1986Q3	55	83.40	Q5,148	420,221	49.91	120,063
1986Q4	57	71.88	14,705	331,114	29.05	94,504
1987Q1	19	78.85	6,830	437,259	8.24	124,931
1987Q2	19	78.72	12,363	368.442	5.00	105,269
1987Q3	45	78.79	8,396	475,395	33.05	135,827
1987Q4	36	75.20	11,379	412,752	27.26	117,929
1988Q1	10	77.90	7,029	559,258	6.89	159,788
1988Q2	37	82.67	25,418	463,978	15.34	132,565
1988Q3	57	85.06	7,905	576,366	24.43	164,676
1988Q4	43	94.85	8,448	450.695	22.19	128,770
1989Q1	35	89.01	11,071	589,666	16.11	168,476
1989Q2	42	87.95	10,679	529,487	25.38	151,282
1989Q3	116	92.06	11,082	666,523	37.44	190,435
1989Q4	142	88.96	9,805	555,219	30.38	158,634
1990Q1	48	91.60	20,556	714,861	15.40	204,246
1990Q2	36	85.86	17,941	631,414	13.15	180,404
1990Q3	85	94.15	18,575	734,059	41.54	209,731
1990Q4	27	92.18	16,296	651,081	33.96	186,023
1991Q1	35	81.99	13,673	554,414	7.81	158,404
1991Q2	30	85.78	92,017	821,107	14.99	177,459
1991Q3	74	97.25	125,983	715,621	35.87	204,4363
1991Q4	85	77.52	15,241	689,269	27.48	196,934
1992Q1	60	85.12	15,644	918,061	8.73	262.303
1992Q2	35	83.62	12,496	792.845	7.02	226,527
1992Q3	64	92.55	13,271	711,120	48.28	203,177
1992Q4	61	58.50	18,127	566,388	23.99	161,825
1993Q1	59	81.04	24,515	800,275	5.24	228,650
1993Q2	27	86.50	25,058	652,467	2.36	186,419
1993Q3	86	87.33	27,999	621,177	33.03	177,479
1993Q4	70	90.65	37,131	670,177	27.34	191,470

1994Q1	65	91.12	21,183	1,017,048	8.96	290,585
1994Q2	34	95.32	21,007	819,119	15.84	234,034
1994Q3	107	92.04	18,233	1,008,354	43,29	288,101
1994Q4	49	94.09	18,313	933,282	18.49	266,652
1995Q1	N/A	82.61	24,544	1,138,547	4.17	325,299
1995Q2	N/A	102.44	19,780	1,145.480	15.96	327,280
1995Q3	N/A	108.17	N/A	1,317.148	39.74	376,328
1995Q4	N/A	97.82	N/A	1,157,660	30.18	330,760

* ppm – Parts per Million

** FC > 199 – Fecal Coliform Bacterial count greater than minimum acceptable level of 199 per 100 ml.

Table 7.5: Ordinary least squares estimation

Dependent variable is FC
36 observations used for estimation from 1986Q1 to 1994Q4

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
RAIN	1.2169	.25408	4.7895 [.000]
NDVST	.0003877	.0001713	2.2629 [.030]
RST	.0002085	.0005777	.36099 [.720]

R-Squared	.94568	F-statistic F (2, 33)	13.8792 [.000]
R-Bar-Squared	.92239	S.E. of Regression	21.6101
Residual Sum of Squares	15410.9	Mean of Dependent Variable	53.3333
S. D. of Dependent Variable	28.4725	Maximum of Log-likelihood	-160.1494

Diagnostic Tests

Test Statistics	LM Version	F Version
A : Serial Correlation	CHI-SQ (4) = 3.2859 [.511]	F (4, 29) = .72822 [.580]
B : Functional Form	CHI-SQ (1) = .052226 [.819]	F (1, 32) = .466490 [.831]
C : Normality	CHI-SQ (2) = 52.6133 [.000]	Not applicable
D : Heteroscedasticity	CHI-SQ (1) = .92952 [.335]	F (1, 34) = .90115 [.349]

A ; Lagrange multiplier test of residual serial correlation
B : Ramsey's RESET test using the square of the fitted values
C : Based on a test of skewness and kurtosis of residuals
D : Based on the regression of squared residuals on squared fitted values

This regression is a significant improvement over the first one. The regression states that for an increase of every inch in rainfall, the extent of pollution exceeding the limits increases by 1.2. The results show that both rain and visitors are related to ocean water pollution.

Impact and solution: Usually, an increase in population and industrial activities pollute the nearshore waters, as a result of the disposal of waste materials. Guam does not have polluting industries such as paper, chemical, steel and metal industries. However, pollution problems in Guam mainly occur from the disposal of waste materials (sewage discharge) from 150,000 residents and 1.3 million visitors (annually). Sewerage from broken sewer outfalls and litter that people throw on beaches are washed to the nearshore marine waters during the rains, polluting the water. The rain carries the pollution out into the ocean.

The loss in water quality and beach closures have a direct and indirect impact on Guam's small business. Direct loss is in the form of the tourist days on the beach, and reduction in beach vendor sales and beach rentals result in a revenue loss to concessionaires.

Indirect losses would be represented by negative impressions of tourists which are transferred to potential tourists in their home country, resulting in a loss of visitors.

Keeping beaches clean and protecting water quality will require effective action from the business community. Pollution is not a problem that can be solved at the government level alone. Protection of Guam's water resources will also require alert and concerned people on the island taking action.

7.5.2 Underground water pollution

Type of freshwater in Guam and aquifer yield: A fresh water aquifer is formed when fresh water, which is slightly less dense, floats above the sea water. Thus, the Northern Lens Aquifer of Guam is formed as precipitation percolates downward through the limestone, and forms a mound of less dense fresh water floating on sea water within the aquifer.

This type of fresh water, common to island and coastal areas, is termed a "Ghyben-Herzberg " lens, after the researchers who first studied it. Figure 7.1 illustrates this phenomenon. The transition between the fresh water and sea water at the base of the lens is not sharp. A mixing zone develops as a result of tidal fluctuations, seasonal fluctuations in precipitation, and pumping of groundwater.

The Northern Guam Lens Study (NGLS) groundwater modeling assumed an aquifer lens with a 12,000-ft radius, a lens height of 5.5 ft. and daily seepage to the sea of 100 ft per foot of shoreline. The modeling concluded that if no recharge occurred for six months, the water table would fall by approximately 0.5 ft because of natural seepage. If 15 million gallons per day (mgd) was removed by pumping, the head would fall approximately 0.06 ft.

Table 7.6 shows the estimated sustainable yield in each of the groundwater management zones in the basal and parabasal aquifers, respectively.

Aquifer quality in different regions: The groundwater chemistry on Guam is similar to that of greatly diluted sea water. The sea salts are picked up when precipitation intercepts the salt spray from the ocean. Salt spray is also deposited on the surface of the island and is picked up when rainfall strikes the surface. This water percolates through the porous limestone formations until it reaches the saturated zone. As the water migrates through the limestone, significant amounts of calcium and bicarbonate are added.

Along the lower limit of the fresh water lens, the concentration of sea salts increases. Groundwater linked in the parabasal section of the aquifer has a salinity of less than 30 mg/L chloride, whereas in groundwater in the basal portion of the aquifer (where it directly overlies sea water), chloride concentration commonly exceeds 70 mg/L. Groundwater in aquifers within the argillaceous limestone nearer the central portion of the island, has slightly higher salinity and hardness.

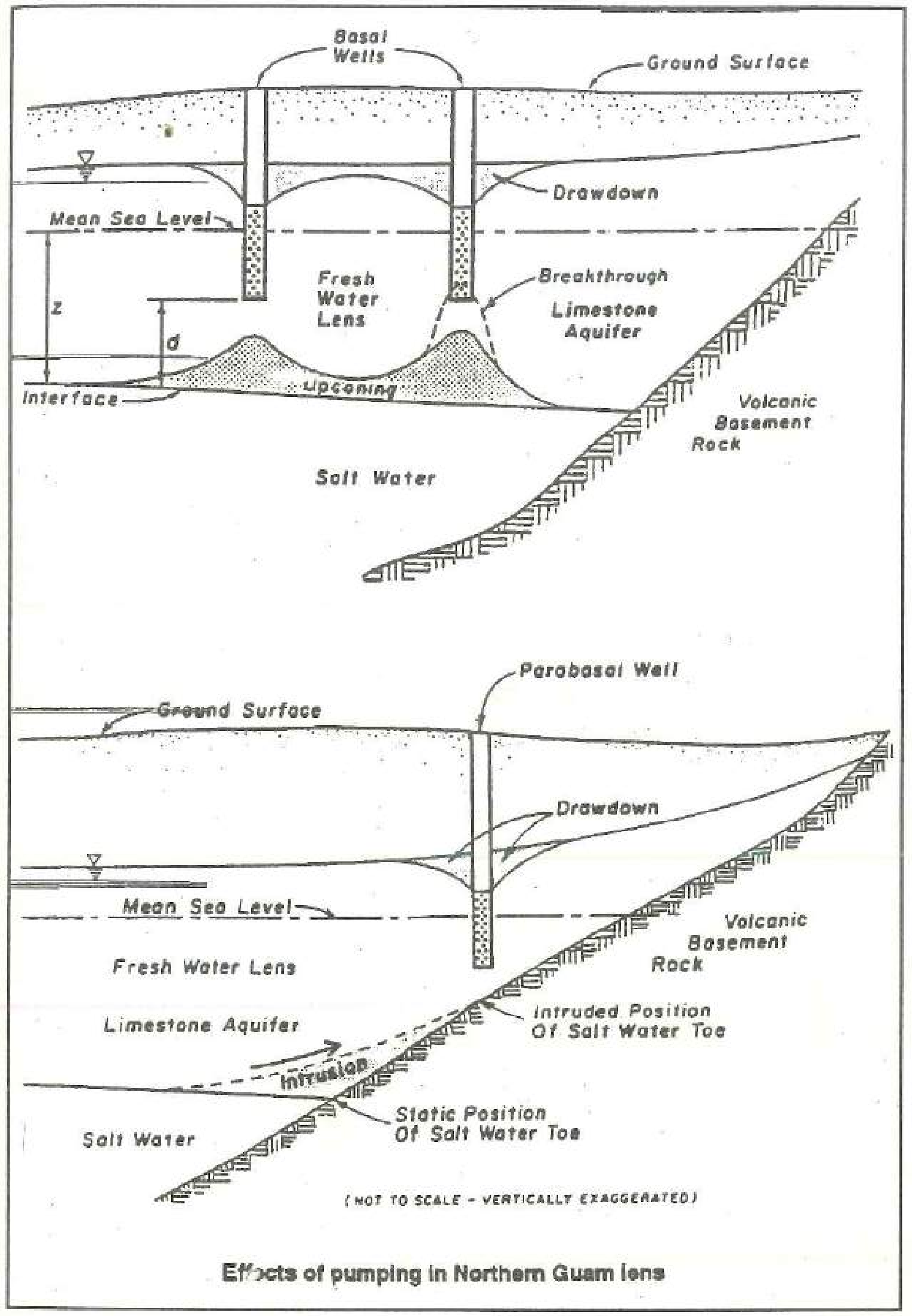


Figure 7.1 : Effects of pumping in Northern Guam lens

A survey of ten wells for priority pollutants was conducted in the 1980s by NGLS. Overall, the groundwater of northern Guam was found to be of excellent quality, usually free of pollutants. Several pollutants were detected, but only selenium in one well exceeded the US EPA maximum contaminant level. Although within acceptable limits (<10 mg/L), the concentration of nitrogen was 1-3 mg/L, approximately 5-10 times greater than typical groundwater.

Within Andersen AFB, a number of investigations have been conducted under the Installation Restoration Program (IRP) to determine the presence, extent and magnitude of contaminants in the sub-surface as a result of past activities. These investigations are continuing and some remedial efforts are in progress.

Chloride analysis: Chloride, in the form of chloride (Cl^-) anion, is one of the major inorganic anions in water and wastewater. In potable water, the salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water. Some waters containing 250 mg Cl^-/L may have a detectable salty taste if the cation is sodium. On the other hand, the typical salty taste may be absent in waters containing as much as 1000 mg/L when the predominant cations are calcium and magnesium.

Chloride may be present in high concentrations because of leakage of salt water into the sewage system. It also may be increased by industrial activities.

A high chloride content may harm metallic pipes and structures, as well as growing plants. Moreover, it may cause reactions with organic contaminants and lead to the formation of new dangerous compounds. The most frequently detected by-products of chlorination, the trihalomethanes, are associated with a wide array of subtle health side effects, such as fatigue, irritability, nausea, and irritation of the eyes, lungs, and skin, that could easily be attributed by medical personnel to many other causes.

The chloride "average level" data used were from test results of 84 wells. The data collected from the PUAG shows there was not much variation in the chloride level, which also fell far below the acceptable level (Table 7.4). While there are anomalous readings at different wells in different years, the well data circled tells a different story and suggests that the high level of chloride in the middle part of Guam displays an over-pumping problem.

Obviously, there is a need for further investigation. This problem, identified in our project, has been brought to the attention of the concerned agencies. To solve the problem, an island-wide survey has started.

This is only an environmental assessment exercise and not a national accounting exercise. It takes stock of the national environmental situation for a variety of resources ranging from air, land, ground water, marine water and the problems associated with them such as soil erosion or waste accumulation, based on future development scenarios.

It then tries to link key indicators which are critical for the environment in the future. Areas where caution will be needed are identified based on the expected growth or change of critical indicators. For a small island where activities are not extensive, this could be one way of preparing an environmental assessment.

Table 7.6: Status of groundwater management zones – parabasal aquifier zones

GW Zone No.	Groundwater Subbasin	Groundwater Management Zone	Total Yield (gpm)	Total Current Production (gpm)	Renaming Yield (gpm)	PUAG Wells Under Const. (gpm)
1	Agana	Pago Bay	310	0	310	0
2	Agana	Chalan Pago	860	1,190	-330	0
3	Agana	Nimitz Hill	2,510	1,544	966	966
4	Agana	Anigua	810	600	210	150
5	Agana	Mt. Barrigada South	210	150	60	0
6	Agana	Mt. Barrigada East	510	100	410	0
7	Mangilao	Mangiloa South	220	0	220	0
8	Mangilao	Mangilao North	290	696	-406	0
9	Mangilao	Adacao	660	125	535	0
10	Mangilao	Sabanan pagat	550	0	550	0
11	Mangilao	Janus	460	0	460	0
12	Andersen	Tarague	710	0	710	0
13	Andersen	Salisbury	1,980	0	1,980	0
14	Andersen	Lupog	1,015	0	1,015	0

15	Agafa Gumas	Agafa Gumas West	600	0	600	0
16	Agafa Gumas	Agafa Gumas Central	2,920	471	2,449	0
17	Agafa cumas	Agafa Gumas East	1,130	0	1,130	0
18	Finegayan	Callon Tranojo	660	410	250	0
19	Finegayan	Finegayan East	760	0	760	0
20	Finegayan	Potts	600	0	600	0
21	Yigo	Mt. Barrigada West	900	470	430	0
22	Yigo	Mogfog	450	0	450	0
23	Yigo	Marbo South	450	0	450	0
24	Yigo	Marbo North	240	0	240	0
25	Yigo	Yigo East	750	964	-214	0
26	Yigo	Mt. Santa Raus	530	0	530	0
27	Yigo	Mataguac	610	0	610	0
28	Yigo	Yigo West	1,320	610	710	0
29	Yigo	Ysengson	2,060	0	2,060	0
TOTAL PARABASAL			25,075	7,330	17,745	1,116
SUBBASIN TOTALS		Agana	5,210	3,584	1,626	1,116
		Mangilao	2,180	821	1,359	0
		Andersen	3,705	0	3,705	0
		Agafa Gumas	4,650	471	4,179	0
		Finegayan	2,020	410	1,610	0
		Yigo	7,310	2,044	5,266	0
30	Agana	Barrigada	260	183	99	0
31	Agana	Toto	430	50	380	0
32	Agana	Agana Swamp	870	0	870	0
33	Agana	Sabanan Maagas	1,200	1,391	-191	0
34	Agana	Manaca	1,150	0	1,150	0
35	Mangilao	Asbeco	230	0	230	0
36	Mangilao	Taguan	210	464	-254	0
37	Mangilao	Sasaijyan	90	0	90	0
38	Andersen	Anao	240	0	240	0
39	Andersen	Andersen	390	0	390	0

40	Agafa Gumas	N.w. Field East	2,360	0	2,360	0
41	Finegayan	N.w. field West	870	0	870	0
42	Finegayan	Finegayan West	440	1,085	-645	0
43	Finegayan	NCS	1,110	752	358	0
44	Yigo	Dededo North	1,340	1,098	242	0
45	Yigo	Mazcheche	870	253	617	0
46	Yigo	Macheche	870	253	617	0
47	Yigo	Asatdas	1,330	1,137	193	0
TOTAL BASAL			15,790	10,734	5,056	0
SUBBASIN TOTALS		Agana	3,910	1,624	2,286	0
		Mangilao	530	464	66	0
		Andersen	630	0	630	0
		Agafa Gumas	2,340	0	2,360	0
		Finegayan	2,460	1,837	583	0
		Yigo	5,940	6,809	-869	0

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ABOUT THE BOOK

How do we measure and value the degradation of air, water, forests and fishing resources? How does the abatement expenditure in general and loss in health, productivity and property / wealth in particular impact sustainable income? Starting from the system of national accounts (SNA), how does one incorporate and internalize environmental concerns in the context of developing countries' economies?

Volume I of this monograph explains how new challenges posed by environmental stress can be addressed using environmental economics and in particular, Integrated Economic and Environmental Accounting.

In Volume II, case studies for different countries in Asia are described. They were first presented at a seminar held at Seoul. The book contains an environmental assessment for India which is a low income, heavily-populated country with a large industrial base. After the overview of environmental problems, air quality accounts and solid waste management accounts are constructed. A local level case study of Mumbai city is also presented. Accounts of water quality for Korea, which has gone through rapid industrialisation contain interesting analysis. Asset accounts for forestry and fishery sectors of the Philippines, vital for the economy, give us an insight into the sustainable management of these two resources. Lastly, an environmental overview of Guam, which is an island country, is presented with reference to future development.