Policy Research

WORKING PAPERS

World Development Report

Office of the Vice President
Development Economics
The World Bank
August 1992
WPS 961

Background paper for World Development Report 1992

Economic Development and the Environment

Conflict or Complementarity?

Wilfred Beckerman

On the whole, there is a strong positive relationship between income level and environmental quality, and developing countries may be expected to improve environmental quality as their income rises. But new factors may change the usual pattern: new pollutants, cross-border environmental effects, "trade" in polluting activities, and the growth of automobile traffic. Consequently, developing countries are unlikely to replicate precisely the environmental histories of developed countries.

Policy Research Working Papers disseminate the findings of work in progress and encourage the exchange of ideas among Bank staff and all others interested in development issues. These papers, distributed by the Research Advisory Staff, carry the names of the authors, reflect only their views, and should be used and cited accordingly. The findings, interpretations, and conclusions are the authors' own. They should not be attributed to the World Bank, its Board of Directors, its management, or any of its member countries.

Policy Research

WORKING PAPERS

World Development Report

WPS 961

This paper — a product of the Office of the Vice President, Development Economics — is one in a series of background papers prepared for the *World Development Report 1992*. The *Report*, on development and the environment, discusses the possible effects of the expected dramatic growth in the world's population, industrial output, use of energy, and demand for food. Copies of this and other *World Development Report* background papers are available free from the World Bank, 1818 H Street, NW, Washington, DC 20433. Please contact the *World Development Report* office, room T7-101, extension 31393 (August 1992, 42 pages).

Although, in the course of development some features of the environment in developing countries may get worse, in the longer run they will be able to reverse trends in more common forms of air pollution and to attain levels of water supply and sanitation essential to an acceptable, healthy standard of living. On the whole, says Beckerman, there is a strong positive relationship between income level and environmental quality.

In the developed countries, effective measures to combat urban air pollution were introduced only when it had reached almost intolerable levels in many cities. This does not mean that as countries develop they will replicate precisely the environmental histories of developed countries. The path of environmental pollution in the developing world today will probably differ from that of the past in at least four respects:

- Changes in technology, relative prices, patterns of output, and policies mean that although traditional pollutants have been brought under control in many (mainly developed) countries, the world is faced with newer pollutants, or with "old" pollutants that, on account of their scale or accumulation, have acquired new significance.

- The global character of many pollutants is becoming more serious. Today, even leaving aside the issues of global warming and ozone depletion, there is evidence of serious regional environmental effects of acid rain and of marine or riverine pollution.

- "International trade" in polluting activities adds a relatively new element. Developing countries may suffer not only from their own pollution but also from "imported" pollution, as enterprises shift their more polluting activities from countries with strict controls to countries in which environmental considerations do not have a high priority.

- Today, the fast growth of automobile traffic means that emissions of carbon monoxide or nitrous oxides have become a serious problem; in the past, the chief form of urban pollution was dense sulfur dioxide, or smoke.

The Policy Research Working Paper Series disseminates the findings of work under way in the Bank. An objective of the series is to get these findings out quickly, even if presentations are less than fully polished. The findings, interpretations, and conclusions in these papers do not necessarily represent official Bank policy.

Produced by the Policy Research Dissemination Center

VII.4
11

ECONOMIC DEVELOPMENT AND THE ENVIRONMENT: CONFLICT OR COMPLEMENTARITY?

Wilfred Beckerman*
Balliol College
Oxford University

Prepared as a Background paper for the
World Development Report 1992

* In preparing this paper I have relied extensively on the generous co-operation and assistance of Andrew Steer and his colleagues on the 1992 WDR team and numerous other members of the Bank staff, and to Paul Gruenwald for invaluable assistance in preparing the diagrams and statistical annex.

CUC MOI TRUONG
MTL 77

The World Development Report 1992, "Development and the Environment," discusses the possible effects of the expected dramatic growth in the world's population, industrial output, use of energy, and demand for food. Under current practices, the result could be appalling environmental conditions in both urban and rural areas. The World Development Report presents an alternative, albeit more difficult, path - one that, if taken, would allow future generations to witness improved environmental conditions accompanied by rapid economic development and the virtual eradication of widespread poverty. Choosing this path will require that both industrial and developing countries seize the current moment of opportunity to reform policies, institutions, and aid programs. A two-fold strategy is required.

• First, take advantage of the positive links between economic efficiency, income growth, and protection of the environment. This calls for accelerating programs for reducing poverty, removing distortions that encourage the economically inefficient and environmentally damaging use of natural resources, clarifying property rights, expanding programs for education (especially for girls), family planning services, sanitation and clean water, and agricultural extension, credit and research.

• Second, break the negative links between economic activity and the environment. Certain targeted measures, described in the Report, can bring dramatic improvements in environmental quality at modest cost in investment and economic efficiency. To implement them will require overcoming the power of vested interests, building strong institutions, improving knowledge, encouraging participatory decisionmaking, and building a partnership of cooperation between industrial and developing countries.

Other World Development Report background papers in the Policy Research Working Paper series include:

Dennis Anderson, "Economic Growth and the Environment"

Dennis Anderson and William Cavendish, "Efficiency and Substitution in Pollution Abatement: Simulation Studies in Three Sectors"

William Ascher, "Coping with the Disappointing Rates of Return of Development Projects with Environmental Aspects"

Edward B. Barbier and Joanne C. Burgess, "Agricultural Pricing and Environmental Degradation"

Robin W. Bates and Edwin A. Moore, "Commercial Energy Efficiency and the Environment"

Wilfred Beckerman, "Economic Development and the Environment: Conflict or Complementarity?"

Richard E. Bilsborrow, "Rural Poverty, Migration, and the Environment in Developing Countries: Three Case Studies"

Charles R. Blitzer, R.S. Eckaus, Supriya Lahiri, and Alexander Meeraus,
(a) "Growth and Welfare Losses from Carbon Emission Restrictions: A General Equilibrium Analysis for Egypt";
(b) "The Effects of Restrictions of Carbon Dixide and Methane Emissions on the Indian Economy"

Judith M. Dean, "Trade and the Environment: A Survey of the Literature"

Behrouz Guerami, "Prospects for Coal and Clean Coal Technology"

David O. Hall, "Biomass"

Ravi Kanbur, "Heterogeneity, Distribution and Cooperation in Common Property Resource Management"

Arik Levinson and Sudhir Shetty, "Efficient Environment Regulation: Case Studies of Urban Air Pollution"

Robert E.B. Lucas, David Wheeler, and Hemamala Hettige, "Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1960-1988"

Robert E.B. Lucas, "Toxic Releases by Manufacturing: World Patterns and Trade Policies"

Ashoka Mody and Robert Evenson, "Innovation and Diffusion of Environmentally Responsive Technologies"

David Pearce, "Economic Valuation and the Natural World"

Nemat Shafik and Sushenjit Bandyopadhyay, "Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence"

Anwar Shah and Bjorn Larsen,
(a) "Carbon Taxes, the Greenhouse Effect, and Developing Countries";
(b) "World Energy Subsidies and Global Carbon Emissions"

Margaret E. Slade,
(a) "Environmental Costs of Natural Resource Commodities: Magnitude and Incidence";
(b) "Do Markets Underprice Natural Resouce Commodities?"

Piritta Sorsa, "The Environment - A New Challenge to GATT?"

Sheila Webb and Associates, "Waterborne Diseases in Peru"

Background papers in the World Bank's Discussion Paper series include:

Shelton H. Davis, "Indigenous Views of Land and the Environment"

John B. Homer, "Natural Gas in Developing Countries: Evaluating the Benefits to the Environment"

Stephen Mink, "Poverty, Population and the Environment"

Theodore Panayotou, "Policy Options for Controlling Urban and Industrial Pollution"

Other (unpublished) papers in the series are available direct from the World Development Report Office, room T7-101, extension 31393. For a complete list of titles, consult pages 182-3 of the World Development Report. The World Development Report was prepared by a team led by Andrew Steer; the background papers were edited by Will Wade-Gery.

Table of Contents

I. Introduction 1

II. The Overall Situation 1

III. Income Levels and Environmental Quality 7

IV. The Role of Policy 20

V. Conclusions 21

Annex 1 Limitations on Indicators of Water and Air Pollution 23
Annex 2 Sustainability or Optimality? 26
Annex 3 Statistical Tables 31

I. INTRODUCTION

This paper is concerned mainly, but not exclusively, with the relationship between, on the one hand, economic growth or development (interpreted here to mean the growth of incomes per head) and, on the other hand, two environmental media, namely local air quality and access to drinking water and sanitation. This does not mean that other ingredients of the environment, such as biodiversity, soil erosion, deforestation, or global pollutants - whether of the air or the waters - are thought to be less important. It is simply that the data difficulties are severe enough even for the media selected, and the difficulties of identifying any generally agreed clear picture appeared to be too formidable to be tackled in the time available.

This paper does not consider pollutants that contribute to climate change or the depletion of the ozone layer. Although these problems may be very important in some respects, they are of little concern to most people in developing countries, where the main environmental problems are water and/or the various manifestations of urban degradation.[1] Nor does this paper examine the alleged threat that continued economic growth will lead to the exhaustion of supplies of minerals, although Annex 2 contains a brief note on this. Finally, this paper does not specifically address the problem of "sustainability", which has become very popular lately, although this too is briefly touched on in Annex 2.

II. THE OVERALL SITUATION

(a) Limitations on environmental data

Statistics of any kind - whether of births, deaths, air pollution or expenditures on food - are usually produced for particular national or local administrative purposes of one kind or another, and not for the benefit of outside analysts to use in estimating the relationship between one or other of the data series and, for example, the tax rate or human welfare or the overall state of the environment. Systematic and regular data collection is an expensive and skill-intensive activity; there is no reason why even rich countries should devote resources to this activity except when necessary for some particular purpose. Hence, it is unsurprising that many of the data needed to draw up a statistically precise picture of how the environment vary from one country to another, or of how it has changed over time, are not available, particularly in developing countries. Such environmental data as are available are subject to numerous conceptual and practical limitations.[2] But, whatever the margin of error and problems of interpretation involved, and without subscribing blindly to the doctrine that "any figure is better than no figure", it is possible to identity the inadequacies of water supply and sanitation and the levels of urban air pollution

---

[1] My views on global warming have been set out in "Global Warming: A Sceptical Economic Assessment" in Helm, D. (ed.) Economic Policy Towards the Environment, Blackwells, Oxford, 1991, and in "Global Warming and International Action: An Economic Appraisal", in Hurrell, A. and Kingsbury, B. The International Politics of the Environment, Oxford University Press, 1992.

[2] These are discussed in more detail in Annex 1.

in developing countries as a whole.[3]

(b) Water supply, sanitation, and health.

Although data deficiencies prohibit precise calculations, it is possible to obtain some idea of the overall situation, particularly as regards access to safe drinking water and reasonable sanitation arrangements. Three points can be firmly established.

First, water supply and sanitation is still a major problem, with at least 1 billion people in developing countries not having access to safe drinking water, and at least 2 billion having no access to satisfactory sanitation.[4] Other estimates, notably those shown in Table 1 below, put the numbers without safe drinking water or sanitation much higher. Second, although during the 1980s water supply was provided for about an extra 730 million people in developing countries, and sanitation for about an extra 400 million, these increases barely kept pace with population growth. Indeed, taking rural areas into account, the number of people without satisfactory sanitation in developing countries rose by about 400 million in the 1980s. Given the expected future growth of population, it is expected that by the year 2000 there could still be well over a billion people without adequate water supply and more than double that without sanitation, chiefly in Africa and Asia.[5] Third, since the rise in population was fastest in urban areas, it is there that absolute numbers of people lacking water supply or sanitation has risen most. During the 1980s, roughly an extra 90 million were without access to safe drinking water in urban areas and an extra 210 million were without satisfactory sanitation.[6]

The severity of the water supply problem in developing countries is not fully represented by aggregate figures. As with any good or service, poorer members of the community have less access to safe drinking water or sanitation than richer members. Thus, in Peru, although only about 78% of the top quintile (in terms of overall consumption expenditures) enjoys access to an indoor supply of drinking water, this is almost four times as great as the corresponding proportion of people in the bottom quintile.

---

[3] The fallacy of the doctrine of "any figure is better than no figure" is illustrated by the story of the man who, after the great San Francisco earthquake, was arrested for peddling "anti-earthquake" pills. Accused by the judge of fraudulent behavior, he conceeded the pills were of no use but asked whether the judge knew of anything better.

[4] These are the estimates contained in Global Consultation on Safe Water and Sanitation for the 1990s, which, as indicated below, were published in 1990 and were lower than other World Bank estimates published in 1988, both for 1980 and for projections to 1990.

[5] Global Consultation on Safe Water and Sanitation for the 1990s, Background paper to Sept. 1990 New Delhi conference of same name sponsored by UNDP and other organizations, and prepared by Secretariat to the conference, page 5. Estimates from this document have to be based on the charts contained therein and so are about as rough as the basic reliability of the data justify. The projections quoted above for numbers without access to safe drinking water or satisfactory sanitation in the year 2000 are lower than those made in the World Bank FY Annual Sector Review Water Supply and Sanitation, Nov. 1988, Annex 1.

[6] Alternative estimates shown below suggest that absolute levels of deprivation are even greater than these figures indicate. Statistical imprecision, however, does not alter the conclusions concerning either the scale of the problem or the failure of the increase in supply of both drinking water and sanitation to do more than keep pace with the population increase, particularly in urban areas.

TABLE 1 POPULATION WITH AND WITHOUT WATER SUPPLY AND SANITATION, IN DEVELOPING COUNTRIES, 1980 AND 1990 (millions or percentages)

	1980	1990	Increase % p.a.[a]	Increase millions
Population				
urban	990	1450	3.8	460
rural	2380	2610	0.9	230
TOTAL	3370	4060	1.9	690
Served				
urban				
Water supply	610	980	4.8	370
Sanitation	300	550	6.2	250
rural				
Water supply	740	1100	2.4	360
Sanitation	240	390	5.1	150
Unserved				
urban				
Water supply	380	470	2.1	90
Sanitation	690	900	2.6	210
rural				
Water supply	1640	1510	- 0.8	-130
Sanitation	2140	2220	0.4	80
Total served				
Water supply	1350	2080	4.4	730
Sanitation	540	940	5.7	400
Total unserved				
Water supply	2020	1980	-0.2	-40
Sanitation	2830	3120	1.0	290

(a) percentage annual average rate of change; estimated from unrounded figures.

Source: The World Bank, FY88 Annual Sector Review Water Supply and Sanitation, Nov. 1988, Annex 1.

TABLE 2 INSIDE SUPPLY OF DRINKING WATER BY INCOME GROUP IN FOUR DEVELOPING COUNTRIES[a] (percent of households having access to inside supply)

	Bottom quintile	Top quintile	All incomes
Peru	26.4	77.7	51.5
Ghana	2.0	23.6	5.5
Côte d'Ivoire:			
Abidjan	(29.0)	..	46.9
Other Urban	(16.0)	..	21.7
Dominican Republic[a]	6.5	38.4	23.2

(a) Data relate to bottom and top quartiles.

Sources: Paul Glewwe The Distribution of Welfare in Peru in 1985-86, World Bank Living Standards Measurement Study, 1987, Table 8, page 26; and The Distribution of Welfare in the Côte d'Ivoire, Table 27, page 51; and Republic of Ghana Statistical Service Ghana Living Standards Survey Table 38, page 75; and World Bank data.

In Ghana the ratio is estimated to be about ten to one. The data on water quality are even more fragmentary than the data on water access. Observations on the basic characteristics of surface water quality, notably dissolved oxygen and biochemical oxygen demand (BOD and DO) are available for many surface water sources at specific locations in developed countries, and time trends are discussed in III (b) below. But inter-country comparisons of surface water quality make very little sense, and there is no evidence for its being any worse in developing countries than in developed countries, though, of course, the consequences for the former - particularly in arid areas where few alternative water supplies are available - could be much more serious. The same applies, on the whole, to groundwater, which makes up a large proportion of total water supplies.

Despite much uncertainty about the precise relationship between water supplies and health, the serious welfare effects on developing countries of inadequate water and/or sanitation supplies are indisputable. For example, it appears that about one to one and a half billion people are affected by water-related diseases in some form - notably schistosomiasis, hookworm, diarrhea, ascariasis, guinea worm and trachoma.[7] Infant mortality caused solely by diarrhea, which is strongly related to water supply and sanitation quality, is reckoned to be about 5 million per annum.[8] For example, in Algeria, where the relationship between water-related disease and the degradation of water supplies is well documented, about one third of all infant deaths are attributed to diarrhea. In fact, in the areas most affected by worsening water supplies, water-related diseases account for about three quarters of all reported sickness.[9] In Pakistan, nearly half of all infant deaths are attributed to the same cause. Moreover, it is not only children who are at severe risk as a result of diarrhea. For example, in Bangladesh, diarrheal diseases account for about one in five deaths in all age groups over five years.[10]

It is true that the relationship between the diseases concerned and water supply is far from simple and numerous other variables are usually implicated. It is well known, for example, that personal and domestic hygiene, access to health care, and other factors - above all adequate nutrition - all influence the vulnerability of any group to diseases associated with water supply quality. On the other hand, the above estimates probably under-state the true incidence of disease since hardly any countries in the world have any incentive to institute large scale reporting systems for morbidity. There is no doubt a large amount of disease that goes unreported and unidentified by any survey.

Whilst adequate supplies of clean drinking water or of water suitable for sanitation purposes is not always a sufficient condition for immunity to water-related diseases, it is almost certainly a necessary condition in most situations.[11]

---

[7] World Bank data; a breakdown by disease is given in Esrey, S.S., Potash, J.B., Roberts, L. and Shiff, C., WASH Technical Report No. 66, July 1990, (report prepared for the Office of Health, Bureau for Science and Technology, U.S. Agency for International Development, Washington D.C.) page vii, but no total is shown. Presumably there is considerable overlap in that people suffering from one of the diseases are also likely to be suffering from one or more of the others.

[8] This estimate refers to mortality among children below five years of age. See Esrey et al. ibid., and Snyder, J.D. and Merson, M.H. "The magnitude of the global problem of acute diarrhoeal disease:a review of active surveillance data", Bulletin of the World Health Organization 1982, Vol. 60, pp 605-613.

[9] World Bank staff estimate.

[10] Aziz, K.M.A. et al. Water supply, sanitation and hygiene education, Report of a Health Impact Study in Mirzapur, Bangladesh, UNDP-World Bank Water and Sanitation Program, 1990, page 10.

[11] For example, see Aziz et al. ibid pages xii - xiii. Of course, the WASH survey quoted above is based on a survey of over a hundred detailed studies, many of which found results similar to those being quoted here.

(c) Air pollution

Similar conclusions can be drawn about air quality in developing countries. As is shown in a later section, the combination of industrialization - often without the benefit of the latest pollution reduction technologies - and rapid urbanization - often accompanied by dramatic increases in urban motorized transport - has led to acute air pollution problems in many cities. One of the best known cases is Sao Paulo, where, by the early 1970s, air pollution had become so severe that there were noticeable increases in mortality. Even worse air pollution was experienced in Cubatao, on account of a combination of the mix of industries located there and unfavorable meteorological conditions.[12]

An aspect of air pollution that is less widely known is the severity of indoor air pollution in rural areas in many developing countries. This is associated with the extremely pollution-intensive character of traditional cooking and heating techniques (notably reliance on biomass fuels), and is believed to be partly responsible for the fact that over 5 million children die every year from acute respiratory illness that is most prevalent in rural areas of developing countries.[13] This is about the same number of children who die every year from diarrhea caused in part by inadequate water and sanitation services.

Ideally, a welfare measure of air pollution should take account of the number of people exposed to it (and also of the duration of their exposure). A foul smell on some totally isolated and uninhabited island caused by rotting vegetation would have no welfare significance at all. Like sin, pollution requires victims.[14] The need to take account of human exposure to given air quality conditions, has given rise to the recently developed concept of "total exposure assessment", or TEA, in which an attempt is made to take account of the numbers of people actually exposed to the air pollution conditions described by the various indicators.[15] Of course, such an exercise is fraught with many difficulties, but some attempts to measure exposure have been made, notably by GEMS and by Kirk R. Smith.[16]

Once one tries to allow for the degree of human exposure to air pollution, account has to be taken of indoor air pollution, partly because in certain circumstances this is often far worse than outdoor air pollution and partly because most people spend much of their time indoors. In more developed countries, important indoor pollutants include NO_2 from certain types of gas appliances and cooking stoves, volatile organics from various furnishings and household cleaning products, and other pollutants often introduced or aggravated by air conditioning, ventilation, or modern heating systems. In developing countries, far

---

[12] World Bank Operations Evaluation Department, Approaches to the Environment in Brazil: A Review of Selected Projects April, 1992, Vol II, "Pollution Control."

[13] See Kirk R. Smith Biofuels, Air Pollution, and Health, Plenum Press, New York and London, Foreword by John D. Spengler, page vii.

[14] One of the members of the Royal Commission on Environmental Pollution, of which I was a member from 1970 to 1973, who was a Bishop, disputed my view that, since it required victims, sin could not exist in isolation, from which I deduced that Bishops have more imagination than I do.

[15] See general discussion of the concept in GEMS Estimating human exposure to air pollutants, WHO Offset Publication No. 69, 1982 . and a particular discussion of it in relation to estimates of air pollution in the USA in Environment, Vol. 30, October, 1988.

[16] See the estimates of population exposures for the different major air pollutants in GEMS Assessment of Urban Air Quality, op. cit. 1988, and Kirk R.Smith "Air Pollution: Assessing Total Exposure in Developing Countries", Environment, Vol. 30, No. 10., Dec. 1988.

more serious air pollution of a more conventional kind is produced by primitive use of biomass - wood, agricultural waste, or dung - for cooking and heating. For example, whereas indoor concentrations of SPMs in industrialized countries are, on average, well below WHO guidelines, in developing countries, they are several times the recommended levels.[17]

If "total exposure assessment" is combined with estimates of indoor air pollution characteristic of different major population groups, as has been done in a recent study by Kirk Smith, one finds that the vast majority of air pollution measurements take effect in areas where less than 2 percent of total global person-hours are spent, namely urban outdoor areas in industrialized countries. Of course, this partly just reflects the fact that "developing" countries have been defined in such a way that they include about 75 percent of the world's population.[18] But even they say little about comparative air pollution per head, these figures, allowing for the number of heads affected, do indicate which pollutants are important in the world. Furthermore levels of indoor pollution per head in developing countries - particularly for SPM - are generally far higher than in developed countries. Hence, inhabitants of developing countries account for about 88 percent of total human exposure to SPM, or over seven times that accounted for by developed country populations. Of course, for many reasons, this allocation to countries at different stages of development of total rural exposure to air pollution levels, is very approximate. But whether total human exposure to SPM in developing countries is seven times as great as in developed countries, as the following table suggests, or five times or nine times, is of relatively little significance compared to the disparity's even rough order of magnitude.[19]

Indeed, as shown in III (c) below, outdoor air pollution in developing countries tends to be either worse or increasing or both, whereas in developed countries it is usually either better or at least decreasing or both. If allowance is also made for the difference between indoor air pollution in developing and developed countries, then it follows that:

> For some important pollutants, urban ambient air pollution appears to be inversely related to income. In other words, poorer cities have more air pollution, in part because of the coexistence of modern and traditional pollution sources, i.e. household and neighborhood use of dirty solid fuels such as wood and coal combined with high-emission industrial and vehicular sources. This interaction exemplifies "risk overlap", which can occur during

[17] GEMS ibid. 1988, table 3, page 86.

[18] The definition of "developing countries" is, of course, arbitrary. The World Bank has tended to classify countries into "low income" and "middle income" groups, as those groups comprising countries with annual per capita income levels in 1989 at or below $580, and between $580 and $6000 respectively, and "developing countries" is often defined as comprising these two groups - i.e. countries in which the annual average per capita income is less than $6,000.(See World Development Report 1991 draft of April 1991, page xv). On this basis the population of developing countries in 1989 was estimated to be 3,800 million out of a total world population of 4,931 million (The World Bank Social Indicators of Development 1990, Johns Hopkins University Press, Baltimore and London, 1991, page xiv).

[19] The full scientific evidence behind the estimates of the relative pollution effects of alternative activities, notably cooking methods in developed and developing countries is contained in Kirk R. Smith Biofuels, Air Pollution, and Health, Plenum Press, New York and London, 1987.

the transition from traditional to modern risk that is inherent to economic development.[20]

TABLE 3 APPROXIMATE PERCENTAGE DISTRIBUTION OF TOTAL GLOBAL POPULATION EXPOSURE TO PARTICULATE AIR POLLUTION (percentages)

	Developed Countries		Developing Countries	
	Outdoor	Indoor	Outdoor	Indoor
Rural	0.1	2.0	5.4	49.1
Urban	0.8	9.3	3.3	30.0
TOTAL	0.9	11.3	8.7	79.1

Source: Kirk R. Smith "Air Pollution: Assessing Total Exposure in Developing Countries", Environment, Vol. 30 No. 10, Dec. 1988. The estimates shown above are obtained by expressing, as percentages of the total, the products of the cells in Tables 2 and 3 in this source. They correspond to the results shown graphically in Figure 3 of the source.

In other words, at an early stage in their development, cities in some countries may get the worst of both worlds. On the one hand, their old-fashioned machinery, techniques and industrial structures make them highly pollution intensive and, on the other, economic growth brings with it newer forms of pollution - particularly those associated with the automobile, urban congestion and waste disposal - before they have adequately reduced their exposure to more traditional pollutants. Nevertheless, as shown in III below, a negative relationship between income level and urban air pollution can be identified.

III. INCOME LEVELS AND ENVIRONMENTAL QUALITY

(a) The general relationship

The prima facie reasons for expecting economic growth generally to be good for the environment, while being bad for it in specific instances and particular time periods, hardly need elaboration. A casual glance at the state of the environment in the major towns and cities of the world shows that the environment that matters most to human beings - access to water and sanitation, housing, social infrastructure and traditional types of air pollution such as SO_2 and smoke - is far better in richer than in poorer countries. As people get richer, their priorities change and the environment moves up in the hierarchy of human needs. When basic needs for food, water, clothing and shelter are satisfied, then people can begin to attach importance to other ingredients in total welfare, including, eventually, the environment. As public perceptions and concerns move in the environmental direction, so communities will be more willing to allocate resources to this end. Further, this shift in expenditure priorities is easier insofar as richer countries will be more able to afford them.

For example, United States' public and private expenditures on pollution abatement and control ("PAC" expenditures) represent nearly 2 percent of US GNP, which is a higher share than that shown for any other country for which comparative data are available. Moreover, that share is still rising, as it also is in the two other major countries for which comparable data are available, namely Germany and

[20] Kirk R. Smith ibid. p. 18-19 and, for a more extended analysis of the same theme, the same author's "The Risk Transition" in International Environmental Affairs, Vol.2, No. 3, Summer 1990.

Japan.[21] The pattern of output in developed countries has also been changing in a direction that tends to impose less of an environmental burden than was the case earlier in their development. At higher levels of income, industry accounts for a smaller share of GDP, while services, which are relatively non-polluting, account for an increasing share. Furthermore, within industry there has tended to be a shift away from the highly polluting heavy industries, including metallurgy and heavy engineering, towards high-tech, high value-added industries, employing large amounts of very skilled human capital and with smaller inputs of energy or raw materials.[22]

On the other hand, in some cases the retreat of older pollutants has been accompanied, or followed, by the advance of new pollutants, including pesticides and fertilizers from agricultural activities, heavy metals and acidic and alkaline compounds in various manufacturing processes, and the growth of plastics and petrochemical products in many industrial and household activities. For example, in Sao Paulo, where considerable progress has been made in improving water supply (so that by 1988 90% of dwellings had water connections and about 60% were connected to sewers), newer pollutants, such as lead, cadmium and nickel, are beginning to pose a threat to water supplies.[23] Similar developments have been documented in Thailand.[24]

Nevertheless, although data do not permit international comparisons of the impact of newer pollutants, as far as the more traditional and ubiquitous pollutants are concerned, the data presented below generally demonstrate: first, that higher incomes are associated with better environments; and second, that poverty exacerbates environmental degradation, often in respect of environmental media not covered in this paper.

(b) Water

Figure 1 below shows the percentage of the population with access to safe drinking water in countries with different income levels, in 1975 and 1985.[25] Unsurprisingly, higher incomes tend to be

---

[21] OECD Pollution Abatement and Control Expenditure in OECD Member Countries, Paris, Nov. 1990; Table 2, page 40, and Kit D.Farber and Gary Rutledge "Pollution Abatement and Control Expenditures, 1984-87", Survey of Current Business, June, 1989, p. 19-23.

[22] Gordon Hughes argues, in "Are the Costs of Cleaning up Eastern Europe Exaggerated?", (draft of paper for the World Bank and the Commission of the European Communities, Nov. 1990, page ii), that insofar as Eastern European economies develop along the lines of the currently advanced Western economies their pollution intensities, and possibly levels, will decline precisely on account of this shift in economic structure that seems to characterize economic growth in almost all countries of the world.

[23] The World Bank Brazil: The new Challenge of Adult Health, A World Bank Country Study, 1990, page 38.

[24] See Phanu Kritiporn, Theodore Panayotou, and Krerkpong Charnprateep, Industrialization and Environmental Quality: Paying the Price, Thailand Development Research Institute (TDRI) 1990 Year-End Conference, Synthesis Paper No. 3, Dec. 1990, p.12.

[25] For the reasons given in Annex 1 figures for individual countries are not strictly comparable. Thus, a more reasonable picture of the income/water supply relationship is provided by grouping countries into broad income bands.

associated with a higher proportion of the population having access to safe drinking water[26]. There has

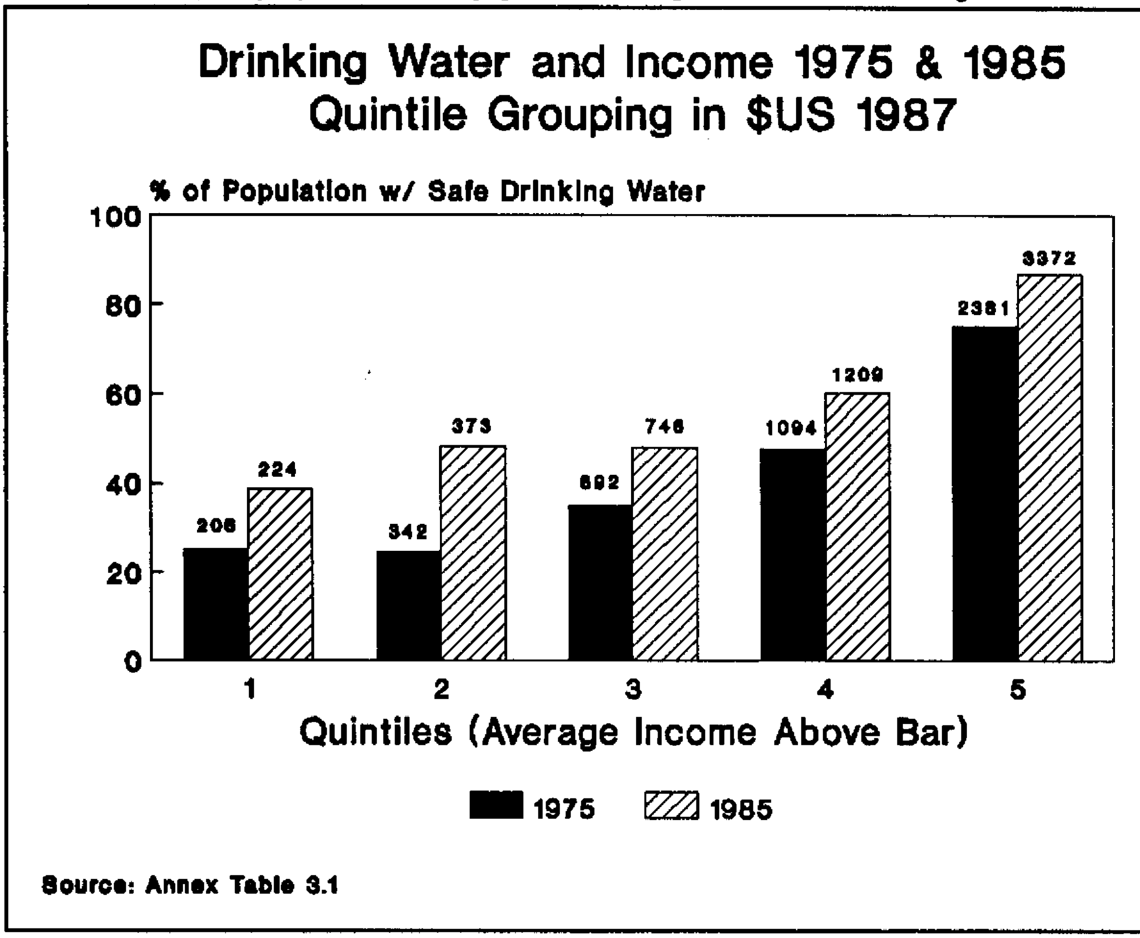

Figure 1 Drinking Water and Income, 1975 and 1985

also been some progress in almost all countries over the period 1975 to 1985, in spite of the rapid growth of the population of most developing countries during this period. It can be seen that a much higher percentage of the population has access to safe drinking water in the top two quintiles, and that in all quintiles, the rise in incomes between 1975 and 1985 was accompanied by a rise in this percentage.

Although satisfactory sewerage and sanitation arrangements are more difficult to define and hence to represent in a simple number, Figure 2 below also confirms expectations - an increase in incomes is the best way of increasing access to the sanitation facilities that most people in developed countries take for granted as normal attributes of a minimum standard of living. Of course, in many countries, the pace of urbanization has meant that sanitation and waste disposal arrangements have been totally unable to cope with the additional demand, and consequently services have not reached levels normally associated with even medium income level countries. For example, even in Thailand, where the growth of prosperity has been remarkably sustained, it is estimated that in Bangkok only 2% of the population is connected to sewers.[27]

[26] Similar correlations between income and water supplies is shown in the UN Economic and Social Commission for Asia and the Pacific, State of the Environment in Asia and the Pacific, Vol. 2.

[27] World Bank staff estimate.

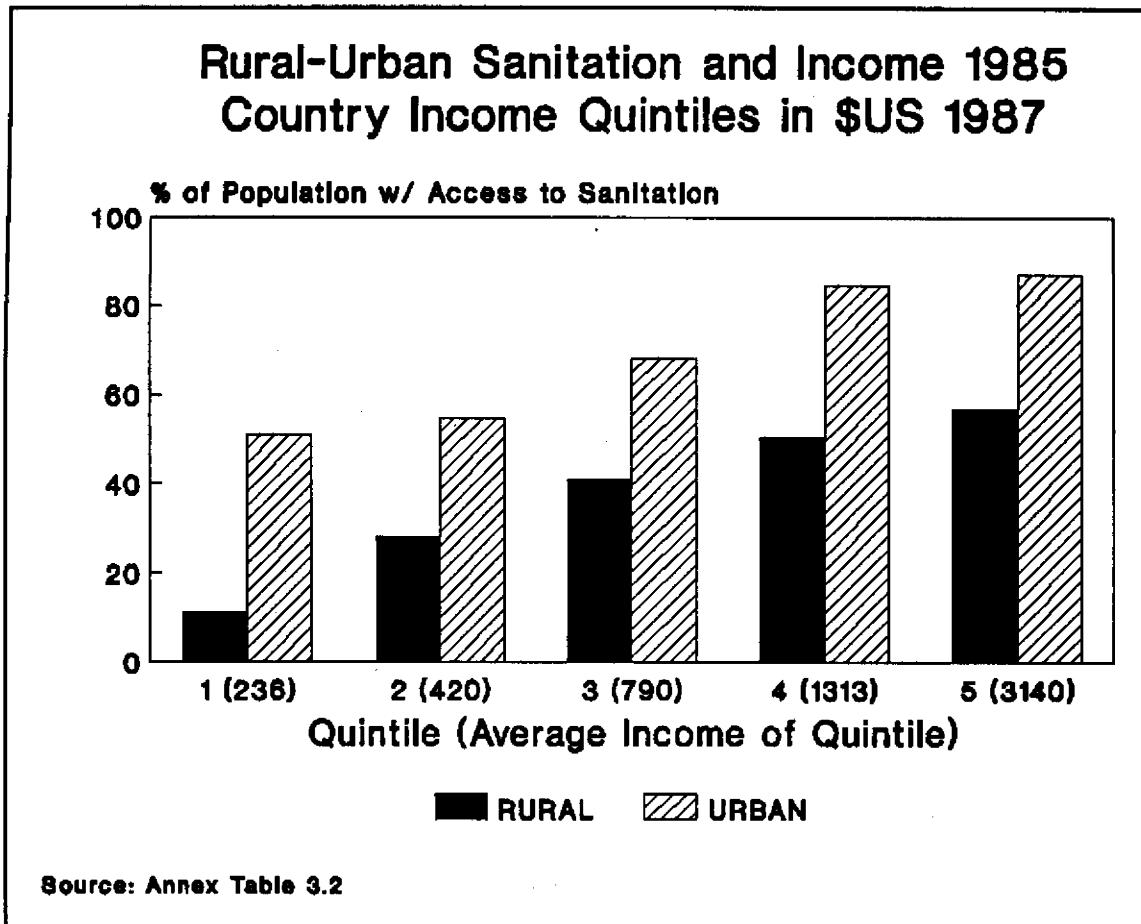

Figure 2 Rural-Urban Sanitation and Income 1985

(c) Air.

(i) SO_2

Figure 3 below shows that in the late 1970s ambient concentrations of SO_2 in the atmosphere were greater the higher the income band. But by the end of the period covered (usually mid or late 1980s), the position had been reversed. As can be seen in the right hand side of the diagram, this corresponded to a decline in SO_2 concentrations of about 8.9% per annum in high income countries and a rise of about 3.7% in low income countries. Taking all the 33 cities covered in the GEMS data on SO_2 ambient air quality, "...27 have downward (at least 3% per year) or stationary trends and 6 have upward trends (at least 3% per year) with most improvements noted in cities of developed countries".[28]

(ii) SPM or smoke

Similarly, for concentrations of suspended particulate matter or smoke, of the 37 cities covered in the GEMS data, 19 showed downward trends, 12 were more or less stationary and only 6 had upward trends. Indeed, measured by the number of days on which the WHO guidelines for SPM or smoke were exceeded during the course of the year, the preponderance of cities in developing countries is

[28] UNEP and WHO GEMS Assessment of Urban Air Quality, 1988, page 15.

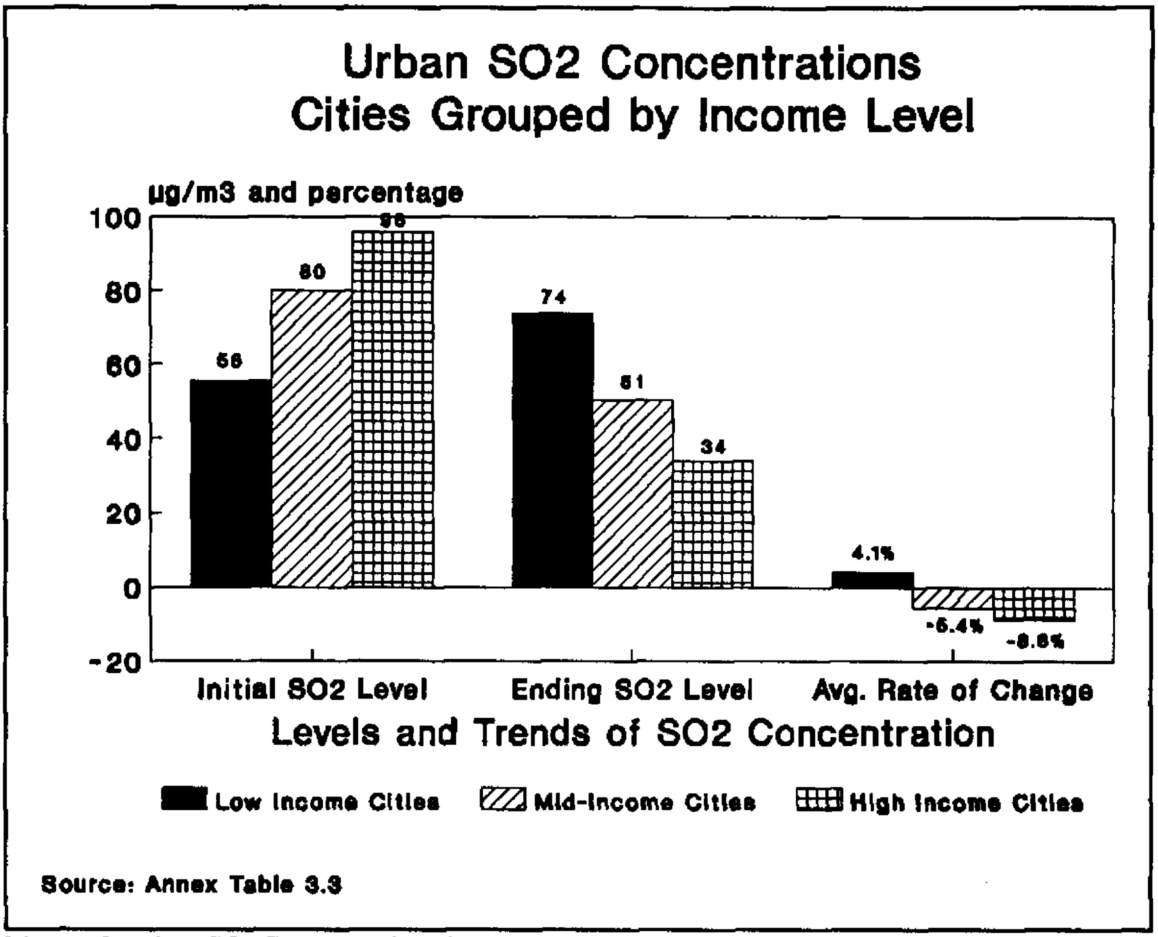

Figure 3 Urban SO_2 Concentrations by Income Group by Country in which Cities Located

overwhelming.[29] For those cities for which adequate data are available, the following diagram shows that cities in low income countries had ambient concentrations of SPM or smoke that were much higher than those in richer countries. Again, it is in richer countries that SPM concentrations have fallen.

(iii) <u>NO_x and CO</u>

For two other pollutants, carbon monoxide (CO) and nitrous oxides (NO_xs), the picture is slightly more confused, since emissions of these, and particularly CO, are heavily influenced by the automobile -

[29] The six worst cities, taking the average of 1980-84, in the GEMS ranking, were Teheran, Shenyang, Calcutta, Beijing, Xian and New Delhi, with Bombay, Kuala Lampur and Bangkok not far behind. In these cities SPM and smoke levels exceeded 230 $\mu g/m^3$ (this being the WHO guideline for the 98th percentile - i.e. exposure level that should not be exceeded more than 2 percent of the time, or 7 days a year) for anything between 200 days and 300 days per year. (UNEP/WHO <u>Assessment of Urban Air Quality</u>, op.cit. Figure 4.9 page 33).

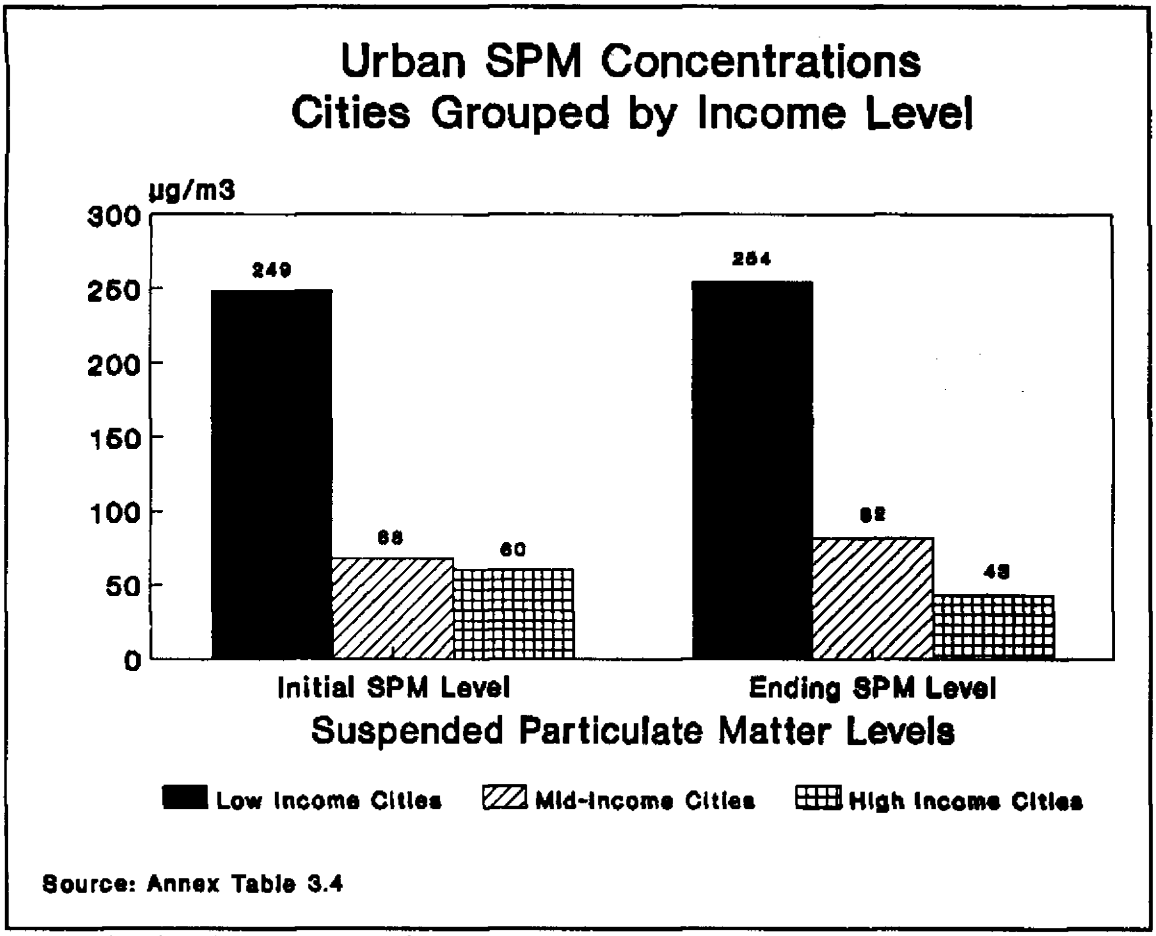

Figure 4 Urban SPM Concentrations by Income Group

both in terms of numbers and the speed of circulation.[30] Furthermore, the limitations on inter-city comparability of measures of these pollutants are particularly severe. Hence, in terms of ambient air concentrations of, for example, NO_xs, "cities of the developing and developed countries are found at both ends of the concentration range ... some of the lowest NO_2 values are reported from the two Indian cities, Bombay and New Delhi, presumably because traffic levels are relatively low".[31]

Nevertheless, some overall difference can be observed between poor and rich country cities. For example, although there are some exceptions - notably London, Frankfurt and Amsterdam - trends in ambient NO_2 concentrations in most other developed countries' cities are now stable or declining, in spite of sustained increases in automobile numbers. By contrast, although data are scarce, it appears that

[30] Up to a point the emission of pollutants from automobiles falls off rapidly as its speed increases, so that a major cause of urban air pollution from automobiles is traffic congestion. See Asif Faiz, Kumares Sinha, Michael Walsh, and Amiy Varma, Automotive Air Pollution, Policy, Research and External Affairs, World Bank Working Papers, Transport, WPS 492, Aug. 1990, Tables 19, 20, and 21, pages 42,43, and 46.

[31] GEMS Assessment of Urban Air Quality, op.cit. page 44.

trends are generally rising in cities in developing countries.[32] The picture is roughly the same for CO ambient concentrations. Data are only available for cities in eleven countries and CO concentrations are declining in all of them. With one exception - Santiago - the cities are all in high income countries. By contrast, as shown in the next section, fragmentary data on a few individual cities in developing countries confirm the rise in concentrations of these pollutants.

(iv) Lead

Another important pollutant from mobile sources has been lead. Relatively accurate indicators are available of the amounts of lead in gasoline in individual countries, and it can be seen that in recent years almost all industrialized countries have taken effective measures of one kind or another to reduce lead emissions from automobiles, often with striking results. For example, the total quantity of lead used in gasoline in the USA was cut from 170,000 tons in 1975 to 40,000 tons in 1984. Japan has made even greater progress. Contrastingly, "[f]ew developing countries have yet made significant reductions in petrol lead content..."[33] There have been no (or only negligible) decreases in lead levels in petrol in Africa, South and Central America and the Caribbean, whereas there have been big falls in Europe and North America, and quite a big fall in Asia, even without taking account of the consumption of unleaded petrol in these countries.[34]

TABLE 4 RANGES OF LEAD LEVELS IN PETROL IN DIFFERENT REGIONS OF THE WORLD, 1974 AND 1984 (in grams of lead per litre of petrol)

	1974	1984
Africa	0.63-0.84	0.63-0.84
Asia	0.31-0.84	0.17-0.56
South/Central America, Caribbean	0.64-0.84	0.64-0.84
North America	0.58-0.95	0.22-0.77
Europe	0.40-0.84	0.15-0.40

Source GEMS, 1988, ibid, Table 7.1, page 60.

In general, therefore, although one cannot say precisely how overall "air quality" should be defined, or at exactly what income level individual aspects of air quality begin to improve with further growth, it is fairly clear that air quality does improve sooner or later. How much sooner or later - i.e. at what point in time or level of income - urban air conditions reach a point when effective policies are introduced, will depend on a host of technical, social and political variables. It is not surprising, therefore, that the record of individual countries shows a reversal in the trend of traditional pollutants (SO_2 and SPM or smoke) at very different stages in their history. In Britain, for which country data on

[32] ibid page 43. Even here, however, there are notable exceptions, namely Singapore.

[33] GEMS ibid 1988, page 60.

[34] ibid. page 60.

these two basic pollutants go back several decades, a considerable improvement began in the late 1950s.[35]

The proposition advanced above to the effect that, like sin, pollution only exists insofar as there are victims, should perhaps be amended to take account of *potential* victims, including future generations. Certain emissions that were harmless in the past, and hence not regarded as pollutants at the time, are now becoming environmentally damaging. This applies, in particular, to CFCs, which mainly affect the stratospheric ozone layer, and to carbon dioxide, the accumulation of which is widely believed to lead to global warming. How far this threat is serious enough to justify costly preventative or adaptive action is outside the scope of this paper, but there is little doubt that, like the other new pollutants mentioned above, carbon dioxide emissions have not followed the same steep downward trends in developed countries that have been followed by more traditional "old" pollutants, such as SO_x.

(d) The poverty-environment nexus

There is a vast range of illustrations of the manner in which the changes in production patterns and techniques associated with economic development lead to environmental degradation of one kind or another. It would be superfluous to enumerate them all here. The poisoning of the air and rivers from industrial effluent that occurred in the past in what are now developed countries, and that is still taking place in some of them and in most developing countries, hardly requires further elaboration. Everybody is now familiar with the harmful effects of, for example, many modern agricultural practices with their heavy use of pesticides and fertilizers which, in the longer run, are responsible for the accumulation of toxic chemicals in water supplies and/or which damage the viability of the agricultural processes for which they were used.

But these harmful effects of economic growth are often inextricably mixed with environmentally-favorable local factors, so that a net balance is difficult to strike. For example, poverty has contributed to deforestation in various countries, notably in Thailand, the Philippines and Brazil. But sometimes, in the same countries, modernization of agricultural techniques also contributes to environmental degradation. This is the case, for example, with CABOCLO agriculture in the Amazon region, which is a traditional form of agriculture that respects the need for sustainability and regeneration. Once farmers are supplied with credits to buy powerful machinery, chemical inputs and so on, the longer-term sustainability of the areas in question tends to be destroyed.[36] Numerous other instances of this same process can be found all over the world. However, in these and other cases, it is often difficult to distinguish how far environmental damage is caused by low incomes per se, and not by rising population.

(i) Urbanization.

This distinction is particularly difficult to make in the analysis of urbanization, which is one of the most striking mechanisms by which economic growth contributes to environmental degradation. This is as much, if not more, the result of population growth, than of any rise in incomes per head, although the ultimate sources of population growth may well be found in the dynamics of the income-population

---

[35] See evidence in Beckerman, Wilfred, In Defence of Economic Growth, Cape, London, p. 123/4 (U.S. Edition Two Cheers for the Affluent Society). This source also documents improvements in air and water quality in the 1960s and early 1970s in a number of developed countries as well as the pollution abatement policies being introduced around that time in the countries in question, pages 124-140.

[36] See Anna Lousisa de Osario de Almeida The Civilization of the Amazon, Texas University Press, forthcoming 1991.

relationship. A rise in incomes per head usually leads to rapid population growth for a period, during which mortality rates decline, and is then followed by much slower population growth as birth rates also begin to decline significantly.

The welfare effects of fast urbanization are complex. On the one hand, the welfare of migrants to cities presumably rises as a result of their move, even given the limitations of their pre-move information. On the other hand, there is a harmful externality effect on the welfare of people already in the cities. Migrants will move into cities when their perceived marginal private benefits exceed their perceived marginal costs. They will not take account of any adverse effects on the existing inhabitants of the cities, any more than automobile drivers take account of the costs imposed on others by their decision to drive into town. Furthermore, the rapid inflow of migrants imposes clear strains on the capacity of recipient cities to meet fast rising needs for housing, waste management, sewerage, and water supply, in addition to more indirect effects on air quality and other aspects of the environment.[37]

Desirable or not, the pace of urbanization in developing countries not only exceeds that in developed countries by a wide margin, but until very recently it has been accelerating, whereas in developed countries it has been slowing down. In 1985, eight of the 12 cities with 10 million or more inhabitants were in developing countries. By the year 2000, it is expected that there will be a total of about 23 cities of that size, of which 17 will be in developing countries.[38]

The effects of rapid urbanization take many forms. In most countries they include poor housing conditions, the inability to handle waste disposal, contaminated water supplies, and other effects particular to individual cities. In Thailand, for example, the effects are reported to include contaminated food and recurrent floods, worsened by land sinking from the digging of deep industrial wells and construction of new buildings.[39] In fact, land subsidence caused by falling groundwater levels is a common feature of many fast growing areas. In Sao Paulo, which is one of the outstanding examples of the price paid by very rapid growth and industrialization, it is reported that water pollution results from a combination of increasing industrial effluents and raw domestic sewage discharged into local rivers and other water bodies. Air pollution is associated with the rapidly growing number of motor vehicles and the emission of a variety of substances by industrial sources.[40]

Because of the effect of very rapid increases in urban populations in most developing countries, the positive relationship between income level and access to safe drinking water shown in Figure 1 above for the <u>total</u> population of individual countries, is less clear-cut when data for <u>urban</u> populations are considered separately (see Figure 5 below). For example, in the 3rd and 4th quintiles, the percentages

---

[37] Residents in the cities are presumably free to move out. Thus, insofar as they do not - or at least not as fast as others are coming in - one must presume that even though their welfare is reduced by the inflow of new migrants it is still higher than it would be if they moved back to rural areas. Nevertheless, their welfare will still tend to be reduced by the inflow of newcomers, so the net welfare effect of the inflow will be the rise in the welfare of the latter less the fall in the welfare of the former.

[38] Faiz et al. <u>Automotive Air Pollution</u>, op.cit. 1990, page 28, and <u>U.N. World Urbanization Prospect</u>, 1990, Tables A5, A6 and A7.

[39] World Bank staff information.

[40] The World Bank, Operations Evaluation Department, <u>Approaches to the Environment in Brazil</u> op.cit.

of the population with access to safe drinking water shows no improvement between 1975 and 1985.[41] In both years, access in countries in the 3rd quintile is worse than in those in the 2nd quintile.

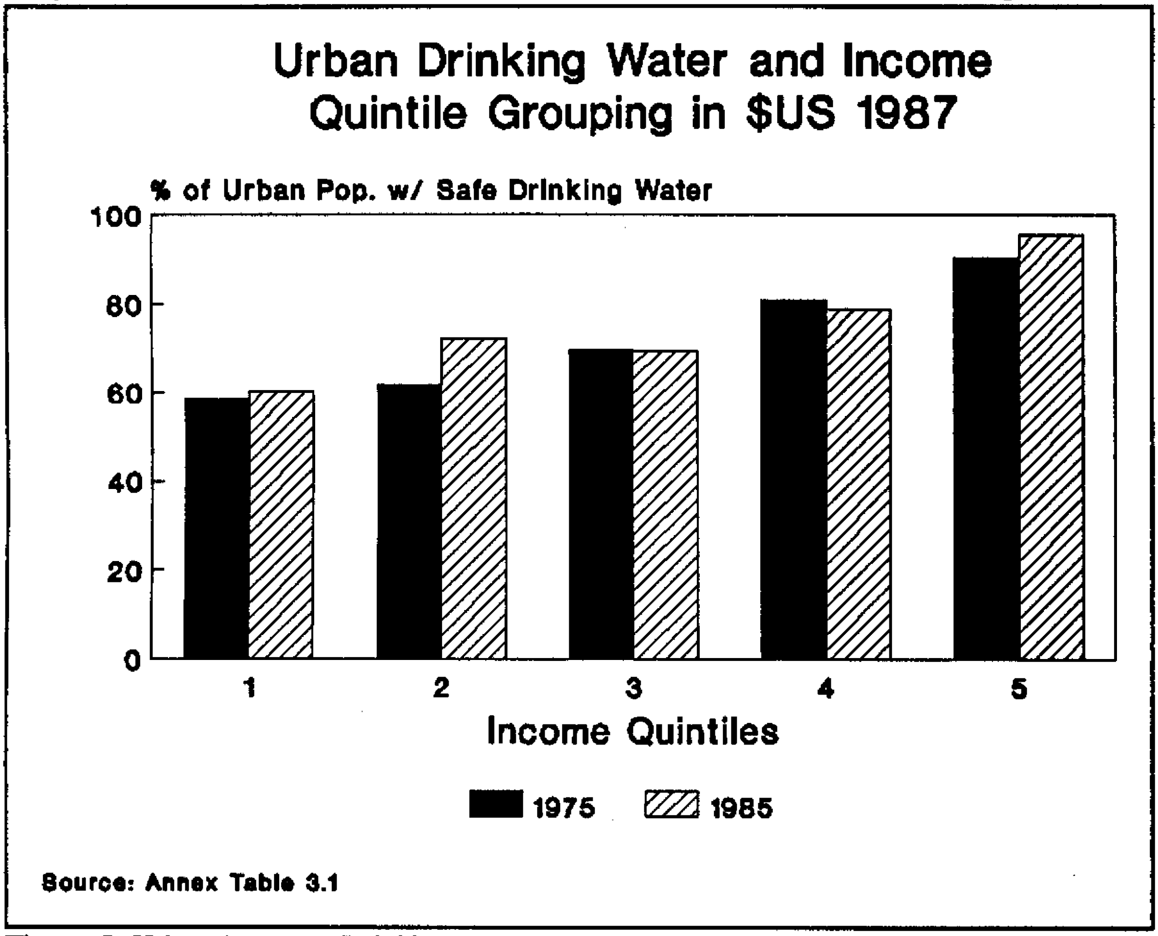

Figure 5 Urban Access to Drinking Water and Income Groups

(ii) Urbanization, low incomes, and automotive air pollution

Rapid urbanization, fast growth of vehicle numbers, plus the particular pollution-intensive character of most vehicles in developing countries mentioned above, means that, as well as experiencing the growth of air pollution previously experienced in developed countries, fast growing cities in developing countries are also suffering from acute vehicle-based air pollution. Table 5 below, which covers 12 cities in developing countries for which relevant comparable data are available, shows that the rise in the numbers of passenger cars has been as much the result of rising incomes - as indicated by rising numbers of cars per head - as of increases in the population of the cities in question. Although data on the corresponding air pollutants - mainly carbon monoxide and NO_2 - are not available, it must be presumed that, as indicated by other evidence quoted above, these pollutants have risen rapidly. Ambient SO_2 levels, in contrast, have been rising in some cities and falling in others; the average for those cities covered has fallen. Ambient SPM levels have tended to rise more, but still to a less

[41] The average income levels of the countries in the 3rd and 4th quintiles increased over the period in question, in real terms, but it is possible that the average income of the urban population did not do so.

pronounced degree than the likely rates of increase for vehicle-generated pollutants.

TABLE 5 GROWTH RATES OF POPULATION, PASSENGER CARS AND CERTAIN AIR POLLUTANTS IN SELECTED CITIES IN DEVELOPING COUNTRIES (annual average % rates of change)

City	Population	Passenger Cars		Concentrations	
		Per Head	Total	SO_2	SPM
Bangkok	4.3	3.4	7.9	-0.8	0.9
Bogotá	4.1	3.6	7.8	-4.4	-2.2
Bombay	3.3	2.7	6.1	5.8	0.1
Cairo	2.7	14.0	17.0	NA	9.6
Calcutta	2.7	2.8	5.6	2.8	-0.3
Hong Kong	2.8	4.5	7.4	9.6	2.6
Jakarta	4.3	5.4	9.8	NA	0.5
Lima	4.2	2.9	7.2	-14.0	-13.6
Manila	5.3	2.5	8.0	-1.2	1.7
Rio de Janeiro	2.2	9.6	12.1	8.4	22.7
Sao Paolo	4.2	3.4	7.8	-6.9	-2.1
Seoul	4.5	6.8	11.7	-7.8	NA
AVERAGE	3.6	4.6	8.8	-0.7	1.7

Source Annex 3

Paradoxically, even the role of the automobile in adding to air pollution in fast growing cities is an illustration, if not of the poverty-environmental degradation nexus, then at least of the low income environmental degradation nexus. In addition to fast growing populations and vehicle numbers, low incomes are associated with less stringent measures to reduce pollution generated by automobiles. Whereas most rich countries have been able to cope - up to a point - with the growth of automobile numbers by means of successively more stringent and expensive measures to reduce pollution emissions, this is not the case in developing countries. A recent World Bank report states that:

> "Motor vehicles in many developing countries are not as fuel efficient as in industrialized countries. Many of the vehicles are old and poorly maintained because of lack of spare parts and other resources.. For example, in India a major portion of the vehicle fleet is older than ten years ... Two-stroke engine motorcycles are also a major source of air contaminants ... Moreover, the gasoline used in most developing countries still has a high percentage of lead."[42]

In Mexico City the number of automobiles has risen from 680,000 in 1970 to 2.6 million in 1989, and the Mexican government estimates that fewer than half of the vehicles are fitted with even modest pollution control devices.[43]

---

[42] Asif Faiz et al. Automotive Air Pollution, op.cit. page 40. Similar accounts can be found for other cities in developing countries. For example, it is reported that the severe traffic problems of Cairo are partly the result of a high percentage of unsurfaced roads, rapid and unmanageable growth of car ownership, and absence of traffic management measures, inadequate parking control, poor traffic signs and signals, and lack of regulatory enforcement. All these variables add to congestion and hence to pollution. (See J.Leitmann, Energy-Environment Linkages in the Urban Sector, Discussion Paper, April 1991, page 17, based on material in the World Bank's Greater Cairo Urban Development Project, 1982).

[43] Josef Leitmann Energy-Environment Linkages in the Urban Sector, World Bank Urban Management and the Environment Discussion Paper, April 1991, page 23.

BỘ MÔI TRƯỜNG
MT 77

"Virtually none are equipped with state-of-the-art exhaust treatment systems. Only recently has unleaded gasoline become available. The lead content of leaded gasoline was lowered during 1986 and 1987, but there are indications that it has increased since then.....In addition, more than 40% of the cars are over 12 years old, and of these, most have engines in need of major repairs".[44]

It is estimated that motor vehicles are responsible for over 80% of air pollution in Mexico City, about 75% of all air pollution in Sao Paulo, about 70% of all air pollution in Tunis, and no doubt similar levels in cities in most other developing countries.[45]

Similarly, poor vehicle maintenance and large numbers of two-stroke motorcycles contribute to high air pollution levels in Indonesia, and in the Philippines, poor quality fuel (notably high sulfur content and lead content) is singled out as a major cause of high urban air pollution.[46] In Bangkok, the costs of switching to less lead and sulphur intensive fuels, together with the administrative difficulties of monitoring compliance with more stringent standards in a situation in which vehicle numbers have risen rapidly, are additional obstacles to any major reduction in pollution from motor vehicles.

(iii) Poverty and non-sustainability

In addition to the generally favorable relationship between higher incomes and the environment postulated above and demonstrated with respect to air quality, water supply and sanitation, there are, of course, numerous particular instances of the ways in which low incomes cause environmental degradation. Mention has already been made of one of the most common instances of this, namely the poverty-deforestation-poverty cycle. In Thailand, it is reported that "[p]overty and deforestation are locked in a vicious circle of mutual reinforcement."[47] Typically, poverty combined with the lack of any other employment alternative drives people to cut down trees and cultivate the resulting land often with damaging long term effects on soil productivity and/or water supplies. In Brazil, the "pull" exercised by certain government policies, including road construction, tax exemptions, fiscal and credit subsidies for investment programs and so on, was probably the main force behind the rapid pace of "frontier settlement" and associated deforestation. There was in addition some "push" coming from landless peasants for whom "migration is basically motivated by the possibility of accumulating wealth (and, with luck, becoming a landowner) through the clearing of lands in a frontier area where property rights are still undefined."[48]

---

[44] Azif Faiz et al. op.cit. 1990, page 17.

[45] For Mexico, ibid, for Sao Paulo, World Bank Operations Evaluation Department, Approaches to the Environment in Brazil op. cit.; and for Tunis, World Bank data.

[46] Azif Faiz ibid page 16.

[47] Phantumvanit, Dhira and Panayotou, Theodore, Natural Resources for a Sustainable Future: Spreading the Benefits, the 1990 TDRI Year-End Conference, synthesis paper No. 1, Dec. 1990, page 27. See also Tongpan, S. et al. Deforestation and Poverty: Can Commercial and Social Forestry break the Vicious Circle?, The 1990 TDRI Year-End Conference, Research Report No. 2, 1990, page 6. See also same conference, Synthesis Paper No. 1, Phantumvanit and Panayotou,op.cit. Chapter 3 "Poverty and Deforestation: A Vicious Circle."

[48] E.J.Reis and S.Margulis Options for Slowing Amazon Jungle-Clearing, paper presented to the Conference on "Economic Policy Responses to Global Warming", Rome,Oct. 1990.

Poverty contributes to deforestation in other ways. For example, deforestation can also be caused by the consumption of biomass fuels in low income situations, even in urban areas. Furthermore, the inverse relationship between income level and the use of biomass for fuels is apparently reversible, and consumers have switched from modern fuels back to biomass as incomes have fallen. "For example, in sub-Saharan Africa, woodfuel demand grew by 3.1% per capita annually from 1975-85, while real GDP per person fell by 1.8% each year."[49] One way or another, deforestation is caused partly, if not largely, by poverty - aggravated in some cases by certain policies. In turn, it can add to poverty. In the longer run, it destroys a valuable source of income from timber, or leads to soil erosion and/or a reduction in local water supplies.[50] The role of deforestation in the poverty-environmental degradation-poverty cycle can also take the form of reducing easy access to water supplies, with a consequent increase in the time taken - invariably by the women in the community - to fetch water for domestic purposes. This then reduces such time as they have available for alternative activities, marketable or otherwise, or domestic activities that help sustain the health of their families.[51] Numerous studies have reported the very long periods of time that women in rural communities in developing countries often have to spend fetching water, with consequent aggravation of poverty if their water supply is threatened by environmental degradation.

In short, a major cause of many forms of environmental degradation is the combination of rising population with a lack of ways to make a living other than those that degrade the environment. Most developing countries share the problem of the Philippines, for which it is reported that:

> "Improved management of natural resources requires an attack on underlying causes of degradation and depletion, specifically excessive population growth and poverty, which are the main sources of migratory "push" into the uplands and coastal areas ... A strong program to reduce population growth rates ... and measures to create jobs for unemployed and underemployed rural residents ... will be crucial to the long-run

---

[49] Josef Leitmann Energy-Environment Linkages in the Urban Sector, World Bank, Urban Management and the Environment, Discussion Paper, April 1991, page 22.

[50] For example, in the Philippines it is reported that "A major external or indirect consequence of forest degradation on sloping lands is an increase in soil erosion...The costs of soil erosion include upstream (on-farm) and downstream components. The former can be measured as the decline in the productivity of the soil as nutrients are lost and structural properties such as moisture retention are degraded. The latter includes the future reductions in agricultural and industrial production...." Philippines: Environment and Natural Resources Management Study, A World Bank Country Study, The World Bank, 1989, pp. 64ff.

[51] For example, in a study of Nepal it was reported that as a result of "rampant environmental degradation including deforestation, in areas where growth is stagnant.....in the long run, water from forest streams becomes more scarce and is replaced by water from more distant or contaminated rivers and ponds", Kumar S.K. and Hotchkiss, D. Consequences of Deforestation for Women's Time Allocation, Agricultural Production, and Nutrition in Hill Areas of Nepal, Research Report No. 69, International Food Policy Research Institute, Washington D.C. 1988, pages 11 and 28. See also Pasha, H.A. and McGarry M.G. (eds.) Rural Water Supply and Sanitation in Pakistan: Lessons from Experience World Bank Technical Paper No. 105, June 1989, page 1. In this document it is reported that 45 percent of all child deaths are caused by diarrhoea.

prospects for reducing the rate of environmental degradation".[52]

IV. THE ROLE OF POLICY

It has been argued above that there is no simple one-way relationship between income level and those features of the environment identified in this paper. In the longer run, higher incomes are clearly associated with improved environmental conditions, but the transition period may be long and painful, during which serious environmental deterioration can occur. How long and painful the transition period is depends largely on government policy, and partly on other variables. Policies do not simply emerge in a vacuum, independent of accompanying economic and social conditions; the former are often highly dependent on the latter. For example, it is doubtful how far stringent air pollution controls would have been introduced in Britain in the 1950s, even after the notorious "killer" smog of 1952 in London, had not other factors - such as the virtual disappearance of cheap domestic service - led to a shift towards more efficient forms of heating in many homes.[53]

As postulated above, one major determinant of environmental policy priorities is, of course, a country's income level. In the past, when income levels were much lower than they are to-day, developing countries were not very worried about pollution. In the early 1970s, for example, countries such as Brazil and Algeria, were in the forefront of opposition to the then newly emerging shift of emphasis - in richer countries - away from economic growth towards greater awareness and consideration for the environment. At the World Environment Conference in Stockholm in 1972, both countries stated their intention to continue industrialization without concern for environmental problems. Within a few years, both countries saw a major policy shift in the direction of environmental protection in both countries.[54]

Automotive pollution provides another clear example of the role played by policy and income level in determining the incidence of particular forms of pollution. The severity of this problem in the fast-growing cities of developing countries has already been noted. By contrast, the largest reductions in automotive pollutants have been achieved in Japan, Germany and the USA as a result of their relatively early introduction of stringent controls on motor vehicles. There have been moves in this direction in most Western European countries, where such policies as have been adopted, appear, in some cases, to have been offset by increased vehicle numbers.[55] Similar regulatory measures have recently been introduced in some developing countries, but, so far, with one or two exceptions, without much effect. As discussed earlier, this is largely the result of their generally lower ability to afford, or to monitor, the required policy changes.

Another important constraint on the design of optimal environmental policy may be the desire to maintain intact assets - including the environmental - to be handed on to future generations. This is often referred to as the "sustainability" constraint. The difficulties of finding an operational definition of

---

[52] Philippines: Environment and Natural Resource Management Study, op.cit., World Bank, 1989, page (xvi).

[53] Ashby, E. and Anderson, M. The Politics of Clean Air, Clarendon Press, Oxford, 1981, p. 116, and Brimblecombe, P. The Big Smoke, Routledge, London, 1987, page 170.

[54] See The World Bank Brazil: The New Challenge of Adult Health, A World Bank Country Study, 1990, page 35 et seq.

[55] GEMS, ibid pages 38-57.

"sustainability" that is consistent with the minimum requirements of some moral theory of inter-generational justice, lie outside the central topic of this paper and are briefly discussed in Annex 2. Here it must suffice to note that the inclusion of any such constraint in the design of optimal policy raises the question of for *whom* a policy is intended to be optimal. This question need not refer only to the interests of future, as against present, generations; it encompasses also the question of for which groups within current populations is policy designed to be optimal. There are, no doubt, major divergences of interest between developed and the developing countries as regards: (i) the importance they attach to economic growth relative to the environment; and (ii) within the environment, the relative importance they attach to its different components - e.g. global warming as against improved access to water supplies and sanitation.

Such differences in policy priorities would not matter much, of course, if environmental policy was purely a national or local concern. But some policy issues have international implications, notably those designed to deal with threats to "the global commons." Developing countries themselves may not see climate change as posing a sufficient threat in the medium term to justify their devoting large resources to reducing their emissions of "greenhouse gases." Yet the greatest potential for preventing or mitigating an otherwise inevitable increase in greenhouse gas emissions lies with developing countries, because of their future population growth and their current relatively low levels of per capita energy consumption. By contrast, developed countries have the resources to take effective action to moderate global warming, but less incentive to do so. This is chiefly because of the relatively insignificant impact of global warming on their economies, given the small share of agriculture in their national product.

Consequently, if significant international co-operation is to take place to moderate the pace of greenhouse gas increases, it will almost certainly have to take the form of substantial transfers of appropriate technology to developing countries. Insofar, therefore, as developed countries are interested in taking out insurance against the threat of climate change they will need to operate through institutions specifically designed to negotiate and carry out the massive transfers required. The structure of the World Bank, its relationship with donor countries and recipient countries, and its traditional role in the field of technology transfer suggest that it will have to play a key role in any such machinery. The Bank's traditional "clients" may not be particularly interested in climate change, but this does not mean that the Bank should not be. However, this, too, is a topic that lies outside the scope of this paper.

V. CONCLUSIONS

The main conclusion emerging from the above is that, although in the course of their development some features of the environment in developing countries may get worse, in the longer run they will be able to reverse the trends in more common forms of air pollution, and attain levels of water supply and sanitation essential to an acceptable, decent and healthy standard of living. On the whole, there is a strong positive relationship between income level and environmental quality - at least, as measured by the particular environmental factors noted here. This has been shown above across broad income bands and in the context of particular country situations that demonstrate the various ways low income levels lead to environmental damage, even if, in many cases, economic progress may also harm the environment.

The generally favorable cross-country relationship between income levels and the environment is, of course, consistent with the well-known historical environmental experience of what are now the developed countries. In the latter, effective measures to combat urban air pollution were only introduced when it had reached almost intolerable levels in many cities, such as London, Sheffield, Pittsburgh, Los Angeles and Tokyo. Instances of response only when conditions are similarly intolerable, abound in developing countries - as in Sao Paulo or Mexico City. But this does not mean that as countries develop, they will replicate precisely the environmental histories of developed countries. The path of environmental pollution in the developing world today will probably differ from that of the past in at least four respects.

First, changes in technology, in relative prices, in the patterns of output, and in policies, mean that although traditional pollutants have been brought under control in many (predominantly developed) countries, the world is faced with newer pollutants, or with "old" pollutants which, on account of their scale or accumulation, have acquired a new significance. Chemical pollutants from pesticides and fertilizers, or carbon monoxide and nitrogen oxide emissions from automobiles, are well-known examples, but there is constant emergence of newer pollutants of the soil, water, and of the air.

Second, the global character of many pollutants is becoming more serious. In the past, the most serious pollution problems were local, although concern with acid rain, or water pollution in some areas, such as shared rivers or lakes, goes back many decades.[56] To-day, even leaving aside the issues of global warming and ozone depletion, there is evidence of serious regional environmental effects - acid rain, and marine or riverine pollution.

A third relatively novel aspect of contemporary environmental concerns is international trade in polluting activities. In the 19th century the fast growing cities of Britain, Germany, and the U.S.A. had to contend with pollution generated mainly by domestically owned enterprises. Today, however, the scale of international re-location of industrial activities combined with major differences between countries with respect to their national pollution regulation policies, opens up many possibilities for enterprises to shift their more polluting activities from countries where strict controls are imposed to countries in which environmental considerations do not have a very high priority. As a result, developing countries may suffer not only from their own pollution, but also from "imported" pollution. A particular striking illustration of this pollution migration came to light recently following a major phenol leak into the water supply of the South Korean city of Taegu.[57] Of course, insofar as countries differ with respect to the absorption capacities of their environments and their relative preferences, both of which may imply differences in their "comparative advantage" for carrying out polluting activities, such international "trade" in pollution could be defended as "optimal." Whether or not this is so, the fact remains that "international trade" in polluting activities adds a relatively new element to the environmental problems that will in the future be associated with economic development.

A fourth difference between the pollution of the early 20th century and that of to-day is the proliferation of the automobile. Although the pace of urbanization in developing countries is not a unique historical phenomenon, the chief impact of urbanization on air pollution used to take the form of increased concentrations of SO_2 or smoke. Today, however, the fast growth of automobile traffic in cities in developing countries, means that emissions of CO or NO_xs have become a serious problem before the growth of more traditional pollutants has been curbed.

---

[56] In 1912 the US and Canadian governments asked the International Joint Commission (a body set up by the two governments for settling such disputes as may be referred to it) to study the pollution problems of the Great Lakes as well as other boundary waters and as early as 1918 the Commission reported that the water quality "...situation along the frontier is generally chaotic, everywhere perilous and in some cases disgraceful" (quoted in The Council for Environmental Quality Environmental Quality, Twentieth Annual Report to the U.S.Congress, printed on recycled paper 1990, page 334).

[57] New York Times, April 6th 1991.

ANNEX 1. LIMITATIONS ON INDICATORS OF WATER AND AIR POLLUTION

(a) General principles

In principle, one would like to measure the flow of utilities or disutilities that people obtain from the environment. In the case of water and air, for example, this would be the use that they make of these two media, which will be functions of their availability and quality. The more polluted the water or the air, the less will be the supply of clean water or air, and so the less will be the utility that people will obtain from them. These flow concepts would thus correspond to those that are measured in monetary terms in estimates of national product. However, with the possible exception of some aspects of water supply, such estimates are not available. The next best substitute, therefore, would be estimates of the stocks of the environmental media in question, such as the stock of clean air and water, since the flow of services to be obtained from them would be functions of these stocks - as well as of other variables. Unfortunately, good data on the "stock" of environmental resources that are directly affected by air and water pollution, are usually very fragmentary.

The indicators most readily available are often variables, such as flows of effluents or emissions of air pollutants, that - subject to many assumptions - cause changes in water supply or air quality. In other words, in the absence of data on the flow of services from the stock of clean air or water, use is often made of data on the flow of pollutants into the air or water resource in question. Other widely used indicators are data on the consequences of water or air quality - such as the incidence of diarrhea or respiratory diseases. Using data on the causes of changes in air or water quality, or on the effects, is like using inputs as measures of the output of goods entering into final demand, or measures of weight or health in place of data on consumers' expenditure on food.

Neither form of proxy variable is justified in the case of pollution. In the first place, the technical relationship between many of the flows into the environment and the subsequent stock of the environmental medium in question is very weak indeed. In the case of air pollution, for example, the effect of a given emission on ambient air quality will depend on the ability of the atmosphere to absorb it. Hence, for example, the effect of smoke from some industrial activity on local ground level smoke concentrations will depend on the height of the chimney stack, the distance of the emission from the location in question, the prevailing meteorological conditions, and various other site-specific physical characteristics. As a result of this and other influences, a given level of emissions can be associated with very different effects on ambient air quality, in accordance with the precise location of the measuring instruments used. For example, for given amounts of emissions from automobiles, notably carbon monoxide and NO_xs, the measured concentration of the pollution in the air can vary by several orders of magnitude if the instruments are placed in one spot rather than another spot a hundred yards away, where the distance from the road may be different as well as the proximity of buildings and trees and so forth.[58] Similarly, with water, the absorptive capacity of rivers or seas is such that, depending on climatic and other conditions, a given level of emissions will lead to widely different degrees of contamination of the recipient body of water according to the measurement point. Of course, this does not mean that data on the flows of pollutants into stocks are irrelevant. Since stocks can only be influenced by changing flows, emission data are valuable indicators of potential stock problems (as, notably, in the case of CO_2 emissions and the global warming phenomenon) or of the relative success or failure of policies to combat pollution.

A further problem is that, in principle, the welfare significance of different degrees of pollution depends on the number of people affected and the length of time to which they are exposed to the

[58] The particular problems of measuring concentrations of NO_x are set out in UNEP/WHO Global Environment Monitoring System: Assessment of Urban Air Quality, Geneva, 1988, page 45.

pollution, since these determine the size of the flow of services (or dis-services) provided by the environmental stock in question, and the loss of welfare imposed by a given exposure to a given type of pollution.

(b) Air pollution data.

The need, in principle, to allow for the number of people affected, in order to increase the welfare significance of pollution indicators, poses greater problems for air pollution than for water pollution. For to a large extent water is a "private good" in the technical sense that if one person is consuming some clean drinking water that water is no longer available for somebody else's use. By contrast, one person breathing clean air does not reduce the amount of clean air available for other people to breathe. Defined in terms of "non-rivalness", therefore, clean air is a public good to a degree that clean water is not.

Hence, whilst it is not too difficult, in principle, to estimate how many people have access to safe drinking water,[59] other calculations would be needed to adjust estimates of air quality for the number of people exposed to the air in question and the duration of their exposure. As GEMS point out:

> The realization is gradually emerging...that fixed ambient air monitoring networks alone, such as are known in most countries today, may not necessarily be able to provide all the data required to determine the exposure of individuals or populations living in a given area.[60]

Another difficulty concerns the large variability in ambient air quality between one part of the day (or week or year) and another. The carbon monoxide count will be incomparably higher at peak traffic congestion times in the center of a city than in the middle of the night at the same point. Most polluting emissions are also much worse in winter than in summer, on account of the greater degree of combustion for heating in the winter, though in some cities the meteorological conditions responsible for photo-chemical smog tend to be worse in the summer.[61]

(c) Water pollution data

Unlike air, which is used almost exclusively for breathing, water is used for a variety of purposes: drinking, washing, industrial cooling and more. A much higher quality of water is needed for drinking purposes than for other uses. Hence, data tend to discriminate between access to safe drinking water, access to adequate sanitation, and measures of water quality in water bodies (rivers, lakes and so on). Each of these types of data give rise to their own special problems.

As regards the former, for example, very little data are available in rural areas, so that it is not surprising that a recent World Bank report concluded, in connection with rural water supplies, that:

---

[59] However, as pointed out below, there are ambiguities in what is meant by "safe drinking water" or "having access".

[60] Global Environmental Monitoring System (GEMS) Estimating Human Exposure to Air Pollutants, WHO Offset Publication No. 69, Geneva, 1982, page 6.

[61] See comparisons of seasonal variations in ambient air quality in United Nations Environmental Programme Environmental Data Report, 2nd edition 1989/90, Table 1.21, page 52.

Just exactly how many people are receiving what services in the rural areas is difficult to estimate. There are no common definitions, for example, of what constitutes "adequate" services or what is meant by "access to services". And few countries keep up-to-date information on what is happening in their rural areas ... There are no reasonable figures on "access" to "adequate sanitary services".[62]

But no sharp dividing line can be drawn between the quantity of water available and various dimensions of its "quality". Consequently, even in urban areas, where the definition of access to safe drinking water is relatively precise - namely to have some water supply, even if only a standpipe, within 200 meters of one's dwelling - there is no guarantee that there is actually any water in the pipe, or even that it would be drinkable. Partly as a result of this overlap between quantity and quality, estimates of the proportions of the population of any country "covered" by adequate water or sanitation supplies are not really comparable except in very rough and ready terms.[63]

As regards the quality of water in rivers and lakes, which, like air pollution, has more of the character of a public good, this can be measured at different points. The GEMS program for monitoring water quality divides monitoring stations into three types, representing water at some point fairly far removed from direct effluent discharges, measuring it at some important impact point, and then measuring it at some reasonably upstream point.[64] Clearly one can go into finer and finer detail, and it would obviously be unrealistic to expect monitoring stations to be set up every 100 yards along every important river or lake likely to be of interest to human habitations, let alone to monitor underwater sources. And, like air pollution measurements, much depends on the precise time of year or of the day. The observations that may be valid for analyzing trends over time in one particular location in a country may be totally unrepresentative of trends in other locations.

Even if one could obtain reliable comparisons of changes in individual water quality indicators, there are many different components of water quality that are of interest, ranging from the more common forms, such as low levels of dissolved oxygen or the - closely related - biochemical oxygen demand, to concentrations of various chemicals and heavy metals. To obtain a reasonably comprehensive picture of water quality, therefore, one would need data on a large number of indicators at a very large number of monitoring stations, and this is clearly not possible in the absence of unlimited resources to be devoted to this purpose.

---

[62] Churchill, A.A., with the assistance of de Ferranti, D., Roche, R., Tager, C., Walters, A.A. and Yazer, A. Rural Water Supply and Sanitation, World Bank Discussion Paper,No. 18, 1987, page 4. An illustration of the wide margin of error to be attached to any estimates of water supplies is the enormous difference between alternative estimates of water supplies for a given area and year. For example, the estimates of the percent of the population having access to satisfactory water in urban areas in all LDCs in 1980 was 62.0% in the World Bank's Water supply and sanitation, FY 1988 Sector Review, and 80.0% in the background paper prepared by the conference secretariat, with World Bank assistance, for the Sept. 1990 New Delhi Conference on Global Consultation on Safe Water and Sanitation for the 1990s.

[63] See also Global Consultation on Safe Water and Sanitation for the 1990s, op.cit., Box 1, page 3.

[64] For a definition of the different classes of monitoring station used in the GEMS monitoring network see UNEP/WHO/UNESCO/WMO GEMS/WATER 1990-2000 The Challenge Ahead WHO Geneva, 1991, pages 3 and 7.

ANNEX 2 SUSTAINABILITY OR OPTIMALITY

(a) How fast, if at all, are finite resources being used up?

Before turning to the philosophical aspects of the concept of "sustainability" it is, perhaps, worthwhile dealing with a relatively straightforward factual issue. This is the widespread assertion that the world is in danger of running out of what are alleged to be "finite resources". Clearly, resources are either finite or they are not. If they are, then the only way to ensure their continuation in perpetuity is to stop using them. Stopping growth is not enough. Levels of consumption would have to be reduced to infinitesimal levels if finite resources are to be made to last for ever. But, of course, even the most fanatical proponents of "sustainability" hardly go that far, and would soon sell a critical pass by confessing that, maybe, the human race could find ways of coping with changes in the balance between demand and supply of resources.[65]

The table below compares the 1970 estimates of reserves of key metals and primary fuels as given in the Club of Rome's Limits to Growth with the 1989 figures and the intervening cumulative consumption figures. As is widely known, the concept of reserves is not a simple one since much depends on how far allowance is made for estimates of reserves that are not economically recoverable.[66] As can be seen in the following table, for all items covered the 1989 reserves are much greater than those reported in 1970, despite the substantial cumulative consumption during the intervening years relative to initial 1970 reserves. Since it is fairly clear that the human race will blow itself up long before it runs out of supplies of fissile uranium, there is therefore nothing to worry about.

TABLE A.1 COMPARATIVE LEVELS OF "KNOWN RESERVES" OF KEY MINERALS, 1970 AND 1989, AND CUMULATIVE CONSUMPTION, 1970-1989

	Reserves[a]		Cumulative Consumption, 1970-89[b]
	1970	1989	
Aluminum	1,170	4918	232.2
Copper	308	560	176.4
Lead	91	125	98.5
Nickel	67	109	13.6
Zinc	123	295	118.1
Oil[67]	550	900	600
Natural Gas	250	900	250

(a) millions of metric tons, unless otherwise stated.
(b) Items other than fuel the consumption figures for 1989 cover only the first nine months of the year and exclude the Soviet bloc countries. This will not significantly affect the estimated cumulative 1970-89 total.

[65] See Chapter 8, "Resources for Growth" in my In Defence of Economic Growth, op.cit. 1974.

[66] The estimates of the non-fuel mineral resources shown below originate with the U.S.Bureau of Mines, where they are defined to "include demonstrated resources that are currently economic, marginally economic and some of those that are currently sub-economic". The Club of Rome used the same source for most of the minerals on their list except for their figure of coal reserves, the source of which is not clear (not that this matters, since there is no dispute that there is little likelihood of running out of coal reserves in the foreseeable future). The estimates for fuels are from Dennis Anderson's paper "Global Warming and Economic Growth", (WDR'92 of Feb. 20, 1991), Table 2, page 5.

[67] Billion barrels of oil equivalent (Bboe); data relate to 1990 reserves and rounded estimates of cumulative 1970 through 1990 consumption.

Sources Reserves : 1970 reserves as in Dennis Meadows et al. The Limits to Growth, (Earth Island Ltd, London 1972) pages 56-59; 1989 reserves of metals from The World Almanac, 1990, page 130 (these data are taken from the U.S.Bureau of Mines estimates); Consumption: metals from Metal Bulletin's Prices and Data, (Metal Bulletin Books Ltd, Surrey, U.K.) 1990, pp 255 and passim; various unit conversions carried out to make them comparable with reserves figures; Fuel reserves and consumption from Dennis Anderson, op.cit.

For food output, in spite of much talk about the damage to soil, to water supplies, to forest cover, to sustainability, and so on, the fact is that world food output has been rising faster than population, so that world food output per head rose by 0.5% p.a. compound over the last twenty years, (the same figure as for the LDCs taken as a group, though it fell in African and Oceanic LDCs).[68] Taking the world as a whole, the last ten years or more have been characterized by food surpluses, not shortages. It may well be that the negative aspects of potential food output can be shown to be gaining on the positive aspects, in spite of the slowing down in the rate of growth of population. But those who make such claims should demonstrate how.

Thus, if one begins from the simple facts, there is no obvious reason for alarm either about the world's capacity to feed the growing population or the pressure of rapidly growing demands on supplies of so-called "finite" resources. Of course, this leaves aside other resources that are even less quantifiable, such as access to clean air and water, or soil that has not been poisoned by pollutants or denuded by soil erosion, or environmental resources included in concepts of "biodiversity".

(b) Optimality or sustainability.

Hence, the fact that world is not, apparently, running down reserves of minerals or exhausting its capacity to feed a growing population, does not mean that there is no need to examine the question of our obligations to leave to posterity a decent environment defined more widely. So suppose that, in the very long run, there is a problem of damaging the Earth's environment or running down the Earth's resource base in one way or the other. How should we take account of this in general, or, in particular, how should we take account of the concept of "sustainability"? And what relation does it bear to the more familiar economist's concept of optimal growth?

Economists traditionally approach the problem of optimal growth policy as a problem of maximizing the present value of some consumption stream subject to certain constraints such as the size of the capital stock that is to be left in place at the end of the period in question. Various value judgements enter into this formulation of the problem, notably those concerning the society whose consumption is to be maximized, the time period in question, the degree of restriction of individual liberty that is envisaged, and so on. The size of the capital stock, or its equivalent, that should be left at the end of the period in question is also, of course, an important value judgement, and it must be admitted that it is one that has been sorely neglected in the economics literature.

For any decision concerning the optimal size of this closing stock has implications for the inter-generational distribution of incomes. It is commonplace that the optimal allocation of resources at any moment of time, in a timeless model, may be defined in terms of equality of various marginal conditions (marginal productivities, utilities and so on) without necessarily generating an income distribution that would satisfy our views of distributive justice. In the same way the application of the basic rule of optimal allocation of resources over time - i.e. equality of rate of return on investment with the social rate of discount - might lead to an inter-temporal distribution of incomes that does not match our views on distributive justice.

The same applies, though not quite so directly, to another parameter of the optimization problem as set out above, namely the discount rate used to convert future income levels into commensurate units

[68] UNCTAD Handbook of International Trade and Development Statistics, 1989, page 456, Table 6.5 (data taken from an FAO data tape).

with current income levels.

Hence, before accepting any particular constraint on the closing stock of assets (however defined) one needs to see how far it is justified in terms of some acceptable theory of distributive justice. Environmentalist critics of the economist's paradigm of optimal growth are quite right in pointing out that a major value judgement involving distributional justice is generally ignored.

Looked at this way, the problem seems to be to see what an acceptable theory of distributive justice would tell us about (i) the constraint relating to the closing date's stock of assets and (ii) the discount rate used to convert future incomes (or welfare) streams into units that are commensurate with present values. Unfortunately, there is no agreed and obviously compelling general theory of distributive justice. Philosophers have debated this topic for at least 2,300 years (the first known discussion of the subject was in Aristotle's Nichomachean Ethics) without coming to any clear conclusion. But since that is a vast and well-tilled field I shall not go into it here. However, the absence of any agreed theory of distribution justice in general, let alone one that deals with the special problems of inter-generational justice, has not prevented the spread of the assumption that "sustainable" development has some morally compelling value.[69]

(c) Definitions and normative prescription

In popular discussion of this problem there is a proliferation of definitions of "sustainability" often accompanied by an appeal to the Hicksian definition of the concept of income. But there is an enormous difference between, on the one hand, what is a matter of definition, notably the definition of the concept of "income" as the amount an individual, a nation, or the world's population, can consume whilst leaving the stock of capital intact and, on the other hand, what is a normative prescriptive matter. There is nothing normative about any definition of "income" any more than about the concept of "net profits from abroad" or of some unit of energy. Under some circumstances it may be preferable and perfectly ethical, given some higher level value judgements, to run down the capital stock or to add to it. The fact that in one case one would be consuming more than one's income and in the other case less than one's income does not necessarily carry any normative significance at all.

What is the appropriate constraint to adopt with respect to any closing level of capital stock - however widely defined - is a matter of technical relationships and preference patterns. It is true that these preference patterns should take account of society's value judgements of a distributional character. In the case of leaving a capital stock to posterity these value judgements should emerge from a theory of distributional justice as applied to different generations. But there is no presumption that such a theory prescribes that any particular level of capital stock should be left to any particular future date in time.

Furthermore, how operational would any such concept of the required closing stock be? One, "hard" version of the "sustainability" concept is that we should bequeath to future generations the same amount of every single component of the environment that one can identify. This definition of the closing stock is at least relatively clear and precise, if not measurable in practice. But surely no theory of distributive justice could confer moral authority on such a constraint. For the cost of achieving any given level (such as maintaining the present level) of every single plant, insect or environmental asset may be astronomic - not just in resource terms but in terms of the human suffering resulting from the allocation of the resources to this objective rather than to, say, the relief of hunger, poverty, sickness and disease. For example, few people would subscribe to the value judgement that the preservation of every single

[69] For a very recent survey of the philosophical issues see forthcoming article by Joanna Pasek "Obligations to Future Generations: A Philosophical Note," World Development, Special Issue on the Environment, April 1992.

one of the over 2 million species of beetles that are believed to exist should be an aim of policy even if it meant prolonging the suffering imposed on millions of children in the developing world on account of inadequate water supply and sanitation, health care and nutrition.

Of course, as David Pearce points out in Blueprint for a Green Economy, there is a whole range of definitions of "sustainability" and some of them seem to be in terms of a "sustainability" constraint that might be more morally acceptable. For example, we might interpret the "sustainability" constraint as a requirement to leave to future generations a stock of assets that gives it some predetermined level of potential for welfare, such as that existing to-day. But even if the difficulties of justifying this constraint in terms of some acceptable theory of inter-generational justice are easier to overcome than with the "hard" concept of sustainability, it is totally non-operational. As Dasgupta and Maler pointed out recently, it is devoid of informational content[70]. For in the absence of any knowledge of future preference patterns and technological possibilities it is impossible to know what substitutions would permit the same level of welfare to be obtained from different combinations of assets - more trees and less insects? more machines and less fish?

Thus the aggregative concept of global "sustainability" that is so widely encountered these days in any environmental discussion seems to have either no clear basis in moral philosophy or no operational value, or neither. As a result, it is not possible to answer a whole battery of questions that are often raised such as "what is a sustainable path of development"? Either the goal is morally repugnant, such as handing down exactly the same environmental capital as we have today - a goal that also happens to be totally impracticable, of course - or it is undefinable. For we simply have no basis for judging what the trade-offs would be in the future between, say, work and leisure, certain forms of economic activity and others, economic welfare as against non-economic welfare of the kind one may obtain from the environment, and so on. Since the goal cannot be defined, therefore, there is no answer to questions about how one should achieve it. Scientists, even social scientists, should not expect to be taken seriously if they go around asking unanswerable and meaningless questions.

(d) Old-fashioned project sustainability

By contrast, the notion of "sustainability" in respect of project design and management is a much more useful concept. It is true that, as Little and Mirrlees recently put it "Sustainability has come to be used in recent years in connection with projects. This is more of a buzzword ...It has no merit. Whether a project is sustainable (forever? - or just for a long time?) has nothing to do with whether it is desirable. If unsustainability were really regarded as a reason for rejecting a project, there would be no mining, and no industry. The world would be a very primitive place".[71]

But although Little and Mirrlees are no doubt correct in pointing out that sustainability is by no means a sufficient condition for a project, there is plenty of evidence for the view that failure to pay due regard to a project's sustainability over a relevant time period has often been a major reason for the failure of many projects to perform as planned. And this is often not just a matter of ensuring the proper maintenance of the project in question. It is often also a matter of ensuring the provision of various ancillary and related services - such as education, health care, transport, and so on.

---

[70] Dasgupta, P. and Mäler, K-G., The Environment and Emerging Development Issues", in The World Bank Economic Review, Proceedings of the World Bank Annual Conference on Development Economics 1990.

[71] Little I.M.D. and Mirrlees J.A. "Project Appraisal and Planning Twenty Years On", The World Bank Economic Review, Proceedings of the World Bank Annual Conference on Development Economics, 1990, page 365.

For example, a 1987 World Bank survey of water projects reported that "..in country after country systems are going out of operation almost as fast as they are being built", as a result of various factors, one of them being lack of capacity of the local communities to ensure even basic maintenance of fairly simple machinery.[72] The same applies to measures to reduce industrial pollution. For example, in Algeria it is reported that a significant proportion of systems for controlling industrial pollution are often out of action for various reasons including lack of trained manpower.[73] In some cases the problem is not so much lack of sufficiently skilled manpower but lack of incentives to carry out the maintenance.[74]

An operationally useful concept of "sustainable" development, therefore - by contrast with the one that is bandied around in much popular discussion - is that development projects have to take account of the requirements of maintenance and, possibly, accompanying developments in other fields, including education, in order to ensure that the benefits of the project are maintained over the economically optimal period. "Sustainability" certainly has a role to play in development economics. But it bears little relation to the concept of "sustainability" that is currently so much in vogue, and which - in spite of its proponents posture of occupying the moral high ground - has either no morally compelling value or little, if any, operational significance.

---

[72] Churchill A.A. with the assistance of de Ferranti, D., Rocher, R., Tager, C., Walters, A.A., and Yazer, A., World Bank Discussion Paper, Rural Water Supply and Sanitation: Time for a Change, Sept. 1987, p.1.

[73] World Bank staff information.

[74] U.S. AID Program Impact Evaluation Report No. 7, Community Water Supply in Developing Countries: Lessons from Experience, Washington D.C., Sept. 1982, p. 17.

ANNEX 3 STATISTICAL TABLES

Table	Title
3.1	Water Availability and Income Quintiles
3.2	Access to Sanitation and Income Quintiles
3.3	Urban Sulphur Dioxide Concentrations
3.4	Urban SPM Concentrations
3.5	Reversals in Urban Sulphur Dioxide Concentrations
3.6	Comparative Trends in Urban Sulphur Dioxide and Carbon Dioxide Emissions in Selected Countries, 1975-85
3.7	Population, Passenger Cars, and Air Pollution in Selected Cities
3.8	Output and Growth of New Pollutants, US

Table 3.1 **Water Availablity and Income Quintiles**

COUNTRY CODE	1975 DATA TOTAL WATER AVAIL	1975 DATA RURAL WATER AVAIL	1975 DATA URBAN WATER AVAIL	1975 DATA PERCAP INCOME	1985 DATA TOTAL WATER AVAIL	1985 DATA RURAL WATER AVAIL	1985 DATA URBAN WATER AVAIL	1985 DATA PERCAP INCOME
ETH	8	1	58	129	14	9	69	105
TZA	39	36	88	163	49	42	90	132
BGD	56	61	22	99	44	49	24	149
NPL	8	5	85	124	28	25	70	172
MDG	25	14	76	313	31	17	81	268
ZAR	19	12	38	300	33	21	52	277
BUR	17	14	31	212	27	24	36	293
HVO	25	23	50	238	65	69	43	304
IND	31	18	80	280	57	50	76	312
QUIN 1	25	20	59	206	39	34	60	224
PAK	25	5	75	189	43	27	83	325
NER	27	26	36	386	46	49	35	327
ZMB	42	16	86	438	58	41	76	331
HTI	12	3	46	347	38	30	59	335
GHA	35	14	86	434	56	39	93	377
TGO	16	10	49	405	57	41	100	397
LKA	19	13	36	293	40	29	82	416
BEN	34	20	100	348	57	34	80	419
IDN	11	4	41	241	39	36	43	426
QUIN 2	25	12	62	342	48	36	72	373
LSO	17	14	65	295	35	30	65	538
PHL	50			569	52	54	49	559
BOL	34	6	81	866	53	27	82	618
HND	41			798	46	45	46	796
DOM	55	27	88	617	50	24	73	814
GTM	39	14	85	855	58		89	840
PNG	20	19	30	1000	25	15	95	892
THA	25	16	69	534	64	66	56	908
QUIN 3	35	16	70	692	48	37	69	746
NIC	56	14	100	1729	48	11	76	931
SLV	53	28	89	1123	54	40	68	954
ECU	36	8	67	895	57	31	81	1051
BWA	45	39	95	449	54	46	84	1087
PRY	13	5	25	713	22	8	48	1320
PER	47	15	72	1271	53	17	73	1334
CRI	72	56	100	1515	93	82	100	1460
MUS	60	22	100	1059	100	100	100	1537
QUIN 4	48	23	81	1094	60	42	79	1209

CHL	70	28	78	1426	87	29	98	1538
MEX	62	49	70	1360	70	51	79	1701
MYS	34	6	100	1293	83	76	96	1875
PAN	77	54	100	1799	82	63	100	2112
KOR	66	38	95	1319	76	48	90	2617
TTO	93	100	79	3692	98	95	100	4299
BRB	100	100	100	4135	100	99	100	5030
SGP	100		100	4029	100		100	7803
QUIN 5	75	54	90	2381	87	66	95	3372

Notes: Quintiles based on income ranking for 1985 in $US 1987.
Country codes follow the World Bank's BESD format.
All income figures are in $US 1987.

Source: Bank Social and Economic Database (BESD).

Table 3.2 Access to Sanitation and Income Quintiles

COUNTRY CODE	1980 DATA			1985 DATA		
	SAN URBAN	SAN RURAL	PERCAP INCOME	SAN URBAN	SAN RURAL	PERCAP INCOME
SLE	31	6	168	86	20	142
BGD	21	1	151	20	6	149
NPL	16	1	139	54	1	172
GNB	21	13	151	29	18	185
MLI	79		215	100		220
BDI	40	35	175	90	15	226
MDG	9		290	12		268
BUR	38	15	274	35	26	293
HVO	38	5	257	38	5	304
IND	27	1	247	40	4	312
PAK	42	2	259	56	5	325
QUINTILE 1	33	9	211	51	11	236
RWA	60	50	364	77	55	329
HTI	42	10	392	42	14	335
GHA	47	17	425	63	22	377
SLB	80	21	309	90		393
TGO	24	10	459	31	9	397
LKA	80	63	323	69	41	416
BEN	48	4	392	60	10	419
IDN	29	21	322	32	38	426
SDN	73		468	40	5	434
LSO	13	14	342	22	20	538
PHL	81	67	650	76	66	559
QUINTILE 2	52	28	404	55	28	420
BOL	37	4	755	51	22	618
SEN	100	2	611	87		618
EGY		10	529	100	65	645
CPV	34	10	560	41		676
HND	49	26	887	22	38	796
DOM	25	4	690	72	59	814
GTM	45	20	1029	73	42	840
PNG	96	3	813	99	35	892
THA	64	41	673	81	57	908
NIC	34		1072	35	16	931
SLV	48	26	1021	89	35	954
QUINTILE 3	53	15	785	68	41	790

ECU	73	17	1047	79	34	1051
TUR	56		1131	95	90	1193
COL	93	4	1021	96	13	1196
JAM	12	2	1174	92	90	1223
SYR	74	28	1191	72	55	1294
TUN	100		1097	84	16	1301
PRY	95	80	963	66	40	1320
PER	57	0	1129	67	13	1334
CRI	99	84	1633	100	88	1460
MUS	100	90	1250	100	95	1537
CHL	100	10	1321	79	21	1538
QUINTILE 4	78	35	1178	85	50	1313
MEX	77	12	1550	77	15	1701
MYS	100	55	1590	100	67	1875
PAN	83	59	1994	99	61	2112
URY	59	6	2192	59	59	2181
ARG	80	35	2926	76	35	2430
KOR	100	100	1807	100	100	2617
VEN	60	12	2675	57	5	2689
SUR	100	79	3653	100	100	3220
IRN	96	43	2351	90	24	3613
TTO	96	88	4988	100	100	4299
SGP	80		5226	99		7803
QUINTILE 5	85	49	2814	87	57	3140

Notes: Quintiles based on 1985 ranking in $US 1987.
All income figures are in $US 1987.
Numbers in table refer to percentage of the population with access to sanitation.

Source: Bank Social and Economic Data Base (BESD).

Notes for Tables 3.3 and 3.4

The only source of data for concentrations of pollutants in urban areas is GEMS (Global Environmental Monotoring System). GEMS provides annual averages and percentiles for SO2 and SPM levels in selected cities from 1973 onwards. Although the original 1973 data set included only a small number of cities (all in developed countries), the scope of the study has subsequently been expanded to include several cities in developing countries. Unfortunately, it is not uncommon to have large gaps in a particular city's pollution data. Data for some cities appear only once or twice in a ten year period. Data for others are from different monitoring sites over the sample period. The tables of SO2 and SPM concentrations were constructed with the following criteria:

- a city needed at least four observations to be included in the sample
- the observations had to come from the same monitoring site (GEMS usually has more than one site per city and these sometimes change)
- highest preference was given to centre city residential monitoring sites (followed by centre city commerical and suburban residential)

On the income side, cities have been classified into income groups according to the per capita GNP's of the countries in which they are located. The following definitions were used to group the cities by income level:

High Income Country	Following the World Development Report 1990, a high income country is one with a per capita GDP of over \$6000. (In the BESD, incomes are measured in constant \$US 1987.) The classification is made according to the income at the start of the GEMS data. Thus Spain, with a per capita income level of \$5327 in 1973, is considered middle income (although by 1988 it had made the high income list)
Low Income Country	A country is classified as low income if its per capita income is below \$700 at the start of the available data. Under the Bank classification of \$545, the SO2 sample would only include Chinese and Indian cities. Under the broader definition Manila and Bangkok are included.

Middle Income Countries are those with per capita GDP between \$700 and \$6000 in the initial year of the GEMS data.

Because of the scarcity of data, it was not possible to have the same beginning and terminal year for all of the cities in data set. Therefore each city has an initial and an terminal year for its own data. These years are noted in the relevant locations on the tables.

Table 3.3 Urban Sulphur Dioxide Concentrations

City	First Yr	Income	SO2	End Yr	Income	SO2	% chg SO2
LOW INCOME GROUP							
Beijing	1981	195	98	1989	295	115	2.0
Shanghai	1981	195	52	1989	295	104	9.1
Guangzhou	1981	195	66	1989	295	99	5.2
Shengyang	1981	195	29	1989	295	70	11.6
Xian	1981	195	108	1989	295	98	-1.3
Bombay	1978	239	29	1982	312	29	0.0
Calcutta	1973	239	70	1982	312	90	2.9
Delhi	1978	268	34	1982	312	39	3.5
Manila	1977	569	57	1982	711	82	7.6
Bangkok	1981	673	14	1989	1094	13	-0.9
LOW GROUP AVERAGE			56			74	4.1
MIDDLE INCOME GROUP							
Bogota	1976	922	18	1982	1064	14	-4.0
Santiago	1976	1115	46	1984	1448	46	0.1
Seoul	1978	1599	178	1983	2297	119	-7.7
Rio de Janeiro	1976	1739	57	1982	1798	86	7.0
Sao Paolo	1976	1739	117	1988	1837	55	-6.1
Caracas	1976	3364	21	1988	2605	21	0.2
Hong Kong	1975	3663	14	1984	7402	32	9.6
Madrid	1973	5327	192	1989	7777	32	-10.7
MIDDLE GROUP AVERAGE			80			51	-5.4
HIGH INCOME GROUP							
Sydney	1975	8537	31	1985	11678	13	-8.3
London	1973	9580	175	1985	11720	43	-11.1
Brussels	1973	10026	185	1982	16381	71	-10.2
Tokyo	1973	10993	60	1988	18458	19	-7.4
Frankfurt	1973	12044	107	1989	20786	26	-9.6
Montreal	1976	12223	23	1985	15585	14	-5.4
New York	1978	16444	91	1986	18070	52	-6.7
HIGH GROUP AVERAGE			96			34	-8.8

Notes: Income is measured in constant 1987 $US per head.
SO2 measurements are in micrograms per cubic meter.
"% chg SO2" is the average annual percentage change in the SO2 concentration. In the rows for the group averages the entry is the growth of the average and not the average group growth rate.

Sources: GEMS, Air Quality in Selected Urban Areas, Geneva: World Health Organization (various issues 1973-82).
Environmental Data Report, 3rd ed., London: UNEP, 1991.
Bank Economic and Social Database. (for income figures)
State of the Environment in Asia and the Pacific, Bangkok: UN, draft copy. (Seoul data)

Table 3.4 Urban SPM Concentrations

City	First Yr	Income	SPM	End Yr	Income	SPM	% chg S
LOW INCOME GROUP							
Guangzhou	1981	195	212	1984	248	207	-0.8
Shanghai	1981	195	255	1984	248	187	-9.8
Shengyang	1981	195	405	1984	248	502	7.4
Xian	1981	195	359	1984	248	466	9.1
Bombay	1978	268	166	1982	297	166	0.1
Calcutta	1977	268	419	1982	297	356	-3.2
Dehli	1978	268	408	1982	297	344	-4.2
Jakarta	1978	323	210	1982	367	216	0.6
Cairo	1975	398	64	1980	529	101	9.6
Manila	1978	629	92	1982	711	100	2.1
Bangkok	1978	641	145	1982	773	151	1.0
LOW GROUP AVERAGE			249			254	0.6
MIDDLE INCOME GROUP							
Bogota	1976	922	33	1982	1064	28	-2.2
Santiago	1976	1115	75	1982	1430	203	18.1
Kuala Lumpur	1978	1375	90	1982	1856	101	2.8
Lima	1976	1425	33	1980	1129	12	-21.6
Rio de Janeiro	1976	1739	31	1982	1798	105	22.7
Sao Paolo	1976	1739	98	1982	1798	74	-4.6
Caracas	1976	3364	20	1982	2760	27	5.1
Hong Kong	1975	3663	48	1982	6578	57	2.5
Madrid	1973	5327	186	1982	7685	128	-4.1
MIDDLE GROUP AVERAGE			68			82	3.1
HIGH INCOME GROUP							
London	1973	9580	42	1982	11585	24	-6.0
Sydney	1977	9895	92	1982	9767	98	1.3
Tokyo	1973	11146	67	1982	18664	57	-1.8
Brussels	1973	10026	41	1982	16381	34	-1.9
Montreal	1976	12223	92	1982	13284	46	-10.9
Frankfurt	1975	13724	59	1982	18768	24	-12.1
New York	1977	15952	27	1982	16007	20	-4.9
HIGH GROUP AVERAGE			60			43	-4.5

Notes: See notes for Table 3.3: Urban SO2 Concentrations.
SPM measurements are in micrograms per cubic meter.

Sources: GEMS, Air Quality in Selected Urban Areas, Geneva: World Health Organization (various issues 1973-82).
Environmental Data Report, 3rd ed., London: UNEP, 1991.
Bank Social and Economic Database (BESD).

Table 3.5 Reversals in Urban Sulphur Dioxide Concentrations

ACTUAL SO2 CONCENTRATION (in ug/m3)

CITY	1976/7	1978/9	1980/1	1982/3	1984/5	1986/7	1988/9
Montreal SR	23.0	24.5	27.5	23.0	23.0	14.0	
Caracas CCC	20.5	27.5	29.5	34.0	27.0	21.0	21.0
Beijing CCR			98.0	147.0	161.0	125.0	114.5
Dublin CCR	49.0	49.5	65.5	47.0	40.0	49.0	28.5
Madrid CCC	68.0	80.0	111.5	80.5	47.5	50.5	31.5

INDICES OF SO2 CONCENTRATIONS (INITIAL VALUE = 100)

CITY	1976/7	1978/9	1980/1	1982/3	1984/5	1986/7	1988/9
Montreal	100.0	106.5	119.6	100.0	100.0	60.9	
Caracas	100.0	134.1	143.9	165.9	131.7	102.4	102.4
Beijing			100.0	150.0	164.3	127.6	116.8
Dublin	100.0	101.0	133.7	95.9	81.6	100.0	58.2
Madrid	100.0	117.6	164.0	118.4	69.9	74.3	46.3

Notes: SR = suburban residential, CCR = centre city residential, CCC = centre city commercial monitoring site.

Sources: GEMS, Air Quality in Selected Urban Areas, Geneva: UNEP, (1976-82).
Environmental Data Report, 3rd ed., London: UNEP, 1991, pp. 30-32.

Table 3.6 **Comparative Trends in Urban Sulphur Dioxide and Carbon Dioxide Emissions in Selected Countries, 1975-85**

	SOX	CO2
United States	-2.03	0.57
Canada	-3.55	0.54
Japan	-5.04	0.04
West Germany	-5.48	0.10
United Kingdom	-3.50	-0.67
Italy	-4.57	1.66

	CO2 Emissions 1975	CO2 Emissions 1985	GROWTH
World	4811	5802	1.89
OECD	2522	2648	0.49
Non-OECD	2289	3154	3.26

Notes: SOx emissions are in thousand tonnes.
CO2 emissions are in million tonnes.

Source: Environmental Indicators, Paris: OECD, 1991, pp. 17, 21.

Table 3.7 Population, Passenger Cars, and Air Pollution in Selected Cities

Table 3.7: POPULATION, PASSENGER CARS AND AIR POLLUTION IN SELECTED CITIES

LEVELS

CITY	POPULATION (millions) 1970	1980	'000 PASS. CARS 1970	1980	CARS/1000 POP 1970	1980
Bangkok	3.11	4.75	172	367	55.2	77.3
Bogotá	2.37	3.53	85	180	35.8	51.0
Bombay	5.81	8.07	100	180	17.1	22.3
Cairo	5.33	6.94	50	239	9.3	34.4
Calcutta	6.91	9.03	55	95	8.0	10.5
Hong Kong	3.40	4.49	98	200	28.8	44.5
Jakarta	3.92	5.99	87	222	22.2	37.1
Lima	2.93	4.43	166	333	56.7	75.2
Manila	3.54	5.96	123	266	34.8	44.6
Rio de Janeiro	7.04	8.79	305	957	43.4	108.9
Sao Paolo	8.01	12.10	913	1935	114.0	159.9
Seoul	5.31	8.28	42	127	7.9	15.3
AVERAGE	4.81	6.86	183	425	36.1	56.8

GROWTH RATES 1970-80

CITY	POPULATION	CARS	CARS PER HEAD	AIR POLLUTANTS SO2	SPM
Bangkok	4.3	7.9	3.4	-0.9	1.0
Bogotá	4.1	7.8	3.6	-4.0	-2.2
Bombay	3.3	6.1	2.7	0.0	0.1
Cairo	2.7	17.0	14.0	NA	9.6
Calcutta	2.7	5.6	2.8	2.9	-3.2
Hong Kong	2.8	7.4	4.5	9.6	2.5
Jakarta	4.3	9.8	5.2	NA	0.6
Lima	4.2	7.2	2.9	NA	-21.6
Manila	5.3	8.0	2.5	7.6	2.1
Rio de Janeiro	2.2	12.1	9.6	7.0	22.7
Sao Paolo	4.2	7.8	3.4	-6.1	-4.6
Seoul	4.5	11.7	6.8	-7.7	NA
AVERAGE	3.7	9.0	5.1	0.7	0.6

Note: Years for SO2 and SPM data vary according to availability. See Tables 3.3 and 3.4.

Sources: World Urbanization Prospects 1990, UN, forthcoming.
Urban Transport, A World Bank Policy Study, Washington: World Bank, pp. 46-47. (70-80 car data)

Table 3.8 Output and Growth of New Pollutants, US

CHEMICAL/OUTPUT (in mill lbs/year)	(1) AVG 63-65	(2) AVG 73-75	(3) AVG 84-86	(4) INDEX (2)/(1)	(5) INDEX (3)/(2)	(6) INDEX (3)/(1)
AMMONIUM SULFATE	599	777	873	129.9	112.4	145.9
SULFURIC ACID	515	658	690	127.7	105.0	134.1
NICKEL	32	41	33	127.0	81.8	103.9
ASBESTOS (FRIABLE)	63	77	84	121.9	108.9	132.8
AMMONIA	249	333	360	133.7	108.0	144.4
CHLORINE	63	82	89	130.3	108.4	141.3
HYDROCHLORIC ACID	552	780	905	141.4	116.0	164.1
METHANOL	536	724	908	135.0	125.5	169.5
CARBON DISULFIDE	101	144	186	143.5	129.0	185.0
TETRACHLOROETHYLENE	73	92	110	125.5	120.6	151.3
TOLUENE	903	1147	1438	127.0	125.4	159.2
NAPHTHALENE	11	14	16	128.9	111.0	143.1
AVERAGE	308	406	475	131.0	112.7	147.9
GNP (in billions of $)	1.99	2.72	3.61	136.8	132.7	181.6

CHEMICAL/OUTPUT GR	(7) 64-74 GROWTH	(8) 74-85 GROWTH	(9) 64-85 GROWTH
AMMONIUM SULFATE	2.6	1.1	1.8
SULFURIC ACID	2.5	0.4	1.4
NICKEL	2.4	-1.8	0.2
ASBESTOS (FRIABLE)	2.0	0.8	1.4
AMMONIA	2.9	0.7	1.8
CHLORINE	2.7	0.7	1.7
HYDROCHLORIC ACID	3.5	1.4	2.4
METHANOL	[illegible]	2.1	2.5
CARBON DIS[illegible]	[illegible]	2.3	3.0
TETRAC[illegible]	[illegible]	1.7	2.0
TO[illegible]	[illegible]	2.1	2.2
[illegible]	[illegible]	1.0	1.7
[illegible]	[illegible]	1.0	1.8
[illegible]	[illegible]	2.6	2.9

Ralph Stengren, IENIN, World Bank.

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS934	Public Hospital Costs and Quality in the Dominican Republic	Maureen A. Lewis Margaret B. Sulvetta Gerard M. LaForgia	July 1992	P. Trapani 31947
WPS935	The Precautionary Demand for Commodity Stocks	Boum-Jong Choe	July 1992	S. Lipscomb 33718
WPS936	Taxation, Information Asymmetries, and a Firm's Financing Choices	Andrew Lyon	July 1992	C. Jones 37699
WPS937	How Soft is the Budget Constraint for Yugoslav Firms?	Evan Kraft Milan Vodopivec	July 1992	CECSE 37178
WPS938	Health, Government, and the Poor: The Case for the Private Sector	Nancy Birdsall Estelle James	July 1992	S. Rothschild 37460
WPS939	How Macroeconomic Policies Affect Project Performance in the Social Sectors	Daniel Kaufmann Yan Wang	July 1992	D. Kaufmann 37305
WPS940	Private Sector Approaches to Effective Family Planning	Karen G. Foreit	August 1992	O. Nadora 31091
WPS941	Projecting the Demographic Impact of AIDS	Rodolfo A. Bulatao Eduard Bos	August 1992	O. Nadora 31091
WPS942	Efficient Environmental Regulation: Case Studies of Urban Air Pollution (Los Angeles, Mexico City, Cubatao, and Ankara)	Arik Levinson Sudhir Shetty	August 1992	WDR 31393
WPS943	Burden-sharing among Official and Private Creditors	Asli Demirgüç-Kunt Eduardo Fernández-Arias	August 1992	K. Waelti 37664
WPS944	How Public Sector Pay and Employment Affect Labor Markets: Research Issues	Gail Stevenson	August 1992	PHREE 33680
WPS945	Managing the Civil Service: What LDCs Can Learn from Developed Country Reforms	Barbara Nunberg	August 1992	P. Infante 37642
WPS946	Retraining Displaced Workers: What Can Developing Countries Learn from OECD Nations?	Duane E. Leigh	August 1992	PHREE 33680
WPS947	Strategies for Creating Transitional Jobs during Structural Adjustment	Stephen L. Mangum Garth L. Mangum Janine Bowen	August 1992	PHREE 33680

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
[illegible]	Factors Affecting Private Financial Flows to Eastern Europe, 1989-91	Mohua Mukherjee	July 1992	R. Lynn 32169
WPS949	The Impact of Formal Finance on the Rural Economy of India	Hans Binswanger Shahidur Khandker	August 1992	H. Binswanger 31871
WPS950	Service: The New Focus in International Manufacturing and Trade	Hans Jürgen Peters	August 1992	A. Elcock 33743
WPS951	Piecemeal Trade Reform in Partially Liberalized Economies: An Evaluation for Turkey	Glenn W. Harrison Thomas F. Rutherford David G. Tarr	August 1992	D. Ballantyne 38004
WPS952	Unit Costs, Cost-Effectiveness, and Financing of Nutrition Interventions	Susan Horton	August 1992	O. Nadora 31091
WPS953	The "Pedigree" of IEC Conversion Factors for Per Capita GNP Computations for the World Bank's Operational Guidelines and *Atlas*	Michael Hee	August 1992	E. Zamora 33706
WPS954	How OECD Policies Affected Latin America in the 1980s	Chris Allen David Currie T. G. Srinivasan David Vines	August 1992	T. G. Srinivasan 31288
WPS955	OECD Fiscal Policies and the Relative Prices of Primary Commodities	George Alogoskoufis Panos Varangis	August 1992	D. Gustafson 33714
WPS956	Regression Estimates of Per Capita GDP Based on Purchasing Power Parities	Sultan Ahmad	August 1992	E. O'Reilly-Campbell 33707
WPS957	Carbon Taxes, the Greenhouse Effect, and Developing Countries	Anwar Shah Bjorn Larsen	August 1992	WDR Office 31393
WPS958	EC Bananarama 1992: The Sequel — The EC Commission Proposal	Brent Borrell Maw-Cheng Yang	August 1992	A. Kitson-Walters 33712
WPS959	Waterborne Diseases in Peru	Sheila Webb and Associates	August 1992	WDR Office 31393
WPS960	Agricultural Pricing and Environmental Degradation	Edward B. Barbier Joanne C. Burgess	August 1992	WDR Office 31393
WPS961	Economic Development and the Environment: Conflict or Complementarity?	Wilfred Beckerman	August 1992	WDR Office 31393
WPS962	Do Markets Underprice Natural-Resource Commodities?	Margaret E. Slade	August 1992	WDR Office 31393