CONSUMPTION PATTERNS

THE DRIVING FORCE OF ENVIRONMENTAL STRESS

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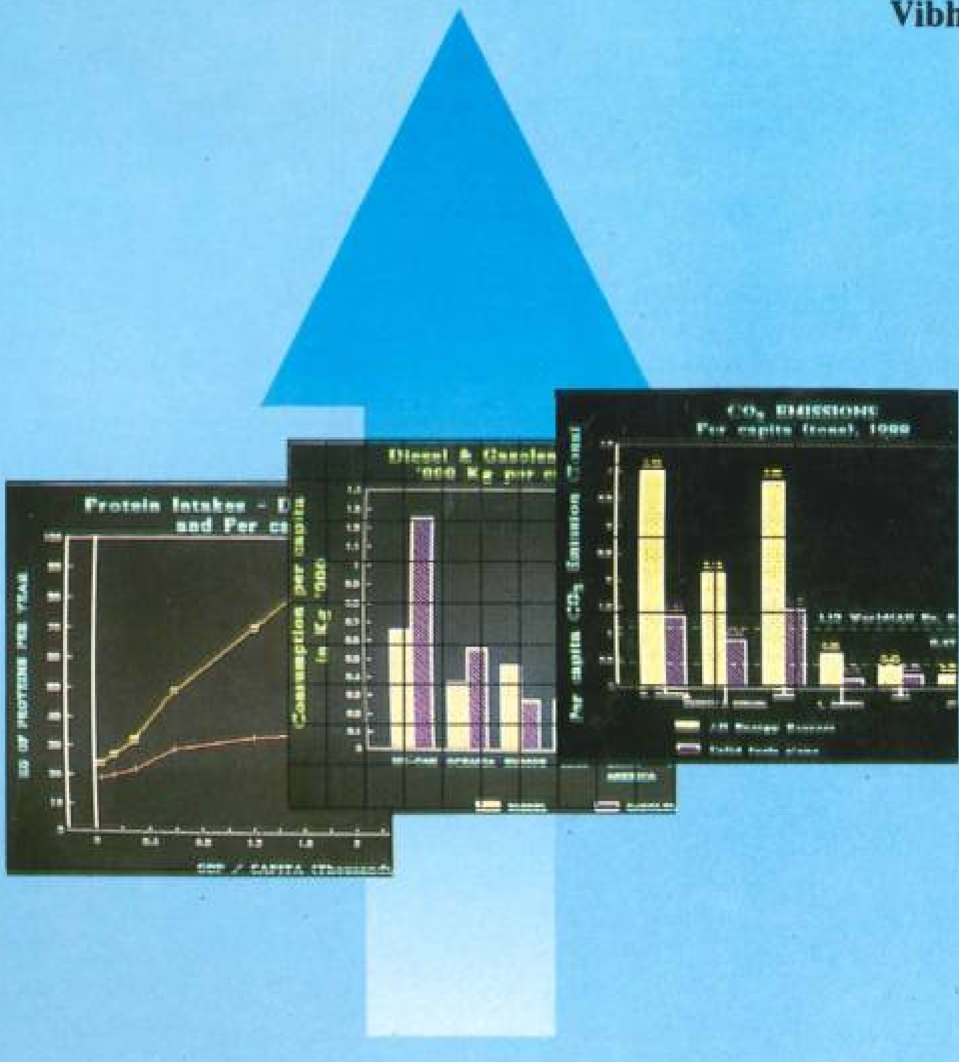

Indira Gandhi Institute of Development Research

Consumption Patterns: The Driving Force of Environmental Stress

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We have used a lot the information provided by the World Resource Institute, Washington who have done extensive work in this area. While we have suggested some modifications in their approach and interpretation to reflect our perceptions.

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Consumption Patterns:

The Driving Force of Environmental Stress

EXECUTIVE SUMMARY

The present patterns of development pose serious threats to the global eco-system. The compulsions of poverty force the poor to live off the natural resources of the land and their environment. On the other hand, the insatiable desires for ever-increasing material comforts of the economically affluent also lead to severe stress on the environment. While the consumption patterns of the poor are unsupportable in terms of land-use and cause degradation of the village commons, those of the rich are unsustainable in terms of non-renewable resources bearing down on global commons at present. Together, they stress the carrying capacity of the earth; at present and in future.

Far too many persons suffer from poverty and deprivation. The sufferings of the poor cannot be relieved without economic development. We would like such development to be sustainable development in which the growth of the "goods" needed for improving the welfare of mankind is not constrained by the environmental "bads" or by the availability of required resources.

The environmental stress of underdevelopment as well as affluence can be studied in terms of consumption patterns, demographic pressures, rural-urban divide and urbanization.

In this paper, per capita and aggregate consumption levels and the environmental consequences of population growth and urbanization in selected developed and developing countries are quantified. The resource needs for overall economic development, the consequences of continued poverty and the trade-offs and priorities among local, regional and global environmental problems are examined. Finally, some policy options to promote sustainable development in an equitable way at both the national level of developing countries and at the global level are discussed.

Each of these is summarised below:

Consumption Patterns and Population Growth

The developed countries (dvlpd.) have only 24% of the world population, but their share in global consumption of various commodities ranges from 50% to 90%. Even for the products that fulfill basic needs like cereals, milk and meat, the consumption of the developed countries constitute 48% to 72%. The consumption shares of the dvlpd. for other products are: 60% for fertilizer, 81% for paper, 86% for copper and aluminum, 80% for Iron and Steel, 85% for chemicals and 92% for cars. The share of energy consumption is 75% for the developed world and it is responsible for about 70% of the total CO_2 emissions. This also means that their per capita consumption is as high as 3 to 8 times that by the developing countries for items of basic needs and 20 times and more for items like chemicals and vehicles. The per capita carbon emissions from the rich countries are 7 times that of the developing countries. Thus, it is the consumption pattern of the developed countries that has led to the global environmental stress and appears to be unsustainable. Therefore, such consumptions need to be restrained as a first priority.

However, we also point out that in addition to curbing unsustainable consumption patterns, it is also necessary to contain the population growth because although in the short run population growth retards growth of per capita consumption and thereby generates less GHG emissions, a larger global population will eventually make it more difficult to reach a steady sustainable state.

Urban and Rural Environment

To what extent urbanization and big cities are responsible for the environmental degradation? These questions are examined in an econometric framework and it is concluded that the levels of overall emissions are largely the result of economic growth associated with urbanization rather than urbanization per se. It is observed that large cities experience greater pollution and health related problems as a result of a greater concentration of industrial activities. Pollution abatement in urban areas is an answer to this problem.

Our study shows that for developing countries the adverse effects on health from local pollution are serious problems. For example, ambient air quality in cities of developing countries have very high level of concentration of particulate pollutants (a daily mean of 200 and above micro gm/cum compared to 100 and below for cities in the developed countries). Air quality in the cities of developing countries has deteriorated whereas improvements are evident in the cities like New York and Tokyo that could afford pollution abatement costs.

Nevertheless, estimated greenhouse effects do appear to be related to countries' urbanization levels, due to high per capita commercial energy consumption in urban areas. This does not vary dramatically with characteristics of urban distribution in very large cities or otherwise.

Reduction in environmental pollution is best undertaken with a variety of economic instruments designed to deal with specific polluting sources in a technologically appropriate manner rather than curbing urbanization which seems to further overall developmental goals. Such actions might include a greater emphasis on mass transit in large cities of developing countries than what many developed countries have seen fit to accord.

Rural Environment

The rural population of developing countries face serious health hazards associated with the use of biofuels. A major part of the domestic energy (mainly cooking energy to the extent of 73%) is provided by biofuels that emit various kind of pollutants like particulates, oxides of sulpher and nitrogen, carbon monoxide, hydrocarbons, etc. The concentration of these pollutants inside the kitchen is several times the maximum recommended by WHO. This results in respiratory problems and other diseases, specially among the rural women who are directly exposed to these pollutants in the kitchens.

Socio-economic Trade-offs and Environmental Priorities

Environmental priorities have to be set depending upon the consequences of the various environmental effects, urgency with which redressal measures are required, the extent of the population involved, the costs to be incurred and whether it is the present or the future generation that is affected. These trade-offs are present at all stages:

- Among the local pollutants and the global pollutants
- Among greenhouse gases i.e. among the socio-economic activities that cause equivalent greenhouse effect.
- Among the regions of the world
- Among the present and the future generations.

Local and Global Pollutants

A variety of pollutants and effluents are generated due to various activities. Some have local effects, and some have global impacts. The "local pollutants" are oxides of sulfur (SOx) oxides of nitrogen (NOx), particulates (TSP), carbon monoxide (CO), etc., whereas global pollutants are carbon dioxide (CO_2), methane (CH_4) and chloroflurocarbons (CFCs). Many local pollutants (LP) have severe health effects. They enter through skin, lungs and eyes. Some of the local pollutants associated with biofuels are carcinogenic and some of these cause and aggravate cardiovascular and respiratory diseases if they exceed certain threshold levels. The health effects result from the total exposure which is obtained by multiplying the amount of pollutant, the number of hours of exposure exceeding the threshold level and the number of persons exposed. The health effects for women and children due to cooking with bio-fuels are substantial.

Trade-offs among Activities

To illustrate the question of trade-offs, let us take the case of greenhouse gases. What are the socio-economic trade-offs in reducing green house gas emissions? What does a reduction of 1000 tons of carbon mean in terms of curtailing socio-economic needs in the developing countries as opposed to the developed countries? 1000 t of carbon emissions represent fuelwood consumption for cooking by 2000 poor households. A reduction of 1000 t of carbon equivalent from methane emissions can be attained by reducing rice production (a staple food for poor) by an amount that is enough for 12000 persons, or by reducing cattle stock by 4000 heads depriving more than a 1000 households of a part of their food and fuel requirements. Alternatively, it could be achieved by reduced electricity production by an amount that would be enough for 2700 to 4600 households. It is clear that to meet developmental needs, emissions from developing countries are bound to increase in near future. On the other hand, the same reduction in GHG emission can be attained by burning less gasoline say by having 800 fewer cars in the USA.

Trade-offs among Regions

How much reduction would have to be done by others when some of the low income developing countries move closer to the world averages? As a simple exercise, we take India and China. We assume that global CO_2 emissions in 2025 should not be more than the 1986 level (i.e. 5.7 bill. tonnes of C).

We assume that per capita incomes increase modestly to $ 796 in 2025 from $ 249 in 1985 for India and $ 2000 in 2025 from $ 310 in 1985 for China. Furthermore we consider a low emissions scenario. Even then the aggregate emissions of these two countries increase by 21% of the gross GHG emissions of the world in 1986. This implies that to stabilize aggregate emissions, the emissions of the developed world have to be reduced by 30% just to provide for modest increases by India and China. It should be stressed that even in 2025, India's per capita emission even if it were calculated on the basis of India's population in 1985, remains lower than the world average in 1985.

Uncertainties in Estimates of Methane Emissions

The aggregate emission data for developing countries include methane emissions from paddy and livestocks. There is a lot of uncertainty about coefficients of methane emissions from the above sources and reliable data are not available. In fact, even the factors on which these depend are yet not properly understood. Therefore, these data and their use to attribute methane emissions to different countries have to be interpreted with caution. Uncertainties on methane emissions are too large to make it a basis for international negotiations.

CO_2 from Deforestation

The same is true of data on deforestation. The data available are not reliable and indicate unrealistic consumption patterns for fuelwood. Even the area deforestated appear to be unrealistic. These anomalies in the data seriously affect the estimate of the global natural sink capacity which is estimated as a difference between etimated gross emissions and measured increase of carbon in the global atmosphere. The sink capacity is high, if estimates of emissions are inflated, and low if these are corrected. Thus, based on CO_2 concentrations increase in atmosphere and two sets of data viz. Oakridge National Laboratory (ORNL) data and World Resources Institute (WRI) data on emissions, the sink capacity could be anywhere between 1.8 to 4.7 billion tons of carbon.

The Main Message

The study concludes that economic growth is desirable not only to mitigate the sufferings of the poor and raise their living standards, but also to reduce environmental degradation that is caused due to poverty. The present patterns of consumption of the rich is unsustainable with the currently available technology and hence this trend needs to be altered to limit environmental degradation. Population growth also needs to be controlled to be able to achieve steady state sooner and at a higher level of sustainable consumption patterns. The important question that arises is how the global environment can be preserved at a least cost. Cooperation of the rich and the poor is a must for this. A fair allocation of emission rights, that would allow development for the poor and adjustment to a sustainable pattern of consumption for the rich is a major requirement for this. Through a fair allocation of rights and marketable permits, the poor would also be able to set their own environmental priorities and through prudent behaviour be able to get capital necessary for development. Besides economic development, reduction of local pollution is also necessary for the developing world.

Specific policy actions like fuel substitution in favour of cleaner fuels like natural gas, energy efficiency improvements, promoting use of renewable sources of energy, and appropriate pricing of fuels (including internalizing the environmental costs wherever necessary) etc. can help in achieving the goals of reduction in environmental degradation and sustainable development. Mechanism like afforestation in third world countries, debt for nature swaps etc. can also be helpful if the condition of the arrangements are fully transparent and the overall impacts of these are fully understood by all.

There are many things we can do to reduce if not eliminate the danger to earth's ecology. If we act well and wisely and with charity, this is an opportunity we can seize to green the earth. For Earth's sake let us do that.

1

Issues and Scope

1.1 The Issues

Globally, there is a growing consensus on the need for sustainable development. It is also recognized that the present patterns of development pose serious threats to the global eco-system. If effective actions are not taken, it can cross some critical thresholds and leap into another phase which may be less friendly to life on earth. (Some say we are already in this phase). Such threats arise from many sources. The compulsions of poverty force the poor to live off the natural resources of the land and their environment. The poor who cannot afford to purchase fuels have no choice but to gather twigs and fuel wood from public land. The landless must graze their animals on the village commons. Population growth in many developing countries increases this pressure on land and other natural resources. On the other hand, the insatiable desires for ever-increasing material comforts of the economically affluent also lead top severe stress on the environment. And most persons in the world, if not all, aspire to be affluent. While the consumption patterns of the poor become unsupportable in terms of land use and its degradation of the village commons, those of the rich become unsustainable in terms of non-renewable resources and environmental impacts on the carrying capacity of the global commons. We need development for improving the welfare of mankind. Far too many persons suffer from poverty and deprivation. Table 1.1 shows the extent of poverty and its manifestations. The sufferings of the poor cannot be relieved without development. Only economic development can provide the finance, goods and services needed to alleviate such widespread deprivation. We would like such development to be sustainable development in which the growth of "goods" needed for improving the welfare of mankind is not constrained by the environmental "bads" or the availability of resources required as inputs. Production of goods and services requires resources and often generates certain undesirable joint products along with desired products and services. When corn is grown, it produces not only corn but also certain changes in soil quality; cultivation of paddy results likewise in emission of methane; generation of electricity with fossil fuel causes emissions of a variety of pollutants and CO_2 in the air; and so on. However, consumption is the driving force behind production as production is directed to fulfill demands. Thus, we should concentrate on consumption patterns, their resource contents and their environmental consequences. In a world of growing trade, consumption does not depend on domestic production alone. Countries import products and also produce for exports. A major reason why trade exists is that the resources used in producing the exports in general, are either different from the resources which would be required if goods are produced in the importing country or not available.

Table 1.1: The State of Human Deprivation in Developing Countries

	Millions of Persons
People below poverty line	1,200
Without access to health services	1,500
Without access to safe water	1,550
Without access to sanitation	2,200
Illiterate adults	1,200
Malnourished children under five	177
Children dying before age five	14.4
Children not in primary or secondary school	300
(of which female)	200

Source: UNDP (1991), Human Development Report 1991.

Therefore, it is important to appreciate that emission levels based on production activities are not the most relevant indicators. The responsibilities for emissions should be attributed to the final consumers. For example, if country A imports cars and country B imports energy and ore to make these cars from, say, the Mid-east and Australia respectively, the emissions due to oil production, transport and refinery as well as those due to ore mining, transport and processing in the two regions respectively are really driven by the demand in country A and should be attributed to the final consumers there. Such accounting will show when a country "passes the buck" to other countries. This way, global checks and balances could be introduced. As and when environmental legislation and its implementation become stringent, polluting activities are bound to be sent to poorer countries. A clean environment might then be a luxury good available only to those who can afford it. Therefore, the exporters of commodities ought to be at least fully compensated for the environmental burden they are undertaking.

With development, the per capita consumption increases and consequently, the patterns of consumption change. The rich consume goods in different proportions than the poor. With higher income, not only larger amounts of goods are consumed but also often these goods are of "higher quality" involving a greater degree of processing. Also, greater variety and convenience of use and access are demanded. Some new goods and services are also added to consumption. The resources embodied in the consumption, thus, change with development and so do environmental consequences. Even for a basic need like food, the resource requirements do not satiate as abruptly as one thinks (See Box 1.1). Reducing resource consumption patterns of the rich constitutes an important alternative for global resources and environmental management, an alternative not discussed enough.

Apart from economic development, growth of population can also increase consumption in a country. When the population increases, more goods have to be produced to continue to meet their basic needs. In particular, more food has to be produced. Either cultivated area has to expand, at the cost of forests and bio-diversity, or more intensive cultivation, with increased intensity of use of chemical inputs which results in water pollution.

Economic development and population growth are often associated with increased urbanization. The urban consumption patterns are different from the rural ones. Daily travel to work often using mechanized transport is needed in a city but not required to the same extent in a small rural community. While such transport does not directly contribute to welfare, it does increase resource needs and adds to air pollution. On the other hand, large cities offer possibilities of exploiting economies of scale in manufacturing which can reduce emissions, as well as in provision of infrastructural facilities such as clean water, waste treatment, health care, education and so on. Similarly, the size of the rural population has a bearing on the use of non-commercial energy resources, denudation of forest cover, over-grazing and decline in soil fertility. Naturally, therefore, rural to urban migration has consequences for resource use and environmental quality.

While the effects on environment of economic growth and demographic pressures are obvious, one should also recognize that lack of economic growth and poverty also lead to environmental stress. While as described above, poverty in rural areas lead to degradation of village commons and deforestation, the concentration of the poor in urban slums threaten health and hygiene.

1.2 The Scope of the Paper

The observations in the preceeding section raise a number of questions:

- What are the consumption levels of items important from environmental considerations, of different groups of countries in aggregate and on a per capita basis?
- What are the resource requirements of these consumption levels?
- What are the environmental consequences of these consumption patterns?
- How does population growth affect consumption patterns, resource use, and environmental stress? Would curtailing population growth reduce the environmental stress?
- How does urbanization affect the environment?
- What are the resource needs for economic development? What are the environmental consequences? What are the consequences of continued poverty?
- What are the trade-offs involved in environmental priorities among local and global environmental problems and what are the regional trade-offs?
- What uncertainties lie ahead in determining contributions of developing countries to greenhouse gas emissions from deforestation and agricultural methane?
- How to limit climate change while promoting greening of the earth?
- What are the policy options to promote sustainable development in an equitable way at both the national level of developing countries and at the global level?

In this paper, we have tried to provide quantitative answers to these questions. Naturally for such a vast canvas one cannot provide a detailed and comprehensive analysis. We therefore, confine our attention to those items of consumption that require use of important resources and to those environmental emissions that have significant consequences.

1.2.1 Environmental Priorities

A variety of pollutants and effluents are generated due to various activities. Some have local effects, and some have global impacts. The "local pollutants" are sulfur oxides (SOx) nitrogen oxides (NOx), total suspended particulates (TSP), Carbon monoxide (CO), etc., whereas global pollutants are carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4) and chlorofluro carbons (CFCs). The local pollutants (LP) have severe health effects. They enter through skin, lungs and eyes. Some of the local pollutants associated with biofuels are carcinogenic and some of these cause and aggravate cardiovascular and respiratory diseases if they exceed certain threshold levels. The health effects result from the total exposure which is obtained by multiplying the amount of pollutants, number of hours of exposure exceeding these threshold level and number of persons exposed. The health effects for women and children due to cooking with bio-fuels are substantial.

On the other hand, global pollutants (GP) such as those that cause global warming threaten the survival of the planet itself. GP are unfortunately not as well understood. In fact, how to compare the effects of methane which has a considerably shorter-life in the atmosphere than CO_2 which lasts in the atmosphere over 50 - 200 years and CFCs which stay for millenia depleting the ozone layer, is a question which involves atmospheric chemistry and is still debated in research journals. Whether and how these pollutants are to be added, for example, using "radiative forcing coefficients", are issues not yet settled. The activities that generate each of these pollutants have different socio-economic factors associated with them. Prior to taking policy decisions based on global warming potentials, some of the socio-economic aspects need to be considered. At stake could be economic trade offs between, say, paddy in Vietnam vs power plants or "gas guzzlers" in the USA, the highest contributor to the accumulation of greenhouse gases. The methane emissions from paddy fields relate to survival or "subsistence emissions" whereas much of the gross CO_2 emissions - apart from those due to deforestation, are "luxury emissions" at least by the standards of poor countries, where even electricity is not considered a basic need.

In addition to air pollution, water and soil pollution also have different relationships with poverty and affluence. Poor countries have bacterial pollution in soil and water due to inadequate sanitation facilities, affluent countries have land fills and industrial waste water. One should also keep in mind that it is only recently that we have come to know about the dangers from global air pollutants like CO_2 and CH_4; better knowledge of ocean pollution can throw up new problems that we are not aware of at present.

1.2.2 The Major Resources of Concern

Even though the global ecosystem should be looked upon in a holistic fashion, it is not practical to do so. For example, the misuse of *oceans* may lead to as serious a threat as the greenhouse effect to global ecosystem but we do not at present know enough about the oceanic ecosystem. For this reason we focus our attention on selected aspects only. The major resources which are of concern in terms of sustainability of development and consumption patterns are as follows:

Land is the most important resource from many points of view. It provides food that we all need and sustains all animals. Agriculture still employs the majority of people in most developing countries. Preservation of land productivity is therefore, important. It is affected by the nature and intensity of use of land which in turn are consequences of population growth and consumption patterns.

Forests not only provide useful products but also prevent soil erosion through water and wind, constitute habitat for wild life, help preserve bio-diversity and are critical elements of the global climate and carrying capacity.

Atmospheric Carrying Capacity, though a renewable resource, is now in short supply. It is important to understand how much of it is stressed by what kind of consumption. Among the non-renewable resources, fossil fuels and minerals and metals are of major importance. They are needed for most economic activities and they contribute to environmental stress in a significant way.

Water is a vital resource and its pollution by agriculture and industry constitute serious local problems for many countries.

1.2.3 The Important Items of Consumption

The items of consumption that draw on these resources and which lead to environmental stress can be grouped under various heads.

Basic Needs: Among the food items required to sustain human beings, we look at cereals, milk and meat as being the most important, both for human consumption and in their use of resources.

Forest products used for different purposes are round wood including fuel wood, sawn wood and pulp and paper.

Other Items of Basic Needs include clothing, fertiliser needed to produce food, and cement for housing.

Among the metals and minerals we will look at iron and steel, copper and aluminium. Among services, road transport, a major resources user and pollution contributor, is examined. Finally, energy sources of relevance are fuel wood, coal, oil, gas and hydro and nuclear electricity.

Global impacts of consumption: Here, apart from the local pollutants associated with each activity, global emissions of carbon-dioxide are of immediate concern.

Box 1.1

Insatiable Desires: even the Demand for Food Resources goes on increasing

Since a person can only eat so much, the intake of food calories cannot go on increasing indefinitely with income. However, the quality of food consumed does go up and keeps on improving. Better quality food requires more resources. For example, to produce 1 kg. of poultry meat requires 3 to 4 kg of grains as feed. Thus, consumption of 1 kg of poultry meat is equivalent to consumption of 3 to 4 kg of grains. Though these grains may be of different kinds than those consumed by humans directly, the resources required to grow these grains may be comparable.

In the figure, the direct protein intake and the consumable protein content of that intake are plotted against per capita income for groups of countries who fall in different per capita income classes.

It is seen that while there is a satiation in terms of consumed protein, the demand for consumable protein keeps on increasing with income and shows no sign of satiation.

Thus, even for the resources needed to meet basic needs, the rich and the poor compete. The environmental stress caused increases with income.

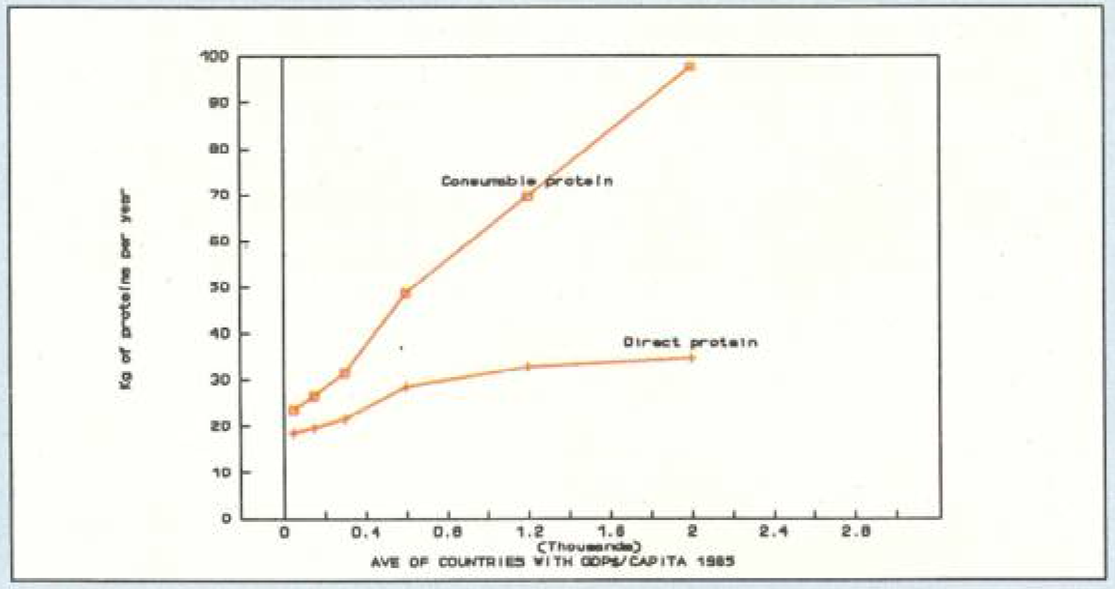


Figure: Protein Intakes - Direct and Indirect and Per Capita GDP

Source: Linnemann et. al (1979)

2

Consumption Patterns of Major Commodities

2.1 The Approach

In this section we compare consumption patterns across different countries for items of consumption broadly grouped as food products, forestry products, industrial products related to basic needs, metals and minerals, transport services and energy products. The consumption pattern of a commodity depends on the nature of commodity, the level of income and the availablity of primary resources needed to produce that commodity which affects its price. An exercise of direct and indirect consumption is given in Box 2.1.

If the consumption of basic necessities, apart from specific items such as milk that the Chinese do not consume, were to be equitably distributed, one would expect the distribution to be the same as that of population i.e, 24% and 76% for developed (dvlpd.) and developing (dvlpg.) countries respectively. However, this is not so. Therefore, to characterize differences in consumption across different groups of countries, we use two measures, average and extreme disparity ratios.

The average disparity ratio (ADR) in consumption levels is calculated by taking the ratio of the per capita consumption levels of developed and developing countries. Due to inclusion of East European Countries in the developed countries and the newly industrialised countries in the developing countries, the ADR is smaller than the real differences between the rich in the west and low income countries in Africa and South Asia.

Extreme disparity ratio (EDR) defines the factor by which per capita consumption is high for the richest compared to the poorest. To make EDR meaningful across commodities, two specific countries need to be chosen such that they are large enough to be representatives of the life style of the richest and poorest and are well documented.

USA and India are two suitable countries for such a comparison. USA is a pace setting country whose life styles others aspire to and India is a poor country where 35% of population live in abject poverty. (Occasionally, however, due to peculiar characteristics of a particular commodity, EDR is less than ADR for which reasons are given).

Technically, all associated indirect consumption for the commodity exported should be attributed to the importing country. That is to say, if a country exports meat, cereals eaten by the animals are shown as direct consumption in exporting country. To illustrate this point, an exercise showing direct and indirect consumption will be shown later. However, in this section, indirect consumption associated with the commodities exported are shown in the exporting country

We now look at the consumption patterns for different groups of items.

Table 2.1 gives consumption of land based commodities viz. food and wood products.

Table 2.1 : Consumption Patterns for Selected Commodities: Distribution among Developed and Developing Countries

Category	Products	World Total (MMT)**	Share		Per Cap (Kg. or M Sq.)		ADR Dvlpd/ Dvlpg	EDR USA/ India
			Dvlpd.	Dvlpg.	Dvlpd.	Dvlpg.		
a) Food	Cereals	1801	48%	52%	717	247	3	6
	Milk	533	72%	28%	320	39	8	4
	Meat	114	64%	36%	61	11	6	52
b) Forest	Round wood	2410	46%	55%	388	339	1	6
	Sawn wood	338	78%	22%	213	19	11	18
	Paper etc.	224	81%	19%	148	11	14	115
c) Industrial	Fertilisers	141	60%	40%	70	15	5	6
	Cement	1036	52%	48%	451	130	3	7
	Cotton & Wood fabrics	30	47%	53%	15.6	5.8	3	6.4
d) Metals	Copper	10	86%	14%	7	0.4	19	245
	Iron & Steel	699	80%	20%	469	36	13	22
	Aluminium	22	86%	14%	16	1	19	85
e) Chemicals	Inorganic Chemicals	226	87%	13%	163	8	20	54
	Organic Chemicals	391	85%	15%	274	16	17	28
f) Transport Vehicles	Cars	370	92%	8%	0.283	0.012	24	320
	Commercial Vehicles	105	85%	15%	0.075	0.0006	125	102

Source: FAO Forest Products Year Book 1988 for Round Wood, Sawn Wood and Paper, etc.
UN FAO Production Year Book 1988
Statistical Year Book 1988

Note: * Cereals data 1987
* Milk data include cow milk, buffalo milk and sheep milk (1987)
* Meat data include beef, veal, pork mutton and lamb (1987)
* Round wood include fuel wood + charcoal and industrial round wood (1988)
* Sawn wood includes both of which are extracted from sawlogs and veneer logs (1988)
* Paperboards include newsprint, printing and writing papersand other paper + paperboard (1988)
Statistical Year Book 1987; Handbook of Industrial Statistics 1989; International Trade Statistics Yearbook 1987 and
UN FAO book of production 1989

Note: * Fertiliser consumption data include nitrogen, phosphate and potash fertilisers

Statistical Year Book 1987; Handbook of Industrial Statistics 1989; International Trade Statistics Yearbook 1987; UN FAO Book of Production 1989.

* Cotton and Wood Fabric : Handbook of Industrial Statistics, 1988 UNIDO
(Cotton fabrics + Wollen fabrics and excluded synthetic which will alter this figures substantially; USSR & China excluded due to non-availability of data)
** Cotton and Wood fibre total consumption figures in billion meter square and per capita consumption figures in Kg. or meter square.
Statistical Year Book 1987

Note: * Per capita data are calculated.

2.2 Food Commodities

Cereals:

Per capita cereal consumption includes both human and animal consumption. The shares of developed (dvlpd) and developing (dvlpg) countries for cereal consumption in the world are 47.6% and 52.4% with per capita consumption of 716 kg. and 246 kg. respectively. It ranges from 130 kg. in Africa to 800 kg. in Australia. While cereals provide calories, as also some protein, needed for survival, the animal protein consumption is provided by milk and meat.

Milk and Meat :

Consumption patterns of milk and meat, both sources of protein, do not show the same behaviour as cereals. The shares of milk consumption in dvlpd. and dvlpg. are 71.7% and 28.3% with per capita milk consumption of 320 kg. and 39 kg. respectively. Meat consumption shares for dvlpd. and dvlpg are 63.8% and 36.2% with consumption levels of 60.6 kg and 10.7 kg respectively. Since meat and milk are protein substitutes their levels are marked by dieting habits and preferences. For example, India has per capita consumption 66 kg of milk but only 1 kg of meat. In China, milk is as low as 6 kg. but meat consumption at 18.6 kg., which is higher than dvlpg. average of 10.7 kg. Regional distribution of cereals and milk is given in figure 2.1.

Forest Products :

Together with the food products, one needs to include forest products consumption to understand the pressure on land resources. Forestry statistics of FAO gives data on round wood which includes wood used for making industrial coal and fuel wood, (sawn wood and paper and paper boards). (We have serious reservations regarding the data on fuel wood). Due to the inclusion of fuel wood, round wood consumption shows that the shares for dvlpd. and dvlpg. are 45.5% and 54.5% with per capita consumption levels of 888 and 339 kg. respectively. The ADR and EDR are 2.6 and 6.4 respectively. The consumption patterns change dramatically for sawn wood which includes only ply wood, particle boards, veneers etc. (used for furniture, buildings and paper). The shares of dvlpd and dvlpg are 77.9% and 22.1% with per capita consumption of 213 kg and 19 kg for respectively.

The paper and paper board which are made using sawn wood and require a lot more processing, have consumption shares of 81.3% and 18.7% with per capita consumption of 147.8 and 10.6 kg respectively. The ADR and EDR for this are the highest, viz. 13.9 and 115.2 respectively.

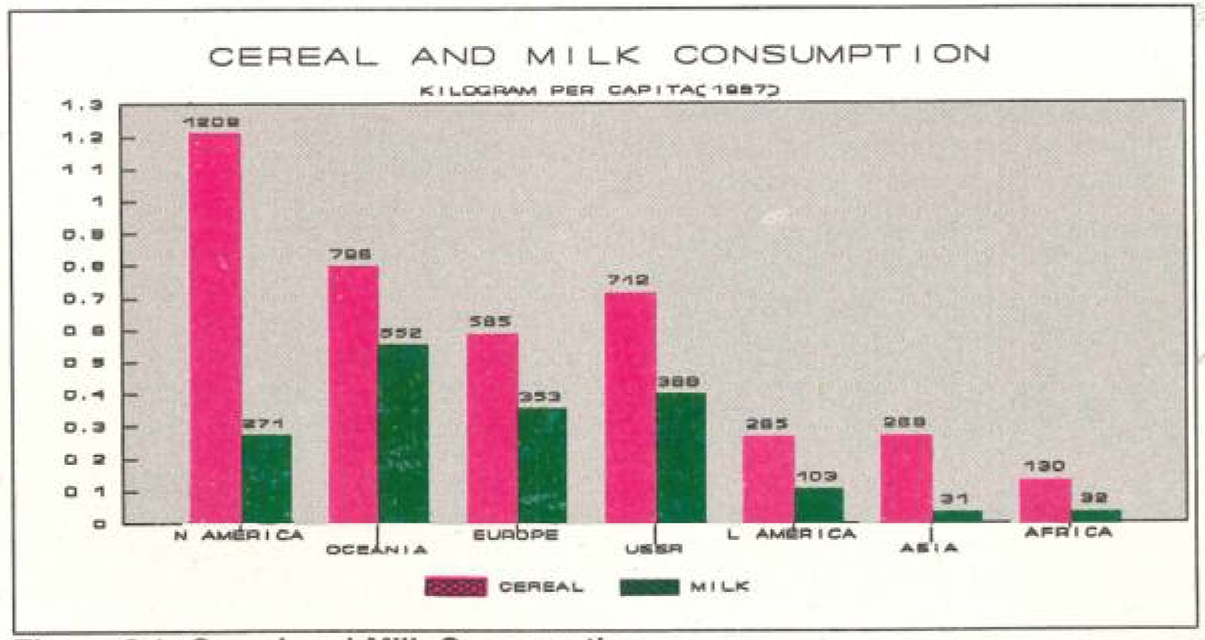


Figure 2.1: Cereal and Milk Consumption

2.3 The Manufacturing Basic Needs Goods

Fertiliser, Textile Fabric, Cement

These three industrial commodities are required to fulfil the basic needs of food, clothing and housing. They are the next basic necessities after food and are gigen in Table 2.1.

Fertilisers:

With their larger populations and relatively smaller land resources, developing countries can be excepted to require fertilisers in large amounts to meet their food needs. However, in practice, the world shares in fertilisers consumption between dvlpd. and dvlpg. are 60% and 40% respectively. The per capita use of fertilisers is 70.1 and 14.8 kg respectively. The average disparity ratio is 4.7 and EDR ratio is 6.4 despite the self-sufficiency in food production that India has achieved in recent years.

Textile Fabric:

The shares for grown cloth consumption by developing and developed countries in the world in 1983-85 are 47.0% and 53.0% respectively with per capita consumption of 15.5 M^2 and 5.8 M^2 respectively. (Unfortunately, available data includes only cotton, woollen and knitted fabrics and excludes synthetics.) Due to the exclusion of synthetics ADR and EDR are 2.7 and 1.3 respectively. Morever, some of the developing countries may be "consumers" of fabrics but are major exporter of ready-made apparels. Net consumption is not given here.[1]

Cement:

Similarly, in the case of cement which is required for the basic necessity of housing and also for construction of roads, bridges, dams, office buildings, factories, etc., the shares in the world for developed and developing countries are 52% and 48% with per capita consumption 451 kg and 130 kg respectively. After meeting their nutrition needs, many of the developing counties build houses for their homeless in a rapid manner. The construction boom in China is reflected in the per capita cement consumption level as high as 171 kg. However, Africa srill remains at only 78 Kg. per person, the world average being 206 kg.

One would execpt that due to high and growing population with poor housing and other infrastructures, developing countries would need to construct a large number of houses, schools, hospitals and offices and developing countries which have hardly any homeless would need cement for only replacements and additional houses. Even then, we have 3.5 times per capita consumption, i.e. the average disparity ratio for cement is 3.5 and EDR is 7.4.

2.4 Minerals and Metals

Table 2.1 shows the consumption of minerals and metal resources. Except for iron and steel the distribution of which is 80:20, 85% of all the remaining metals and minerals shown, viz. copper, aluminium, inorganic, and organic chemicals, are consumed by the developed countries. The ADRs therefore are nearly 20. The US per capita consumption is higher than that of India by factors of 245 for copper, 85 for aluminium, 55 for inorganic chemicals, 28 for organic chemicals and 21 for iron and steel despite the fact that India is one of the more industrialised low income developing countries and a major iron ore producer. The inorganic and organic chemicals follow similar distribution as aluminium. The regional distribution of cement and iron and steel is given in Fig. 2.2.

2.5 Services

In addition to resource consumption, a major lifestyle indicator is service. Typically, they would include a variety of services like access to safe water, hospitals, education, banks, telephones, transport, gas supply, electricity and so on. While all of them are important, not all of them are

1. Country-wise, destination wise statistic is needed to account for the export of fabrics. Exported apparels are given in numbers and not in m² of fabrics or kg. of yarn. There are a number of hurdles in comparability of statistics, so as to account for net consumption.

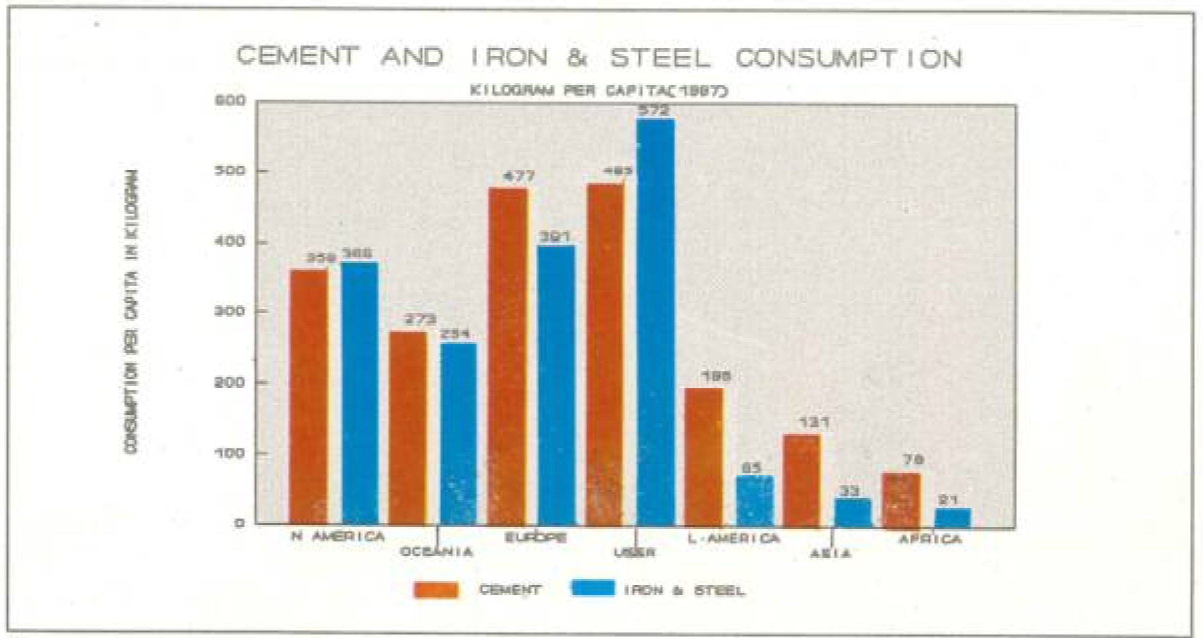


Figure 2.2: Cement and Iron & Steel Consumption

relevant from the view-point of environment. To illustrate the differences in life styles, transport is discussed in detail. Transport also provides access to markets and access to other socio-economic needs. Thus, when a road connects a village to a market, farmers in the village get better price for a produce. Transport can be done in several modes: road, railways, shipping and air. Since road transport is the most important from environmental view point, it is discussed here.

Road Transport :

As shown in Table 2.1, 91.5% of cars and 85.1% of commercial vehicles are in the developed countries. The per capita availability of cars is 0.283 and .012 in the dvlpd. and dvlpg. countries respectively with ADR 23.6 and EDR 319. However, due to a relatively higher use of public transport in developing countries, the per capita availability of other commercial vehicles is 0.075 and .006 respectively giving an ADR of 12.5 and an EDR of 102. These services consume gasolene and diesel which are discussed later.

2.6 Energy

Energy is required for all human activities and in all sectors including transport, power, industrial, commercial and domestic sectors. Thus, all the consumption levels described above translate into needs for energy. Since energy consumption accounts for most of the air pollutants - local and global - and also water pollution, it is discussed in detail. With a rise in the income level, the share of energy for cooking reduces drastically and the share of personal transport and electricity increases. Therefore, while 82% of fuel wood is consumed by developing countries on the one extreme, 82% of gasolene and electricity are consumed by the developed countries on the other. The share in total world commercial energy consumption by dvlpd. and dvlpg. is 74.8% and 25.2% and per capita consumption is 4.38 toe to 0.45 toe with ADR and EDR 9.3 and 34.9 respectively. The energy source-wise patterns are given in Table 2.2 and region-wise patterns are given in Figure 2.3.

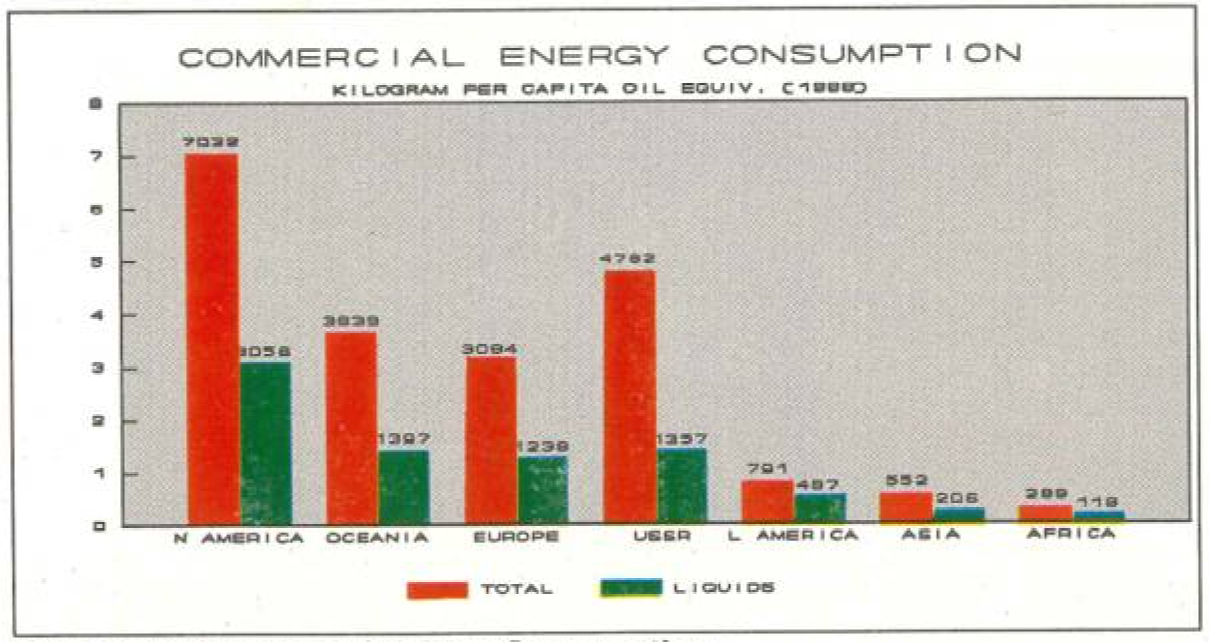


Figure 2.3: Commercial Energy Consumption

Table 2.2 : Patterns of Energy Consumption and CO_2 Emissions

Item	World Total (MMTOE)"	Share		Per Cap (KgOE.)		ADR Dvlpd/ Dvlpg	EDR USA/ India
		Dvlpd.	Dvlpg.	Dvlpd.	Dvlpg.		
Fuel and Electricity :							
Solid	2309	66%	34%	1278	199	6	14
Liquid	2745	75%	25%	1720	175	10	61
Gas	1611	85%	15%	1147	61	19	227
Electricity	343	81%	19%	230	17	13	46
Total	7009	75%	25%	4376	453	10	35
Diesel	756	72%	28%	452	55	8	29
Gasolene	725	82%	18%	495	34	15	390
Elec. (Thermal)	7040	78%	22%	4574	397	12	39
Elec. (Total)	11017	79%	21%	7260	599	12	40
Global Emissions :							
Total Emissions	5723	70%	30%	3.36	0.43	8	27
Cum. Total Emissions (50-88)	112060	77%	23%				
Solid	2413	64%	36%	1.31	0.22	6	14
Liquid	2205	70%	30%	1.33	0.16	8	54
Gas	907	82%	18%	0.62	0.03	21	228
Flaring	48	25%	75%	0.01	0.01	1	4
Cement	148.8	49%	51%	0.06	0.02	3	6

Source: Energy Statistics Year Book 1988
UN FAO Book of Production 1989 : ' All total consumption figures in MMTOE of oil equivalent and per capita figures in Kg. (Except for Thermal Elec.); ' Per capita data are calculated; ' Thermal Electricity total consumption figures in BKWH; ' Thermal Electricity per capita figures in Kg. Oak Ridge National Laboratory Tape : ' Emission data 1988; ' Emission data figures in million metric tons of carbon and per capita in MT.; EDR is defined as the ratio of per capita consumption of USA and India; ADR is defined as the ratio of average per capita consumption in developed and developing countries.

2.6.1 Primary Energy Sources

Consumption by primary energy source depends upon the resource availability.

Fuel wood :

In the developing countries, significant cooking energy needs in the rural areas are met with fuel wood, animal dung and agricultural residues. Fuel wood often does not come from forests. Our reservations on this data are expressed elsewhere in the report. Surprisingly, developed countries also use substantial fuel wood for a variety of reasons. Distribution of 17:83 for dvlpd:dvlpg leads to per capita consumption levels of fuel wood of comparable magnitudes viz. 0.16 t and 0.25 t respectively.

Coal :

The shares of dvlpd:dvlpg are 64% and 36% respectively with per capita consumption of 1826 kg. and 284 kg. respectively while ADR and EDR are 6.3 and 13.8 respectively. Coal is a major source of local and global emissions. Coal is a major energy source for India and China, Therefore, they have higher shares in coal compared to other fuels.

Liquids :

Liquids consumption include crude oil consumption, and net imports of petroleum products. The world shares for developed and developing are 75% and 25% respectively, the per capita consumption being 1720 and 175 kgoe. respectively. The average and extreme disparity ratios are 9.7 and 61.1. Thus, despite the fact that developing countries have substantial shares of world production and resources, this has not yet led to their having an equitable share in the world consumption.

Gas :

Natural gas is a newly found resource for many developing countries. Many of them have not yet found ways and means to exploit this to their advantage. Many of the countries are still flaring even the associated gas from the refineries. Therefore, their world share in consumption is only 14.8% and per capita level of 61 kgoe leading to high average disparity ratio of 18.5.

2.6.2 : Secondary Energy Sources

Above primary energy sources are then converted into many types of secondary energy sources. Only diesel, gasolene and electricity are discussed as life style indicators. Regional distribution of diesel and gasolene and electricity are shown in Figures 2.4 and 2.5 respectively.

Diesel :

The shares of developed and developing countries in the world for diesel are 72% and 28% respectively, with per capita levels of 452 kg and 55 kg respectively. The disparity ratio between extremes is 29 for diesel as compared to 390 for gasolene. This is because in the developing countries, diesel consumption is more of a necessity than other oil products. It is required to transport basic goods and for public buses. Diesel is also used for centralised and decentralised electricity generation.

Gasolene and Electricity :

The world shares of gasolene consumption are 82% and 18% for developed and developing countries with ADR of 14.7. The extreme disparity ratio for gasolene between U.S. and India, is as high as 390!

The shares of total electricity consumption for dvlpd. and dvlpg. also have similar percentages namely 79% and 21% respectively with per capita consumption of 7260 and 593 kWH. However, contributions from thermal electricity, i.e. from fossil fuels, coal, oil and gas, are 4574 and 397 KWH per capita respectively. This shows that the developed countries have a smaller share of thermal electricity and higher shares of hydro and nuclear in total electricity consumption.

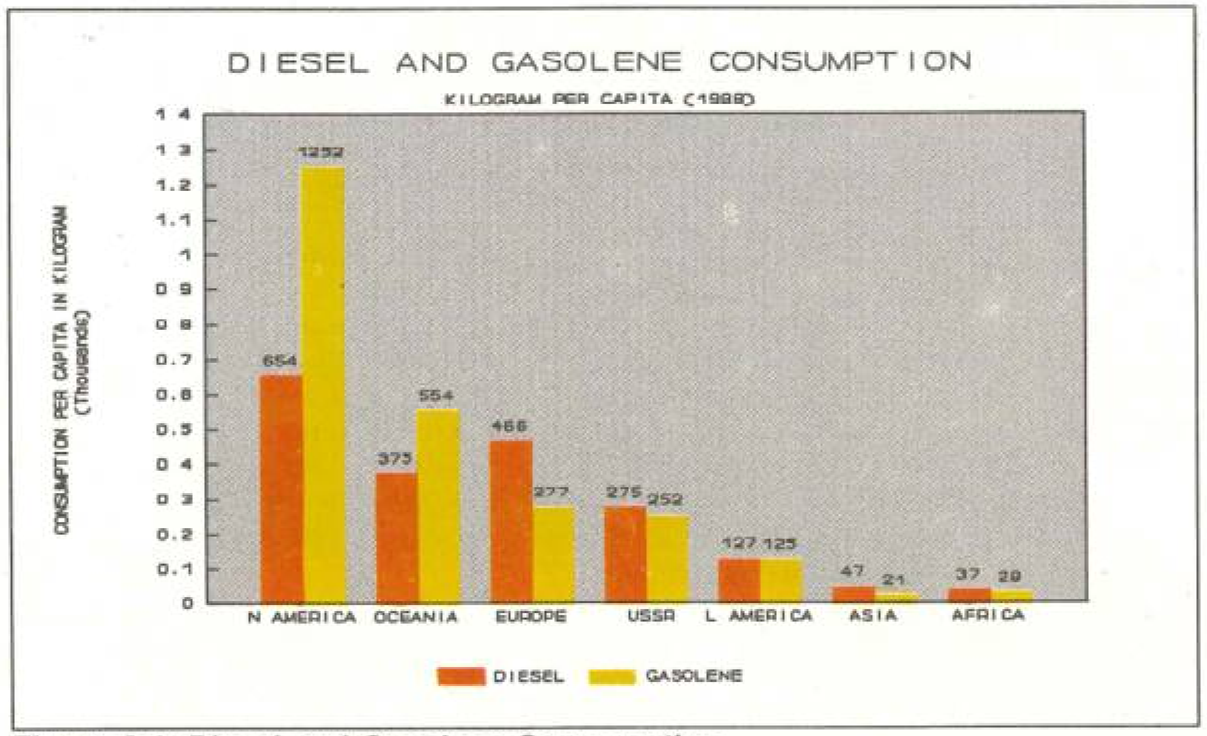


Figure 2.4: Diesel and Gasolene Consumption

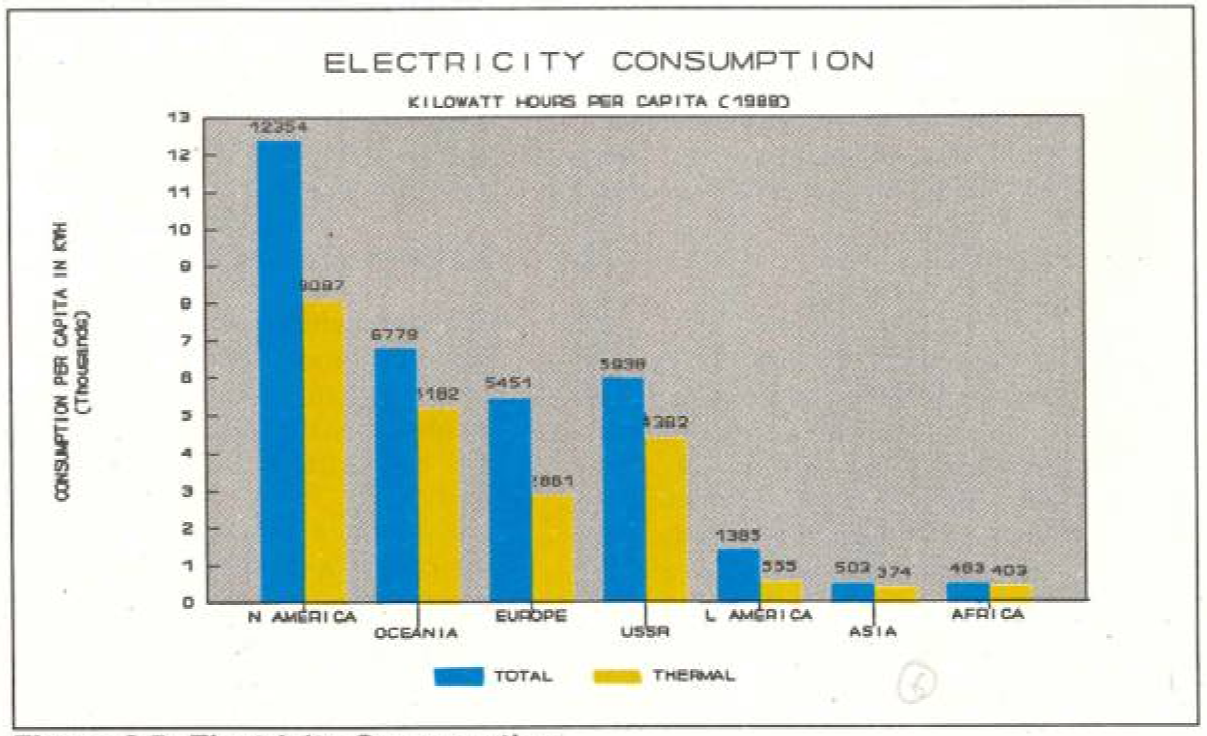


Figure 2.5: Electricity Consumption

2.7 Environmental Stress of Consumption Patterns

The nature of environmental stress depends on consumption patterns. Local pollutants related to various activities and problems arising out of them are different for developing countries than for developed countries. Not only high consumption but also inadequate consumption cause stress. In addition to these problems, the recent debate on global pollutants throws up a number of questions to which we now turn.

2.7.1 Carbon Emission Levels

Gross carbon dioxide emission levels :

As shown in Table 2.2, the shares in global emissions of CO_2 in 1988 by dvlpd. and dvlpg. are 68% and 32% with per capita emission levels of 3.257 t and 0.465 t respectively. India emits as little as 0.2 t and the USA as high as 5.39 t giving an extreme disparity ratio of 27. Since the CO_2 lasts for 50-200 years in the atmosphere, it is worthwhile to talk about accumulated CO_2 emissions. The world share of dvlpd. countries is 77.15%, in the accumulated emissions from 1950-1988 for which the details are available. This share would be even larger, if emissions were to be cumulated from the beginning of the century. The responsibility to reduce the CO_2 emissions should be in proportion to the share in the stock of accummulated CO_2 and the share in annual flow of CO_2 emissions. This is discussed later.

2.8 Relationship of Consumption Patterns with GNP Levels

We have seen that the lower growth rate of per capita income at least slows down the growth of per capita consumption. What would be the net effect of lower per capita consumption by a larger number of people?

The answer to this question depends on how rapidly consumption grows with income. To look at this we use the elasticity of consumption which measures percentage increase in consumption for one per cent increase in income. Higher the elasticity for an item is, the more rapidly the consumption of it increases in per capita GNP levels. When elasticity is greater than 1.0 it implies that 100 persons with a given per capita income will demand more of that commodity than 200 persons with half the per capita income.

The per capita consumption elasticities with respect to GNP per capita are given in Table 2.3. These elasticities give percentage increases in per capita consumption or emission for one per cent increase in per capita GNP. It can be seen that while the elasticities for basic needs and associated products are low and the elasticities for metals are nearly one, those for passenger cars, gasolene, gas and carbon dioxide are all greater than one.

This implies that if population in poor countries were half of what they are now with aggregate GNP remaining the same as at present, their per capita income levels would have been doubled and consequently their consumption would have been higher by a factor greater than two, due to consumption elasticities with respect to per capita GNP exceeding 1.0 for many products. In fact, with lower population they would have had much higher rates of economic growth and their per capita income levels would have been still higher. In fact, population growth retards development in poor labour surplus countries and hence retards consumption levels.

This is illustrated in Table 2.4 for CO_2 emissions the elasticity for which is 1.20 in Table 2.3. The first row in Table 2.4 shows the base year population, GNP, GNP/Cap, CO_2/Cap and total CO_2 emissions by a hypothetical country. If the population of this country doubles in 30 years and the total GNP also doubles during this period the per capita GNP and CO_2/Cap. remain the same, but due to the doubling of the population of this country, total CO_2 emissions also double. However, in scenario B, the population of the country remains at

100. The per capita GNP now has increased by 100 per cent and with the elasticity of 1.20, CO_2/Cap. emission would increase by 120 per cent. The total CO_2 emissions are now 220C which is greater than 200C of scenario A when the population is twice as much.

Table 2.3 : GNP Elasticities[1] for Per Capita Consumption of different Commodities

Items	Elasticity	Items	Elasticity	Items	Elasticity
Food Products:		**Consumption Items:**		**Commercial Energy[3]:**	
Cereals	0.34	Iron & Steel	1.13	Solid	1.17
Milk	0.80	Aluminium	0.76	Liquid	0.99
Meat	0.57	Copper	0.61	Gas	0.96
				Electricity	1.04
				Total Energy	1.02
Associated Basic Needs:		**Transport:**		**Greenhouse Gases*:**	
Cement	0.80	Passenger Car	1.12	Carbon Dioxide	1.20
Fertilisers	0.82	Commercial Vehicles	0.84	Methane	0.38
Textile fabrics[2]	0.31	Gasoline	1.01		
		Diesel	0.94		

Source : IGIDR Calculations : Based on data of per capita GNP from World Development Report, 1987, World Bank and consumption of commodities from United Nations Statistics.

* - Greenhouse gas emissions are taken from World Resources, WRI (1990-91) and exclude CO_2 emissions from deforestation.

1 - Obtained from cross-country regressions of more than 100 countries most of them relating to 1987.

2 - Only direct consumption is considered. Therefore, textile fabrics which is exported as ready-made apparels is not accounted in the importing countries, explaining low GNP elasticities.

3 - These are somewhat higher than those obtained in the literature of previous years (around 0.8), and are almost close to 1. This may be due to reduction in oil prices and changes in US dollar exchange rate.

Table 2.4: CO_2 Emissions and Population Growth

Year	Population	GNP	GNP/Cap	CO_2/Cap	CO_2
1990	100	100000	1000	C	100C
Scenario A: High Population Growth					
2020	200	200000	1000	C	200C
Scenario B: No Population Growth					
2020	100	200000	2000	2.2C	220C

2.9 Pattern of Consumption : Summary

Despite the fact that 76% of the world population (1988) reside in the developing countries, the shares of their consumption levels of almost all commodities, are considerably less than 76%. While for food commodities such as cerals their shares are as high as 51%, the shares for meat and milk, which are indicative of protein consumption - a requirement for nutrition - are as low as 36% and 28% respectively. Among developing countries, again, there is a wide diversity. The two large countries, India and China, - which have 50% of the population - have very low shares of consumption levels. The disparities in consumption levels rapidly increase (from 3 to 20 and more) as one moves from food to iron and steel, gasolene and electricity. The environmental stress from consumption of each item is larger by the developed countries. Despite the high population of developing countries even the strain on land resources put by developed countries is higher when one considers all land-related products and impacts from consumption of cereals, milk, meat, wood, paper and fertilisers.

Populated countries like India and China are considerably below average not only in per capita consumption levels of all type of commodities but also in overall shares. Therefore, population growth, far from contributing to consumption growth, is in fact a factor inhibiting development and hence per capita consumption. No doubt, population needs to be curbed to achieve higher growth by developing countries, but it should not be mistaken as a solution to environmental stress. In the short run population growth retards economic growth in labour surplus developing countries and leads to less environmental stress. The poor have adapted survival strategies which minimise monetary cost of consumption. Deforestation2 is the one environmental stress which appears to be accelerated by population growth and has to be addressed.

While a higher pòpulation growth is less polluting from a short term point of view, as far as the greenhouse effect is concerned, in the long run it can have adverse impacts. If one thinks of a future steady state, when the population of the globe is stable and when all persons on the earth have comparable incomes (and this is the only state one should think of as equitable, if the earth is one indivisible spaceship that belongs to all mankind) then a higher population growth means that it will take longer to reach a sustainable steady state. What is worse, it might even make it impossible to attain a sustainable steady state. Thus, while population growth by itself is far from being the cause of global environmental problems at present, reducing the population growth rate is desirable to lessen the severity of problems in future.

2. Reservations on deforestation data are shown elsewhere

Box 2.1

Domestic Absorption: Directly and Indirectly through Trade

The true usage of environmentally significant resources by an economy is not always reflected by their apparent consumption (direct absorption) in the economy. Some amount of these resources is embodied in the commodities that the economy exports or imports. For example, Japan may be a large importer of coal, which is used in manufacturing processes within the country; however, when it exports steel and automobiles to the United States, the usage of coal in the production of the exported quantities is attributable to the United States' demand for these quantities, even though the emissions from its combustion are generated in Japan.

A more accurate measure of a country's resource usage, therefore, is the volume of these resources embodied in its consumption basket, regardless of where the commodities in the basket are produced. This measure of direct and indirect absorption of resources is provided in the Table, for some countries over a set of environmentally significant resources. Each entry in the table is the ratio of direct and indirect absorption of the resource to its direct absorption in the economy.

The ratios were computed from input-output tables for each of the countries (for the year specified in the table) provided by UNIDO*.

If this ratio for any resource is equal to unity, the embodied resource content (direct and indirect absorption) of the country's consumption basket is exactly equal to the direct absorption of that resource. A ratio greater (less) than unity implies that the embodied resource content exceeds (falls short of) the direct absorption of the resource. Note that we have implicitly used the "Destination Technology" assumption in order to measure the resource content of imports. This means that the resource content of an imported commodity is assumed identical to its domestically produced equivalent.

---

* In technical terms, the ratio for the ith resource is provided by:

$$\frac{[(I - A)^{-1}(C + IN + G)]_i}{(Y_i + M_i - X_i)}$$

where,

A ≡ Technology Coefficient Matrix C ≡ Private Consumption

IN ≡ Investment required to produce domestically used output.

G ≡ Government Expenditure

Y_i ≡ Gross output of the ith resource

M_i ≡ Import of the ith resource

X_i ≡ Export of the ith resource.

The numerator is the ith element of the $(I-A)^{-1}(C+IN+G)$ vector. The denominator is the apparent consumption (direct absorption) of the ith resource.

Box 2.1 contd.

Consider the ratios for coal usage in Japan and South Korea from the Table. The Japanese ratio of 0.76 implies that the embodiment of coal in the domestic consumption basket is 24% less than the total usage of coal (in a given year). The difference is attributable to those countries that import coal intensive products from Japan. This suggests that even if Japan is a large user of coal, the emissions from the use of coal are not entirely attributable to Japan itself. On the other hand, the South Korean ratio of 1.20 implies that it should be attributed with the usage of 20% more coal than is actually used in the economy. The other ratios can be interpreted in a similar way.

Since the input-output matrices differ widely across countries, in terms of both definition and aggregation of commodities, the ratios should be interpreted and compared with caution. They mainly serve the purpose of highlighting the concept of direct and indirect absorption of resources.

Given the significance of trade between nations, the principle of holding individual countries accountable for emissions based on their internal usage of resources may detract from the true pattern of accountability, which should ideally be based on usage of resources inherent in the country's consumption basket. The measure developed above is one way of addressing the problem.

Box 2.1 contd.

TABLE B2.1: RATIOS* OF DIRECT AND INDIRECT ABSORPTION TO DIRECT ABSORPTION

RESOURCE	U.S.A. 1985	JAPAN 1980	SPAIN 1980	S.KOREA 1980
WOOD	1.04	1.34	0.81	0.99
COAL	0.85	0.76	0.67	1.20
PETROLEUM	0.97	0.95	0.60	1.03
CEMENT	1.00	N.A.	0.97	N.A.
NON-METALLIC MINERAL PRODUCTS	N.A.	0.95	N.A.	1.04
PLASTICS	1.16	0.88	0.85	N.A.
CHEMICALS	1.02	0.82	0.55	1.04

NOTE: The category of non-metallic mineral products is included as a proxy for cement, which is not listed as a separate product by Japan and S.Korea.

* In simple words, when a country's ratio exceeds 1, it is indirectly importing that commodity embodied in other goods and is therefore indirectly causing environmental damage elsewhere. Conversely, when it is less than 1, the country is exporting that item embodied in other goods and is therefore not responsible for the damage. For example, 24% coal in Japan is embodied in their exports.

Box 2.1 contd.

TABLE B2.1: (CONT.) RATIOS OF DIRECT AND INDIRECT ABSORPTION TO DIRECT ABSORPTION

RESOURCE	INDIA 1979	CHINA 1981	KENYA 1976	EGYPT 1973	ECUADOR 1981	COLOMBIA 1982
WOOD	N.A.	0.88	N.A.	1.14	1.13	1.29
FORESTRY PRODS.	1.00	N.A.	0.91	N.A.	N.A.	N.A.
COAL	1.10	0.88	N.A.	1.58	N.A.	N.A.
MINING	N.A.	N.A.	0.07	N.A.	2.44	1.79
PETROLEUM	1.03	0.80	0.68	1.46	1.34	1.31
CEMENT	1.01	0.82	N.A.	N.A.	N.A.	N.A.
NON-METALLIC MINERAL PRODUCTS	N.A.	N.A.	0.79	1.09	2.06	1.15
PLASTICS	1.01	N.A.	N.A.	N.A.	N.A.	N.A.
CHEMICALS	1.03	0.93	0.35	1.16	1.74	1.41

NOTE: The categories of forestry products, mining and non-metallic mineral products are introduced as proxies for wood, coal and cement respectively.

3

Demographic Pressure: Urban and Rural Enviroment

3.1 Urbanization and Economic Development - Related but Distinct Phenomena

To maintain income parity between agricultural and non-agricultural workers, agricultural productivity per worker has to increase. With limited land, this is often achieved by workers moving out of agriculture into non-agricultural employment, wherever opportunities for such emploment exist.

While it may be possible to create the needed non-agricultural jobs in rural areas to absorb this outflow from agriculture, it is generally observed that many of these jobs are created in urban areas and urbanization proceeds with economic development. Obviously, there must be some economic advantages to urbanization, at least from the point of view of entrepreneurs who create jobs in urban areas, if not from the point of view of society. High income levels of large cities suggest that they can be economically productive and offer "economies of agglomeration".

These have to be balanced against the negative externalities of urbanization in the form of stress to the environment. These are of two types. First, the higher densities place a burden on the absorptive capacities of the environment. Effluents, which, if spread over an extensive area might be dissipated due to the natural cleansing powers of the environment, are not as easily cleared. This has consequences for the health and welfare of urban residents, as well as for economy-wide patterns of resource usage. Second, the large amounts of transportation costs incurred by the spatial specialization that is inherent in the process of urbanization, and the resources expended in intra-urban commuting impose significant environmental costs. Most forms of energy use entail environmental stress; energy production and consumption is arguably the single most important contributor to the deterioration of air quality. The high-density construction methods dictated by the premium on spatial access and the consequently high land values in urban areas are intensive in the use of cement and iron and steel, the production of which is a major source of pollution. Similarly, the direct and indirect energy costs of the special infrastructure requirements of setting people in urban areas (quite apart from the content of urban production and the accompanying consumption patterns) are resource costs to be accounted for in any analysis of the adverse environmental impacts of urbanization. So also, the global greenhouse effects of activities resulting from urbanization.

3.2 Economic Development, Urbanization and Environmental Stress

To what extent do generation of wastes and emissions of pollutants depend on the level of economic development (represented by GNP per capita in US$), on the structure of the economy (represented by the share of manufacturing in GDP), on the per capita availability of land, and on urbanization (represented by urban population as a percent of total population)? To explore this and other questions we carry out cross-country comparisons. Income levels are assumed to be correlated with consumption levels.

Apart from the overall level of urbanization, the patterns of urbanization in a country, i.e., whether it is dominated by one large metropolis or many medium-sized cities, may also affect environmental stress. This pattern is characterized by two alternative variables PRIMECITY - a relative measure denoting the percentage of a country's urban population accounted for by its largest city, and URBCON - a measure of the proportion of a country's urban population residing in cities with population exceeding 500,000.

Results of the regressions of wastes per capita on the set of explanatory variables appear in Table 3.1. As expected, GNP per capita contributes positively and significantly to estimated waste discharges, whereas the effect of population density, while positive, is not significant, suggesting the dominant influence of increases in per capita consumption levels in waste generation. It is not surprising that the nature of settlement patterns do not seem to have much influence on the estimated average levels of waste generation. The reason is that these variables, including municipal waste, as they are defined and estimated, do not suggest levels of consumption and waste uniquely necessitated by urban activities other than industrial production per se. Admittedly, all inferences are tentative, owing to the small samples involved, but most appear to be quite robust across specifications.

Air pollutant emissions per unit area (sq. kms.) given in Table 3.2 do not increase with respect to income, but are much more robust for manufacturing's share in GDP. Expectedly, the contribution of population density to per unit area discharges is consistently positive, and statistically significant in the case of NO_2 and CO in particular. Urbanization does not play a major role, except in the SO_2 emissions. The share of the largest metropolis in urban population appears to influence CO emissions significantly. This may be due to excessive automobile use in large cities that require extensive commuting. This theme will also be explored further in the following section.

The results of this section indicate that, by and large, there is no evidence that country-wide aggregate (or per capita) emission rates increase as a consequence of urbanization itself, as distinct from the effects of increases in income, population and shares of manufacturing activity. There is, thus far, only weak evidence that urbanization imposes higher costs in terms of conventional pollutant aggregates. However, problems associated with urban pollution arise due to highly localized concentrations of pollutants over a relatively small but densely settled area. Therefore, a more suitable analysis would be at the level of the urban area rather than the country at large, and a more appropriate index of the harmful effects of the negative aspects of urban growth is measured ambient air pollution rather than estimated emission levels. We pursue this in Section 3.3.

3.3 City Size and Ambient Air Quality

It is the urban concentrations rather than aggregate emissions that constitute the chief danger from air pollution. Figure 3.1 presents a picture of ambient air quality in six selected cities, three each from developed and developing countries. Two observations may be made for even this restricted sample. One, pollution levels in respect of both Suspended Particulate Matter (SPM) as well as sulphur dioxide are considerably higher for the developing country cities, Delhi, Rio and Sao Paulo, than for the developed country urban areas. Secondly (Chicago notwithstanding), there seems to be no easily discernable relationship between population - or city size - and air quality.

Table 3.1 : Annual Waste Generation at the National Level (Kg. per capita)

	Municipal Waste Generation			Industrial Waste Generation		
N	19	19	19	18	18	18
DEPVAR. MEAN:	361.2105	361.2105	361.2105	9.0433	9.0433	9.0433
	MWASTCAP	MWASTCAP	MWASTCAP	IWASTCAP	IWASTCAP	IWASTCAP
	(1)	(2)	(3)	(1)	(2)	(3)
GNPCAP	0.0219 ** (2.360)	0.0232 ** (2.121)	0.0216 ** (2.292)	0.0020 *** (4.660)	0.0020 *** (4.087)	0.0020 *** (4.577)
MFGGDP	-5.5558 (-0.851)	-4.9295 (-0.686)	-4.8596 (0.481)	0.6021 * (2.017)	0.6159 * (1.924).	0.5861 * (1.908)
POPDENS	0.0547 (1.278)	0.0344 (0.380)	0.0275 (0.488)	0.0011 (0.723)	0.0006 (0.174)	0.0018 (0.932)
URBAN	0.9300 (0.348)	1.3916 (0.422)	1.5243 (0.540)	-0.3756 *** (-3.126)	-3.3619 ** (-2.460)	-0.3944 *** (-3.106)
PRIMECITY		0.9611 (0.256)			0.0329 (0.175)	
URBCON			1.7180 (0.763)			-0.0623 (-0.611)
CONSTANT	243.0462 (1.101)	159.6859 (0.402)	108.1801 (0.379)	4.0462 (0.374)	1.6024 (0.089)	8.4571 (0.639)
R-SQUARED	0.4867	0.4893	0.5087	0.6710	0.6718	0.6809
ADJ. R2	0.3400	0.2928	0.3197	0.5697	0.5351	0.5479

*** = 1%; ** = 5%; * = 10% levels of significance; (Figures in parentheses are t - statistics)

MWASTCAP = Per capita annual Municipal waste generation (Kg.)
IWASTCAP = Per capita annual industrial water generation (Kg.)

Data Source : World Resources, 1990-91, World Resources Institute

GNPCAP = Gross National Product per capita (US $)
MFGDP = Share of manufacturing in gross domestic product (%)
POPDENS = Total population density (persons per sq. km.)
URBAN = Urban population as per cent of total population (%)
PRIMECITY = Per cent of urban population in largest city (%)
URBCON = Per cent of urban population in cities population exceeding 500,000 (%)

(Data Source : World Tables and Social Indicators of Development, World Bank, 1985).

Table 3.2 : Estimated Annual Pollutant Emissions at the National Level ('000 M. Tonnes Per Sq. Km.)

	Nitrogen Oxide Emissions			Sulphur Dioxide Emissions			Particulate Emissions			Carbon Monoxide Emissions		
N	16	16	16	16	16	16	11	11	11	10	10	10
DEPVAR. MEAN:	3.71	3.71	3.71	4.48	4.48	4.48	0.88	0.88	0.88	13.84	13.84	13.84
	NOXAREA	NOXAREA	NOXAREA	SO2AREA	SO2AREA	SO2ARE A	PARTAREA	PARTAREA	PARTAREA	COAREA	COAREA	COAREA
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
GNPCAP	0.0002 (0.630)	0.0002 (0.663)	0.0002 (0.630)	-0.0009 ** (-2.261)	-0.0008 * (-1.809)	-0.0008 * (-1.917)	-0.00007 (-0.780)	-0.00003 (-0.242)	0.00002 (0.183)	0.0001 (0.291)	0.0001 (0.375)	0.0006 * (2.168)
MFGGDP	0.0430 (0.382)	0.0463 (0.392)	0.0423 (0.359)	0.2246 (1.469)	0.2298 (1.434)	0.2237 (1.396)	0.0656 (1.792)	0.0637 (1.642)	0.0682 * (2.098)	0.6706 *** (4.521)	0.7236 *** (6.122)	0.6549 *** (8.152)
POPDENS	0.0262 *** (4.087)	0.0266 *** (3.877)	0.0266 *** (3.784)	0.0085 (0.980)	0.0092 (0.988)	0.0090 (0.947)	0.0018 (0.791)	0.0021 (0.860)	0.0042 (1.678)	0.0657 *** (7.187)	0.0643 *** (8.992)	0.0775 *** (13.092)
URBAN	0.0225 (0.380)	0.0273 (0.425)	0.0200 (0.314)	0.2333 *** (2.895)	0.2411 ** (2.760)	0.2301 ** (2.667)	0.0127 (0.667)	0.0196 (0.850)	0.0037 (0.207)	0.0360 (0.372)	-0.0151 (-0.190)	-0.0115 (-0.214)
PRIMECITY		0.0182 (0.276)			0.0293 (0.327)			0.0169 (0.612)			-0.1638 (-2.064)	
URBCON			0.0079 (0.195)			0.0100 (0.180)			0.0250 (1.619)			0.1201 ** (3.618)
CONSTANT	-3.8882 (-1.123)	-5.2427 (-0.860)	-4.3468 (-1.006)	-9.7701 * (-2.077)	-11.9477 (-1.445)	-10.3476 (-1.762)	-1.2555 (-1.092)	-2.5744 (-1.040)	3.1175 * (-2.028)	-16.9033 (-1.922)	-10.8232 (-1.453)	-24.9249 *** (-4.750)
R-SQUARED	0.7847	0.7864	0.7855	0.6950	0.6982	0.6960	0.5521	0.5833	0.7062	0.9674	0.9842	0.9924
ADJ. R^2	0.7064	0.6795	0.6783	0.5841	0.5473	0.5440	0.2535	0.1665	0.4123	0.9414	0.9645	0.9829

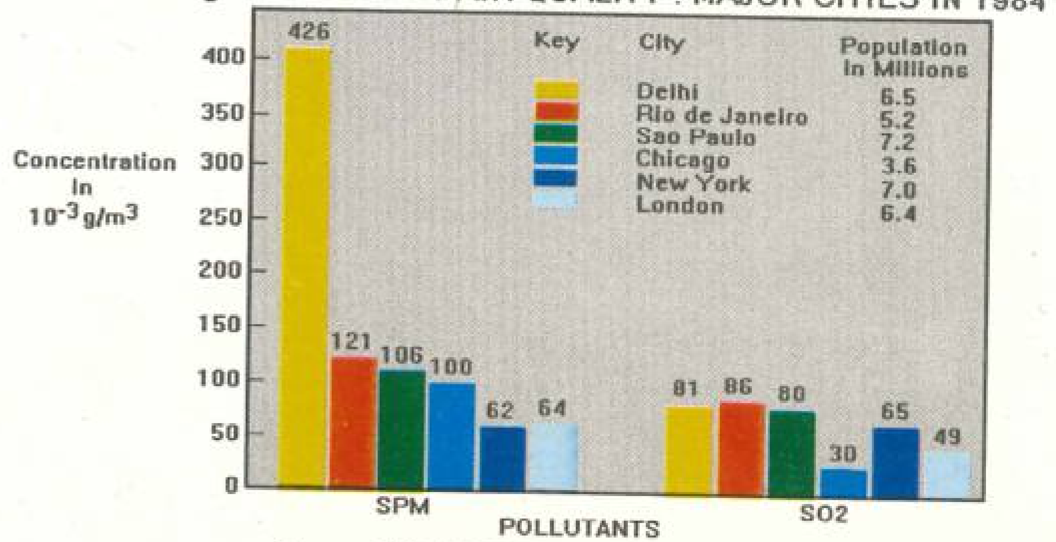
*** = 1% ; ** = 5% ; * = 10% levels of significance. (Figures in parantheses are t - statistics)

Dependent Variables :
NOXAREA = Estimated annual emissions of oxides of nitrogen ('000 metric tonnes per sq. km.)
SO2AREA = Estimated annual emissions of sulphur dioxide ('000 metric tonnes per sq. km.)
PARTAREA = Estimated annual emissions of suspended particulate matter ('000 metric tonnes per sq. km.)
COAREA = Estimated annual emissions of carbon monoxide ('000 metric tonnes per sq. km.)

Data Source: World Resources, 1990-91, World Resources Institute.

Explanatory variables : See Table 3.1

Fig. 3.1: AMBIENT AIR QUALITY : MAJOR CITIES IN 1984



Source: NAQM NEERI Report 1982-85, World Health Organisation & United Nations Environment Programme.

Air pollution is one of the principal reasons why the social costs of urban growth may lie above private costs. The relationship between city size and pollution concentration depends on types of industry, types of fuel used, degree of reliance on automobile transportation, and weather differences.

To explore the existence and verify the nature of any positive relationship between urban air quality and city size, we regress the average and maximum number of days on which measured levels of sulphur dioxide, particulate and smoke emissions exceeded specified thresholds over a given monitoring period - for some 45 urban areas internationally. The explanatory variables include absolute size and urban density, a country's GNP per capita, and its square, the share of manufacturing in GDP of the country. The absolute size of population variable (and its square) are, of course, specific to the urban area. The square term may be used to capture any acceleration/deceleration/downturn that may occur in ambient air quality with increasing city size. We experimented with two, measures of urban density - one, a city-specific measure, persons per room and the other, a country-wide measure of total population density, with the presumption that high overall national densities make for higher densities in individual urban areas, diminishing the potential for absorption or dilution of large concentrations of gases emitted in the air. While the structural measures are by necessity country-specific (such information not being readily available by urban area), we believe them to be good proxies, by and large, for urban income and industrial structure. The GNP-squared term was entered in an attempt to capture a possible rise in abatement efforts and a consequent reduction in pollution at sufficiently high levels of national income per capita.

The results of selected regressions are shown in Tables 3.3.

The results show that manufacturing's share in GDP, expectedly, for SO_2 and smoke, causes deterioration of urban air quality. (For SPM - Suspended Particulate Matter - it improves it, an unexpected result that may be attributable in part to GNPCAP's high correlation with MFGGDP for the sample.)

Table 3.3 : Sulphur Dioxide, Particulate, Smoke Emissions and City Size

	Sulphur Dioxide				Particulates				Smoke			
N	48	48	48	48	30	30	30	17	9	9	9	9
DEPVAR. MEAN	15.2	15.2	36.5	36.5	70.3	70.3	115.9	47.88	12	12	25.4	25.4
DEPENDENT VARIABLE	SO2AVG	SO2AVG	SO2MAX	SO2MAX	PARTAVG	PARTAVG	PARTMAX	PARTMAX	SMOKAVG	SMOKAVG	SMOKMAX	SMOKMAX
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
GNPCAP	-0.0041 (-1.489)	-0.0051 (-1.634)	-0.0066 (-1.321)	-0.0073 (-1.256)	-0.0278 *** (-2.651)	-0.0258 ** (-2.183)	-0.0423 *** (-3.646)	-0.0317 ** (-2.467)	-0.0199 *** (-9.010)	-0.0153 ** (-4.367)	-0.0387 ** (-5.271)	-0.0276 (-2.225)
GNPCAPSQ	1.47E-07 (0.874)	1.85E-07 (1.064)	1.87E-07 (0.604)	1.86E-07 (0.574)	1.27E-06 * (1.871)	1.04E-06 (1.480)	1.87E-06 ** (2.495)	1.30E-06 * (1.698)	1.51E-06 *** (9.526)	1.67E-06 (5.331)	2.96E-06 ** (5.586)	3.18E-06 * (2.878)
MFGGDP									8.9770 *** (15.108)	14.5968 ** (5.397)	18.5491 *** (9.368)	30.3373 * (3.172)
CITPOP	3.21E-06 (0.595)	4.05E-06 (0.765)	1.06E-05 (1.065)	1.34E-05 (1.359)	4.57E-05 ** (2.055)	4.38E-05 * (1.894)	4.92E-05 * (1.997)	4.64E-05 * (1.848)	6.70E-06 ** (4.783)	4.49E-06 (1.717)	1.51E-05 * (3.236)	1.04E-05 (1.130)
CITPOPSQ	-1.93E-13 (-0.347)	-2.78E-13 (-0.506)	-9.32E-13 (-0.910)	-1.20E-12 (-1.177)	-4.95E-12 * (-1.961)	-4.42E-12 * (-1.699)	-5.18E-12 * (-1.852)	-4.59E-12 (-1.626)	-1.09E-12 ** (-7.610)	-9.21E-13 * (-3.642)	-2.46E-12 ** (-5.163)	-2.09E-12 (-2.336)
POPDENS	0.0009 (0.180)		0.0078 (0.817)			-4.3333 (-0.283)		19.5236 (1.174)		50.0035 * (2.892)		108.9369 (1.782)
PERSROOM		-3.5633 (-0.689)		-5.3190 (-0.553)	0.2158 (1.461)		0.2554 (1.560)		0.0045 ** (5.408)		0.0109 * (3.945)	
CONSTANT	24.8485 * (1.923)	32.7698 * (1.873)	48.6767 ** (2.046)	57.9415 * (1.782)	55.6803 (1.149)	87.7742 (1.385)	134.3362 ** (2.502)	106.3231 (1.546)	-156.9261 *** (-9.803)	-363.1797 ** (-4.165)	-330.9692 ** (-6.204)	-771.4858 (-2.502)
R-SQUARED	0.2245	0.2325	0.2640	0.2577	0.6291	0.5975	0.7529	0.7426	0.9948	0.9843	0.9858	0.9518
ADJ. R2	0.1321	0.1412	0.1763	0.1693	0.5518	0.5136	0.7014	0.6890	0.9791	0.9370	0.9432	0.8071

*** = 1% ; ** = 5% ; * = 10% levels of significance. (Figures in parantheses are t-statistics)

Dependent variables :
SO2AVG = Average no. of days per year SO2 conc. exceeds 150 micrograms/cu. mt.
PARTAVG = Average no. of days per year SPM conc. exceeds 230 micrograms/cu. mt.
SMOKAVG = Average no. of days per year smoke conc. exceeds 150 micrograms/cu. mt.
SO2MAX = Maximum no. of days per year SO2 conc. exceeds 230 micrograms/cu. mt.
PARTMAX = Maximum no. of days per year SPM conc. exceeds 230 micrograms/cu. mt.
SMOKMAX = Maximum no. of days per year smoke conc. exceeds 150 micrograms/cu. mt.

Explanatory variables : See Table 3.1
CITPOP = Population of urban area, c. 1985.
PERSROOM = Living space (person per room)

Data Sources: World Resources, 1990-91, World Resources Institute; Life in the world's 100 largest metropolitan cities, Population Crisis Council.

Population density is found to be almost uniformly positive and significant in increasing the incidence of poor urban air quality, although, it may be recalled, the variable comprises overall country-wide densities, and is only an imperfect gauge of actual urban densities. The persons per room variable, which is an urban-area specific variable and, therefore, a conceptually purer potential proxy for the influence of density, is also generally positive and significant, but regressions where it is featured perform less well due to its correlation with GNP per capita, a strong determinant of housing consumption, and thus, of living space per household.

To summarize, the association of city size with urban pollutant concentrations, becomes considerably less significant once other variables are controlled for. The empirical associations are particularly strong in respect of particulate pollution, and reasonably so in case of smoke. By contrast, sulphur dioxide concentrations have fewer consistent associations with city size, although, it may be recalled, country-level SO_2 discharges exhibited a positive relationship with percent urban in the regressions in Table 3.2. The positive coefficients on particulates and smoke are consistent with the hypothesized consequences of heightened transportation and construction activity in large urban areas.

For a more intuitive understanding of the relationship between ambient air quality and city size, it may be instructive to turn to the consideration of specific cases. Figure 3.2, which plots mean particulate levels and changes against city size, corroborates these observations for a larger sample of cities. The top panel (Fig 3.2a), again, suggests that residential areas in the cities of developing countries are subject to much greater concentrations of particulate pollutants. Significantly, polluted small cities as well as relatively clean large ones are in evidence, showing the connection between pollution concentrations and city size to be tenuous, at best. The bottom panel (Fig. 3.2b) plots changes in particulate concentrations in various cities over the 1976- 1985 period. Several of the larger cities appear to have experienced declines in pollution levels, while some of the smaller urban areas featured deteriorating air quality over the period. In large cities such as New York and Tokyo, part of the reason for air quality improvement no doubt lay in the implementation of pollution control and abatement measures. These cases illustrate that there is no inevitability about urban growth increasing measured pollution levels. Nor is it necessarily true that restricting city size would, by itself, guarantee lower pollution levels. In fact, as the WRI report of 1988-89 observes, technological solutions to urban pollution problems exist. "The challenge is to mobilize the commitment and financial resources to use them."

3.4 Urbanization and Greenhouse Gas Emissions.

How does urbanization affect greenhouse gas emissions? The higher transportation requirement of urban living may lead to larger emissions of CO_2. Solid waste disposal in urban areas may imply higher methane emissions. Accordingly, we regress estimates for CO_2 per capita and methane per capita on the same set of variables we have used earlier. Results are presented in Tables 3.4, along with those of a regression for total per capita greenhouse emissions. As expected, the share in urban total population is uniformly significant and positive variable both for the total per capita greenhouse gases emissions as well as for CO_2 and CH_4 individually. The estimates of Table 3.4 may be used to project the global warming consequences of alternative income and urbanization scenarios.

Figure 3.2: City Size, Mean Particulate Levels and Their Changes

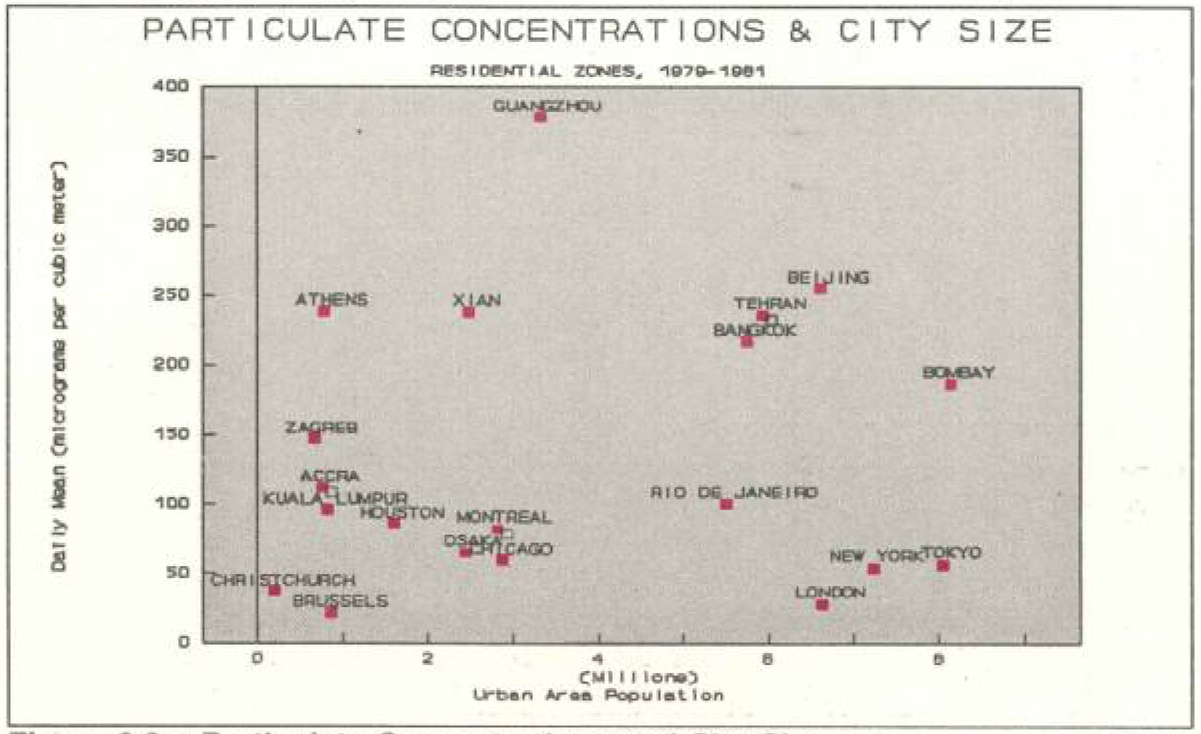


Figure 3.2a: Particulate Concentrations and City Size

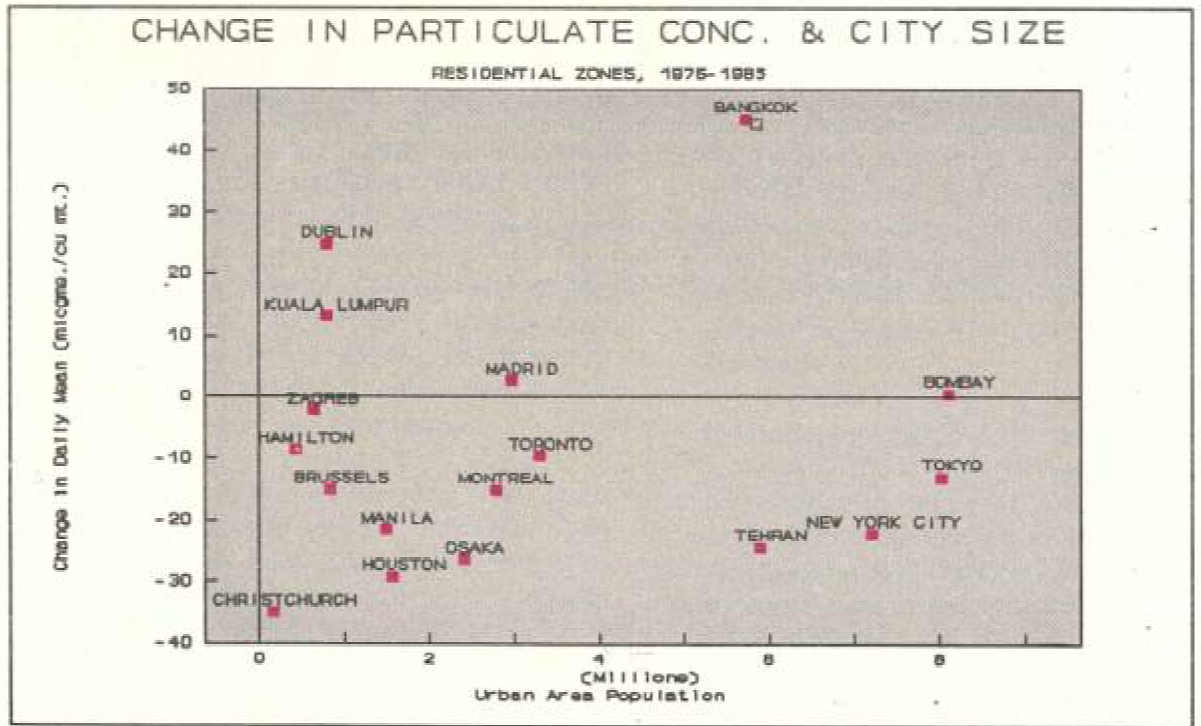


Figure 3.2b: Change in Particulate Concentration and City Size

Table 3.4: Estimated Annual Additions to Greenhouse Emissions

	CO_2	CH_4	Net Total Greenhouse Additions
N	83	83	83
DEPVAR. MEAN:	1.6229	0.5627	11.9831
	PCAPCO2	PCAPCH4	PCNETINC
	(1)	(2)	(2)
GNPCAP	0.00003	0.00007 **	0.0012 ***
	(0.520)	(3.065)	(3.938)
AGRGDP	0.0025	0.0108	0.0212
	(0.140)	(1.591)	(0.242)
POPDENS	-0.0002	-0.0004 ***	-0.0009
	(-0.590)	(-2.476)	(-0.420)
URBAN	0.0306 **	0.0140 ***	0.1869 ***
	(2.139)	(2.547)	(2.644)
CONSTANT	0.2017	-0.4230	0.5135
	(0.218)	(-1.189)	(0.112)
R-SQUARED	0.1780	0.3281	0.5048
ADJ.R^2	0.1359	0.2936	0.4794

*** = 1% ; ** = 5% ; * = 10% levels of significance.
(Figures in parantheses are t-statistics).

Dependent Variables :
PCAPCO2 = Anthropogenic additions to carbon dioxide flux (metric tonnes carbon per capita)
PCAPCH4 = Anthropogenic additions to methane flux (metric tonnes methane per capita)
PCNETINC = Net total increase in contributed atmospheric concentrations of greenhouse emissions (metric tonnes carbon per capita)

Data Sources : World Resources, 1990-91, World Resources Institute.

Explanatory Variables : See Table 3.1; AGRGDP = Agriculture's Share in GDP (%).

3.5 Conclusions : On Urban Growth and Environment

- Both in light of past development patterns and with currently available technology, urbanization seems to be associated with industrialization and economic growth.

- Aggregate emissions increases are largely attributable to economic growth rather than to urbanization. Additionally, one major city or a few large cities. or a so-called "imbalance" in a country's city size distribution do not appear to significantly lead to environmental deterioration in an aggregate sense.

- Nevertheless, urbanization does place a distinct burden on the scale and pattern of resource use due to high per capita commercial energy consumption in countries with large cities.

- Therefore, urban density and large city size result in higher concentrations of ambient air pollution. These have damaging health effects for local workers and residents.

- However, this positive association is not irreversible - several cities, large and small, have achieved significant pollution abatement, the capacity for which should increase with economic affluence.

- Estimated greenhouse effects do appear to be related to countries' urbanization levels, though not varying dramatically with characteristics of urban distribution in very large cities or otherwise.

- Cities of developing countries face more immediate and serious damages from local rather than global pollution; it is hence recommended that priority efforts be directed at the former.

- Given overall developmental goals, the necessary role of industrialization in securing and sustaining higher incomes and consumption levels, policies to curb the magnitude of urbanization in less developed countries are not the best, or even necessarily effective strategies to reduce the effects of environmental pollution. Such reduction is best undertaken with a variety of economic instruments designed to deal with specific polluting sources in a technologically appropriate manner.

- Actions to reduce pollution discharges associated with urban living might include more emphasis on mass transit in large cities of developing countries than many developed countries have seen fit to accord.

- With regard to city size, several measures hold the promise that there will be less additional pollution with future city growth than there has been historically, enabling larger (and more productive) cities to be sustained at much lower cost than in the past. More stringent environmental controls, along with judicious land-use zoning can avoid excessive exposure to industrial pollution for urban residents.

3.6 Growing Rural Population Density in developing countries

With growing populations in many developing countries, inspite of rapid urbanization, population densities in rural areas are growing. Unchecked growth of rural populations can lead to environmental problems when the demands of the rural population exceed the carrying capacity of the land.

It is obvious that the demand for biomass increases with population, but it also increases with income. Biomass in the form of food or feed, pulp and paper, furniture and construction material are demanded in increasing amounts as incomes increase. The only biomass use that goes down with income is the use of firewood as fuel.

With limited cultivable land in many Asian, Latin American and some African countries, the increasing demand for biomass can only be met through more intensive cultivation. Such cultivation however, often involves use of chemical inputs which cause their own problems of effluents in run-off and ground water.

In countries where land is available, cultivation is expanded to new areas, often at the cost of forests. Agriculture, in a sense, is by definition, an unnatural ecosystem and expansion of agriculture through deforestation increases the area under one ecosystem. The loss of variety and bio-diversity, apart from the soil erosion and associated consequences of deforestation, make the system more fragile.

Thus, a growing demand for biomass increases the fragility of the ecosystem, when intensive or extensive use of land takes place. A fragile ecosystem is unable to return to its initial state after a shock.

The propensity for the demand for biomass to exceed productive capacity of land is much higher when population of rural poor increases. For their needs of fuel and forage, they depend on limited common property resources. Once the biomass demand exceeds the natural regeneration rate, such common property resources degenerate rapidly and turn into waste land. It is, therefore, necessary to limit biomass extraction from such common property resources and involve people in their management. While voluntary and cooperative efforts have occasionally succeeded in doing so, a better policy is to absorb the rural poor in gainful employment outside agriculture. Economic development is essential to create the needed employment opportunities.

3.7 Emissions from biofuels : Health Effects in Rural and Urban Areas

There is yet another dimension to biomass use for fuel in the households, both in rural areas and in urban slums.

Domestic pollution due to use of biofuels is a major area of concern, as it causes several types of diseases. About 33% of the developing countries energy requirements are met by biofuels against 3% of those of the developed countries (Smith, 1987). A major part of this (73%) goes into meeting the cooking energy needs of developing countries. For each million megajoule of delivered energy, the burning of wood for cooking emits 3800 kgs of particulates, 250 kgs of SOx, 300 kgs of NOx, 3200 kgs of hydrocarbons, and 34000 kgs of carbon monoxide. Compared to this, local emissions from natural gas and electricity , mostly used for cooking in developed countries, are negligible, except for CO (250 kgs in case of natural gas) (Smith, 1987). These local pollutants are highly toxic in nature and cause diseases related to respiratory system; moreover, some of the hydrocarbon pollutants emitted by biofuels like Benzo(a)pyrene (BaP), formaldehyde, etc. are carcinogenic. The annual exposures to these pollutants in the rural areas of developing countries is very high. For example for BaP, the annual doses in typical rural kitchens in India using biofuels were observed between 4200 - 6100 mg. compared to a U.S. rural average of 0.4 mg, and for Respirable Suspended Particulates (RSP), the annual dose was 12000 gms for persons involved in cooking, against the limit of 170 gms recommended by WHO (Smith, 1987). Formaldehyde (HCHO) concentrations in rural kitchens were observed to be 1.0 mg/m^3 against the limit of 0.2 mg/m^3 recommended by WHO. In the case of CO, the dose from cooking one meal in a wood stove could itself be as high as 340 mg against 5.9 mg from the use of natural gas. WHO recommends a limit of 10 mg/m^3 mean concentration for the day.

Since most of the cooking is done by women, they, along with their young, home-based children are in close proximity to sources and have high exposures to pollution from these fuels. CO, for example, causes anemia and subsequent adverse effects on unborn children in pregnant women and respiratory diseases. Both of these phenomena in developing countries are widely observed the latter leading to chronic lung diseases. Incidence of chronic cor pulmonale (a cardiovascular disease, that could be caused by smoking) in women has been observed to be about the same as for men in India, although there were only 10% smokers among women against 75% among men. This has been attributed to their exposure in the kitchens to such pollution. In all, 21% of deaths in developing countries were related to respiratory diseases as against 7.5% in the developed countries.

Access to safe water, specially in rural areas, is yet another major problem of developing countries.

The relationship between infant mortality and access to safe water is discussed later.

These environmental trade-offs raise some issues:

- Local vs. global pollution trade-offs have consequences for health effects for the present generation and impinge upon the welfare of the future ones.
- High exposure vs. low exposure trade-offs relate to health for women and children who are close to sources on the one hand vs. pollution abatement in power plants and industries away from populated areas.

These issues have relevence while setting the priorities to tackle the environmental problems.

4

Economic Growth, Resource Availability and Trade-offs

4.1 The Importance of Growth

We have seen above that consumption is the driving force behind much environmental stress. Moreover, lack of economic growth when poplution is growing also results in a different type of environmental stress. For most of the developing countries, economic growth is needed and only through economic growth they will be able to reduce the stress on environment and natural resources such as land. Only economic growth can provide the means to adopt more sustainable techniques, adoption of which require resources.

To attain economic growth, a country needs to have either natural resources such as land or minerals, or stock of man-made productive capital or skills and labour. Since these resources can substitute for one another and since international trade makes it possible to import the products that require these resources, in principle, any country can grow.

4.2 Economic Stress of Consumption Patterns

In addition to environmental stress, unsustainably high consumption levels also bring economic stress; not only to those who consume more but also to others. Excessive oil consumption by the developed countries made it possible for OPEC to raise oil prices in 1973, altering the economic growth path for almost all categories of countries.[3] Table 4.1 shows the growth rates of per capita GNP from 1965 to 1988 of various country groups. Low income economies had per capita growth of more than 3 per cent during 1965-73 but have slowed down since 1973. The South Asian economies have shown a steady and accelerating growth but it has been too low to bridge the gap of per

3. Except South Asia, where due to previous oil exploration efforts domestic oil production could increase keeping imports lower than anticipated

Table 4.1 : Population and GNP per capita, 1980, and GNP and Growth Rates, 1965 to 1988

Country group	1980 GNP (billions of dollars)	1980 population (millions)	1980 GNP per capita (dollars)	Average annual growth of GNP per capita (per cent)					
				1965-73	1973-80	1980-85	1986	1987	1988[a]
Low and middle income economies	2347	3354	700	4.1	2.7	1.2	2.7	2.5	3.5
Low income economies	765	2459	310	3.3	2.6	3.9	3.6	3.0	6.5
Middle income economies	1582	894	1770	4.6	2.6	-0.3	2.1	2.1	2.5
Sub-Saharan Africa	200	356	560	3.1	0.5	-3.7	0.8	4.4	-0.2
East Asia	566	1362	420	5.1	4.6	6.4	5.8	6.8	9.3
South Asia	221	923	240	1.4	2.0	2.9	2.2	0.9	5.6
Europe, Middle East, and North Africa[b]	591	338	1730	6.0	2.4	0.0	1.0	-0.2	0.1
Latin America and the Caribbean	698	347	2010	4.1	2.5	-2.2	1.8	1.9	-0.9
17 highly indebted countries	892	494	1810	4.2	2.6	-2.6	1.7	0.5	-1.0
High income countries	7961	741	10740	3.5	2.2	1.5	2.0	2.8	3.0
OECD members	7698	716	10750	3.5	2.1	1.7	2.1	2.7	3.3
Total reporting economies	10308	4095	2520	2.7	1.5	0.6	1.3	1.8	2.6
Oil exporters	951	479	1980	4.7	2.7	-2.3	-2.7	-1.3	–

a - Preliminary. b. - Figures after 1980 exclude Iran and Iraq.

capita income ($ 300) even with other developing countries.

On the other hand, the middle income economies, the sub-Saharan African economies and the Latin American and Caribbean countries (many of them highly indebted) all show decceleration in growth rates of per capita GNP and some of these groups have recorded negative growth rates over the 80's.

Since the data seem to suggest breaks in the growth rates in 1973 and 1979, one is naturally tempted to ask to what extent these disturbances are due to the oil shocks of 1973 and 1979. For the sub-Saharan African countries oil shocks may explain their subsequent growth process.

Even in the early eighties, revival or turn-around did not take place except in East Asia which has two oil exporters, Malaysia and Indonesia, and Thailand which found gas. Moreover, East Asia's modest gain in growth rate in the 80's has to be in the context of the depressed GNP growth during 1973-80.

Thus, the growth process of developing economies was disrupted, worsening the plight of poor, especially in Sub- Saharan Africa and Latin America. Developing countries are deprived of the opportunity to build themselves up with cheap oil. After nearly two decades of rise in oil-prices, with the exhaustion of global atmospheric carrying capacity and its overload by the profligate life style of the developed countries, new handicaps may be imposed on developing countries in the form of emission reduction protocols, carbon tax and so on. It would be indeed tragic, if in the name of environmental concerns, the growth process of developing countries is once again disrupted.

4.3 Socio-economic Trade-offs and Environmental Priorities

Environmental priorities have to be set depending upon the urgency of the measures required, extent of population involved, costs to be incurred and whether it is the present or the future generation involved. These trade offs are involved at all stages:

- Local pollutants vs. global pollutants
- Among greenhouse gases i.e. what socio-economic activities generate equivalent greenhouse gases.

We discuss both as follows.

4.3.1 Local Pollutants vs. global pollutants

Bio-fuels used by the poor generate local pollutants which have severe health effects due to high exposure received by women and children in the inadequately ventilated houses of the poor, whether in rural areas or urban slums. Similarly, infant mortality rates are closely linked with access to safe water as shown in Figure 4.1. Pedestrians in urban areas are subjected to severe exposures of exhaust gases from usually poorly maintained vehicles. Affluence is associated with different types of local and global pollutants. Solid waste generation and waste water from industries are the problems of the rich while bacterial pollution of air, water and soil due to lack of sanitation facilities, in-house livestock keeping, emissions due to cooking with bio-fuels, contamination due to inappropriately used fertilisers and pesticides, are the problems of the poor. While problems of future generations need attention, a high priority should be placed on reducing the environmental stress for this generation.

4.3.2 Socio-economic trade-offs for greenhouse gases

Typically, different greenhouse gases are considered equivalent of each other through "radiative forcing" index. Why methane, particularly agricultural methane, should be left out at this stage is explained in Box 4.1. Following this, why CO_2 from deforestation is unreliable is also explained in Box 4.2. Some of the socio-economic trade-offs for

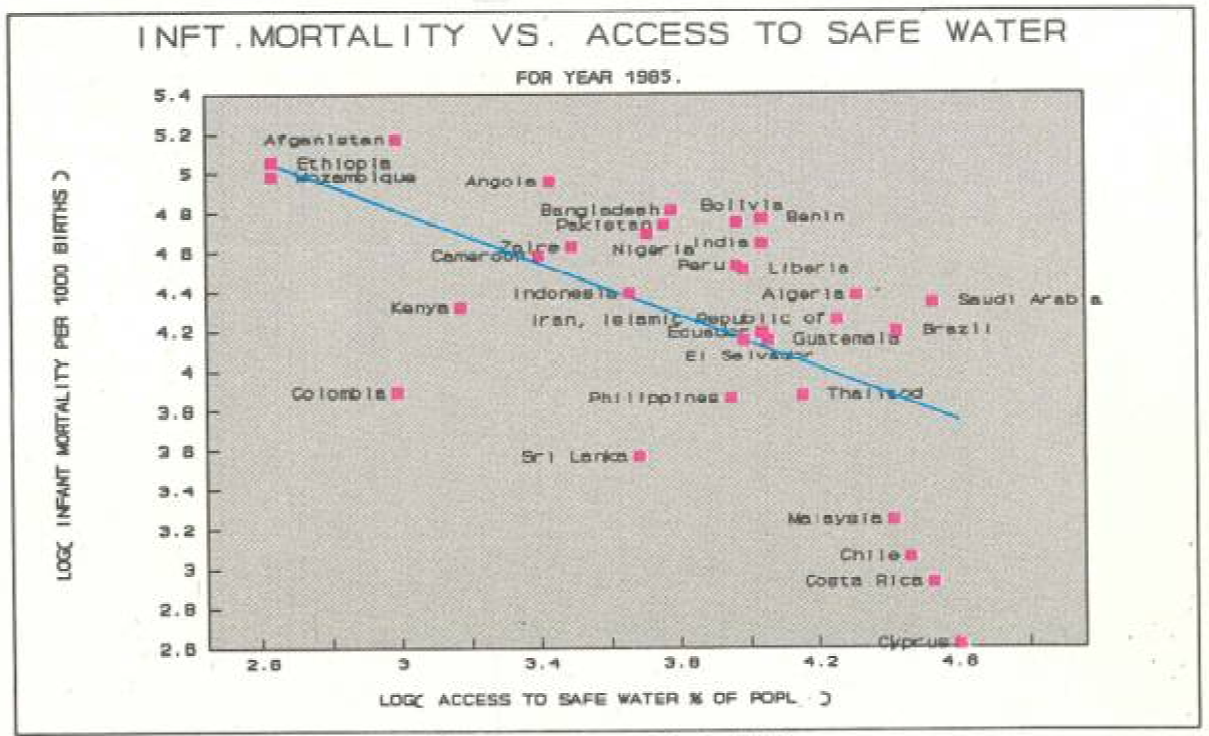


Figure 4.1: Infant Mortality Vs. Access to Safe Water

1000 t of carbon emission consumption patterns are given in Table 4.2.

Thus, reduction in fuelwood use to reduce 1000 t of carbon emissions would mean depriving more than 500 households of their energy to cook their food. Most of these households in poor countries do not have buying power to switch to other fuels, which may emit less CO_2. In terms of rice production, reduction of 1000 tonnes carbon equivalent reduction in methane emissions implies 12000 persons would have to give up eating rice, a staple food for poor in most of the rice producing developing countries like India, Bangladesh, etc. Alternatively this methane reduction could also be achieved by reducing number of cattles by 4000, but that would imply problems for more than 1000 rural poor households whose fuel, energy and food requirement are met partly by cattles. Reduction in cement use and hence housebuilding activity for 1000 t of carbon translates into 1000 to 3000 houses for poor, in countries that are already short of housing. Similarly 3200, 4600 and 5500 MWH of electricity production from coal, oil and gas would have to be sacrificed. The 1000 t carbon reduction can also be achieved by reducing 800 cars on the road. For developed countries, it could imply reduction in number of cars per family or less driving. In the long term, this could also be done by switching to fuel efficient public support.

4.4 Trade-offs among Regions: The Needed Emission Reductions

How much reduction would have to be done by others when some of the low income developing countries move closer to the world averages? As a simple exercise, we take India and China. We assume that global CO_2 emissions should not be more than 1986 level (i.e. 5.7 bill. tonnes of C) in 2025. For this, per capita emissions of developed countries will need to be brought down so that per capita emissions of developing countries may increase. The economic growth, necessary to provide a reasonable level of living standard in developing countries will lead to higher energy use and hence higher emissions. For a GDP growth rate of 5% per year till 2025 for India, this brings per capita GDP to $796 from $249 in 1985, the CO_2 emissions are almost four times the 1985 levels, for a low emissions scenario, (LBL,1990). In case of China, the growth is from $310 per capita in 1985 to $2000 in 2025 (LBL, 1990). This implies per capita CO_2 emissions of 0.36 t and 0.96 t for India and China respectively by 2025 as compared to world average of 1.12 t in 1985. Corresponding CO_2 emissions for low emissions growth scenario (i.e. assuming possible efficiency improvements take place), are shown in Table 4.3.

As against the stabilization of carbon emissions at 5.7 bill tonnes per annum assumed in his exercise, the IPCC (1990) emission scenarios take the levels of carbon emissions at 6.3, 6.2 and 5.1 billion tonnes for 2025 for scenarios of low emission, control policies, and accelerated policies respectively. Afforestation has been taken to absorb 0.5 billion tonnes carbon in all these scenarios. While such actions to increase the capacity of global sinks provide some leeway, it is clear that very substantial reductions in CO_2 emissions have to be made by the industrialized nations.

It can be seen in Table 4.3 that to stabilize the global total emissions at 1986 level, developed world has to reduce emissions by 30%. Even after this, India's per capita emissions and per capita GDP are nowhere near per capita emissions and GDP of developed countries in 1986 or in 2025. Since, besides India and China, other developing countries, who are also below world average, also will have higher emissions than in 1986, the reduction over their present emissions needed by developed countries will be higher than 30%.

Table 4.2 : 1000 Tonnes of Carbon Equivalent Emitted in a Year by

Consumption Activity	Magnitude	Socio-economic needs
Gasolene[a]	1580 K. litres	Could be used by 800 cars/year (at 20 MPG, US data)
Fuelwood[b]	(i) 75 Ha of open forest land, providing 2500 tonnes of wood (ii) 20 Ha of open forest land (only 25% from deforestation) corresponds to 10,000 tonnes of fuelwood use.	(i) Can meet cooking energy needs of 2500 persons (or 500 households). (ii) Can meet cooking energy needs of 10,000 persons (or 2000 households).
Rice Cultivation[c]	750 Ha. land	Rice Production from this could be 1125 tonnes (@ 1500 Kg./ha.), sufficient to meet annual requirements of about 12000 persons in a poor country @ 0.25 Kg./capita/day.
Livestocks[d]	4000 cattles	These support more than a thousand households to meet part of their fuel, agricultural energy, fertilizer requirements and milk and meat needs.
Cement for house[e]	7500 tonnes	This could be sufficient to build about 1000 to 3000 houses (of moderate size of 500 sq. ft. depending on type of construction).
Elect[f] Power Plant:		
Coal based	3200 MWH	Sufficient to meet annual electric energy requirements of about 2700 households. (Each household consumes about 100 KWH/month).
Oil based	4600 MWH	3800 households electricity requirements
Gas based	5500 MWH	4600 households electricity requirements

Notes:

a) Each car with average of 20 miles/gallon and yearly driving of 10,000 miles (US average car run). This is about 1.45 tonne gasolene/car/year.

b) Assuming that all of it is from deforestation, it will add 1000 tonne C in atmosphere. In a tropical climate, this means approx. 75 ha. of open forest land is used up. However, not more than 25% of fuelwood may come from deforestation (it is 5 to 7% in India; Leach, 1988). If balance 75% is from regeneration, it means actually 2500 x 4 = 10000 tonnes of fuelwood, used by 10000 persons.

c) 750 ha. of rice cultivation produces methane (@ 0.20 gm. CH_4/M2/day), which is equivalent to 1000 tonnes of carbon. Equivalence for CH_4 is taken as 21 times that of CO_2 (on weight basis), corresponding to the time horizon of 100 years.

d) Cattle is taken to emit 43 Kg. CH_4 per year, considering the weight as 200 Kg. The quantity of CH_4 emitted by a cattle is yet to be properly determined.

e) The cement is taken to contain 63.5% Cao. It excludes energy required for producing cement.

f) Carbon per GJ of delivered electricity; for coal based 90 Kg, for oil based 79 Kg. and for gas based 52 Kg.

Table 4.3 : CO_2 Emission Stabilization Scenario

		Case I Oak Ridge data for 1986 (No deforestation taken)	Case II WRI data for 1987 (with deforestation)
China	Carbon/Cap.(tonnes) Total (Mill. tonnes)	0.56 610	0.60 596
India	Carbon/Cap.(tonnes) Total (Mill. tonnes)	0.20 164	0.40 294
World	Carbon/Cap.(tonnes) Total (Mill. tonnes)	1.12 5724	1.7 8600
		Scenarios 2025	
China	Carbon/Cap.(tonnes) Total (Mill. tonnes)	0.96[a]/2.86[b] 1365	0.96/2.86 1365
India	Carbon/Cap.(tonnes) Total (Mill. tonnes)	0.36[a]/0.8[b] 615	0.36/0.8 615[c]
World	Carbon/Cap.(tonnes) Total (Mill. tonnes)	-- 5724[d]	-- 8600[d]
Reduction required in emissions of developed world[e]			
Total Reduction[f] (Mill. tonnes)		1206	1206
% Reduction required[f]		30%	30%
Per capita emissions of developed countries after reduction (tonnes) (assuming 1986 population base)		2.35	2.35

Notes:

a) This refers to low carbon emission scenario for India and China. LBL-30060, Dec. 1990.

b) Even if low carbon emission scenario is considered for 1985 population base, per capita emissions for India remain at 0.8 tonne, less than 25% of per capita emissions of developed world and below the world average of 1.12 tonne for 1986. For China this is 2.86 tonnes, about 85% of developed world average.

c) Assuming no net deforestation by 2025.

d) Assuming the total emission to be kept at same level as in 1986 (Case I) and 1987 (Case II). In case II this however, implies net addition of carbon in the atmosphere to the tune of 3.7 billion tonnes. Elimination of deforestation by 2025 will make Case II identical to Case I.

e) Developed world accounted for 70% of carbon emissions in 1986 as per Oak Ridge data. This worked out to per capita 3.36 tonnes and gross 4025 million tonnes. For Case II (WRI data) also developed world was taken to account for same amount (i.e., 4025 million tonnes), as 2800 million tonnes was due to deforestation as per WRI. The balance difference of 79 million tonnes could have been accounted for by developing countries, due to increased energy use in 1987 compared to 1986.

f) This reduction is needed to keep CO_2 emissions at 1986 levels and only account for increased emissions by India and China. This will be much higher, as other developing countries will also increase energy consumption and hence CO_2 emissions.

Box 4.1
CO_2 Emissions Vs. Agricultural Methane

There are the following reasons why the two cannot be at par.

Measurability : The reliability of estimates of emissions:

Gross CO_2 emissions by country could be calculated within reasonable reliability levels, knowing energy balances given by individual countries themselves to the United Nations. Gross CO_2 emissions do not depend too much on the technology with which the energy sources are used. There is a reasonable degree of agreement about how much gross CO_2 emissions are contributed by which country. Agricultural methane emissions, on the other hand, depend significantly on the

- weight and diet of livestock,
- their breeding patterns,
- manner in which paddy is grown (wet or dry)
- climate
- effects of organic as well as inorganic fertilizer applications.
- biomass decay from forests and agriculture.
- methods of solid waste disposal.

These factors vary from country to country and the signs of how these factors affect methane emissions are not yet understood across countries, and within countries.

Sink effects : Global Absorption capacities for the emissions.

- In addition to the estimates of gross methane emissions, the absorption phenomena for methane is equally uncertain.
- The fact that, gross CO_2 emissions are larger than global absorption capacity is certain and the rise in CO_2 is measured.
- The lifetimes of methane in the atmosphere - estimated to be around 10 years are much shorter than CO_2 which lasts in the atmosphere over a 100 years. Even atmospheric chemistry is not clearly understood regarding methane absorptions.

Adding them up: How does one add CO_2 and methane? :

- The scientific debate on radiative forcing coefficients which add these pollutants for equivalent "greenhouse effect" (the same way one adds energy sources through heat values of solids, liquids, gas and so on) has yet to settle down. The coefficients depend on whether the effect being considered is instantaneous or a century later, and are still debated in journals. The global warming potential approach neglects the socio-economic aspects discussed below.

Box 4.1 (Contd.)

Socio-economic aspects :

- Agricultural methane emissions result from activities that are closer to human survival than CO_2 emissions where the need for management is much stronger.
- The constraints in methane emissions, if imposed, are likely to affect the poor and malnourished.
- Even if one does not control agricultural methane emissions, their increase is not likely to explode out of proportions as has gross CO_2 emissions because there is a saturation for methane consumption levels. The saturation can be seen by comparing the patterns of estimates available for developed and developing countries. (WRI report 1991).
- The costs of emission controls and monitoring low level decentralised activities such as paddy growing and livestock keeping could be substantial compared to the gains expected in emission reductions. CO_2 emissions controls, mainly emitted by power and transport sectors could be relatively easily monitored and enforced.
- CO_2 emissions have already gone much beyond global absorption capacity. Considering the urgency of curbing CO_2 emissions, this has to be taken up first, till such time methane emissions and absorptions processes are understood better.

Box 4.2

Deforestation Rates : Assumptions Chasing Assumptions

Despite the involvement of a number of organisation in the estimation of CO_2 emissions the element of fact is sadly missing. The story originates from FAO which produces fuel wood per capita consumption data.

Constant Fuelwood Per Capita Consumption: For as many as 57 countries, FAO data for fuel wood production is generated by keeping fuel wood per capita consumption constant - sometimes upto three digits and sometimes for over two decades, regardless of

- changes due to income levels and preferences for high quality fuels such as kerosene, electricity and gas.
- substitution by other fuels because of unavailability of wood such as crop and forest residues.
- adaptation strategies to cope with scarcity of fuels
- reductions that would be expected in production itself, if larger and larger amounts of fuelwood a' : consumed. Two examples are taken to illustrate the propagation of assumptions. Ivory Coast and Equador. Table B4.1 shows that they are at best "requirements" rather than consumption. Even if this fuel wood is consumed, it would be inappropriate to assume that it came from "forests". G. Leach (1988) has strongly disputed the belief of fuel wood causing deforestation in India by showing from NCAER (1985) data that 90% of the cooking energy that is contributed by biomass, does not come from felled trees and the deforestation damage may even be a lot less than this suggests, since some of the trees felled may have been replanted.

Population: Even population data given in FAO is simply obtained by adding the same amount of populations or assuming the same growth rate.

Forest Area: Reduction of the forest area by the same amount every year e.g., 0.5 mha. for Ivory Coast and 0.3 mha for Equador for the last 10 years.

Productivity: This in turn leads to the assumption of increasing wood from reducing forest area and hence increased productivity.

The World Bank takes these forest area data by FAO and converts them into "deforestation rates". Time series for more than 20 years are constructed using this data. Naturally, since an increasing amount of fuel wood is required for larger and larger population with a fixed norm of per capita consumption, one has ever increasing deforestation rates!

Box 4.2 (Contd.)

WRI uses these deforestation rates and converts thèm into estimated CO_2 greenhouse emissions due to deforestation or "land-use changes". Although WRI mentions that the deforestation is not due to fuel wood consumption alone, and are also due to land clearing for agriculture and pasture purposes, timber felling and so on, the basic data of land- use change originates from FAO sources for many countries. Although, remote sensing data is used for at least some countries, they have come up with even larger deforestation rates than indicated by forest area data by FAO. Therefore, one wonders, if remote sensing data needs to be taken every year over a period of time to be conclusive about deforestation rate. In case of India, the forest survey statistics (1989) shows much less defòrestation than the figures quoted by WRI.

As much as 2.8 billion tons of CO_2 is assumed to be emitted from land-use change mostly by the developing countries. Neat pie charts showing 35% of CO_2 attributed to deforestation appear in number of articles around the world. In fact, due to this phenomenon, countries with low consumption levels like Ivory Coast, Myanmar (formerly Burma), Lao P.D.R. and Equador, all of them with fixed per capita consumption over a decade, have the dubious distinction of being listed in the world's top 20 net emitters of carbon dioxide! It is shown in a number of surveys that rural population of developing countries have to increasingly resort to inferior fuels such as animal dung and crop residues as fuel wood is no longer available. Since both animal dung and crop residues are grown annually, they do not enter into land-use change by anthropogenic actitivies.

This controversy has an important bearing on the sink availability for CO_2. ORNL report wisely does not consider CO_2 emissions due to deforestation. As shown in the Table below 5.8 billion tons (bt) are gross emissions due to fossil fuels and cement and 2.8 bt is the contribution of "land-use change", according to WRI figures.

CO_2 from Deforestation and "The Missing Sink"

	WRI 1990	ORNL 1988
Fossil fuels and cement	5.8	5.7
Land use change	2.8	--
Total Gross CO_2 emissions	8.6	5.7
-CO_2 observed in the atmosphere	-3.9	-3.9
Available sink for CO_2	**4.7**	**1.8**

Note: WRI data is for 1987 and ORNL data is for 1986.

Thus, correcting for gross emissions of CO_2 concentrations observed in the atmosphere, CO_2 sink capacity could be anywhere between 1.8 bt to 4.7 bt, depending on land-use change. If the land-use change data is disputed then, the global CO_2 sink capacity estimate is also disputed. The question of the distribution of these sink capacities among various countries is discussed elsewhere.

Box 4.2 Contd.

Table B4.1 : Fuelwood and Deforestation from FAO Statistics

Year	Fuelwood Production (M CUM)[1]		Population (Millions)[2]		Fuelwood Productio per capita (CUM/Cap)[3]		Fores Area (M Hectares)[4]		Deforestation Rate[5]		Productivity: Fuelwood Production/ Forest Area (CUM/Ha.)[6]	
	Ivory Coast	Equador	Ivory Coast	Equador	Ivory Coast	Equador	Ivory Coast	Equador	Ivory Coast	Equador	Ivory Coast	Equador
1977	5.97	4.26	7.341	7.453	0.81	0.57	11.4	14.9	-4.39	-2.01	0.52	0.29
1978	6.22	4.39	7.656	7.668	0.81	0.57	10.9	14.6	-4.59	-2.05	0.57	0.30
1979	6.49	5.53	7.985	7.891	0.81	0.70	10.4	14.3	-4.81	-2.10	0.62	0.39
1980	6.77	5.55	8.327	8.123	0.81	0.68	9.9	14.0	-5.05	-2.14	0.68	0.40
1981	7.06	5.57	8.683	8.363	0.81	0.67	9.4	13.7	-5.32	-2.19	0.75	0.41
1982	7.36	5.60	9.053	8.609	0.81	0.65	8.9	13.4	-5.62	-2.99	0.83	0.42
1983	7.67	5.81	9.438	8.861	0.81	0.66	8.4	13.0	-5.95	-2.31	0.91	0.45
1984	8.00	6.00	9.838	9.118	0.81	0.66	7.9	12.7	-6.32	-2.36	1.01	0.47
1985	8.73	5.88	10.252	9.378	0.81	0.63	7.5	12.4	-6.67	-2.42	1.16	0.47
1986	8.68	6.24	10.681	9.639	0.81	0.65	6.9	12.1	-7.25	-2.48	1.26	0.52
1987	9.05	6.30	11.606	10.204	0.81	0.64	6.4	11.8	-7.81	-2.54	1.50	0.53
1988	9.43	6.38	12.092	10.490	0.81	0.63	5.9	11.5			1.60	0.55

1. The estimated fuelwood production by FAO are taken from FAO year books of forest products.
2. Population data is extracted from FAO production year books.
3. Uniform per capita fuewood production figures in case of Ivory Coast and more or less uniform per capita production Figures in case of Equador reveals the fact that they are taken as norms based on which fuelwood production figures have been estimated. However, the constancy of norms gives rise to doubts on sanctity of the estimates of fuelwood production.
4. Forest Area is the Forest & Wood land Area data from FAO production year books. Forest area reported as declined at Uniform rat of 0.5 MHa per annum in Ivory Coast and 0.3 MHa per annum in Equador raises doubts about the authenticity of the data.
5. The annual deforestation rate figures are estimated from the forest area figures of FAO. They are similar to those reported in Social Indicators of Development tables of the World Bank and then taken by WRI (90-91) to conclude that 30% of global greenhouse gas are emitted due to land-use change.
6. Since increasing amounts of wood is produced from decreasing forest area, significant rise in productivity is seen.

5

Policy Options for Sustainable Development

Before we think of policy options, we should consider the objective or a vision of the world towards which policy should lead us. We must recognize that the ecology of the globe is one indivisible whole, that unless all of mankind cares for it and shares it, an earth that is healthy and hospitable for human beings cannot be preserved. The vision that should guide us is a state of the world where all men and women have equal opportunities to live fulfilling lives at comparable levels and in harmony with nature without creating problems for their fellow beings. No nation by itself is going to ensure a sustainable world. Cooperation, willingly given from all, will be needed to preserve our earth. Thus, no vision but the one of an equitable global future is a feasible vision. It is also an ethically just one. Policies should be so chosen that they lead us to such a world.

5.1 Development is Needed, is Desirable and can be Environmentally Beneficial

Inspite of unprecedented economic development since the end of World War II, large number of people still suffer from poverty, hunger, malnutrition and ill health. In the developing countries with a total population of 3900 million in 1988, more than 1100 million children are malnourished, 870 million adults are illiterate, 1750 million persons have no access to safe water, 1500 million have no health services and 2800 million are without sanitation facilities (Human Development Report-1990). These deprivation result from poverty and the only solution is to provide the poor with opportunities to earn more income. This requires increasing productivity of land, providing more skills and creating more employment opportunities. Economic development is needed to deal with these problems. Economic development is desirable as these deprivations must be eliminated.

In thinking of any policy options for sustainable development, these realities must be borne in mind. The main threats to sustainability at the local levels, related to soil degradation, deforestation and air and water pollution, are the outcomes of poverty and lack of development. Economic development, if environmentally sensitive manner can, therefore, be enviornmentally beneficial.

5.2 Population Growth is not the Main Cause of Present Environmental Stress, but it should be Slowed Down

Population growth, which reduces growth of per capita income by a larger percentage, does not by itself aggravate emissions or use of many non-renewable resources. We have already seen that the GNP elasticity of energy use is nearly 1 and that for CO^2 emissions is 1.2 in developing countries.

Nevertheless, it is important to curtail population growth as soon as possible, to ensure mankind reaches a steady state sooner and at a lower level of population, so that the eventual sustainable consumption pattern could be higher.

Rapid economic development and spread of education in the developing countries which accelerate the demographic transition to a stable population are therefore environmentally very desirable. The low income developing countries need and should be given all help, including aid, to accelerate their economic growth rates.

5.3 The Present Consumption of the Industrial Countries is Ecologically Unsustainable with Current Technology

While it may be possible to produce food to meet the demand by a stable population of 8 billion persons all consuming at the present level of consumption of food by the industrial countries, energy use at the level of consumption of the industrial countries by 8 billion persons cannot be supported with current technology by the global ecology.

As seen in Table 2.1, the cereal consumption by the developed countries was 720 kg\capita and the average disparity ratio was 2.9 in 1988 with a global population of roughly 5 billion. The world cereal production of three times the present amount can feed 8 billion persons at the level of 729 kg\capita. This may not be difficult. The developed countries of Europe today more or less feed themselves despite a very high population density. It should not be difficult for the presently developing countries to reach such levels of productivity. Presently available techniques of water conservation, controlled use of chemical fertiliser and pesticides, and integrated pest management are capable of sustaining the needed cereal production without undue ecological stress.

The same cannot be said about consumption of energy intensive services and products. If each of 8 billion persons were to emit 3.26 t of CO^2 per year, as is the present average emission rate of industrialized countries (or 5.4 t as in the USA) then the annual gross atmospheric emissions would be 26 billion tonnes (or 43 billion tonnes using US rate) compared to present gross emissions of CO^2 of 5.3 billion tonnes per year. The rate of CO^2 build up in the atmosphere would be more than 8 to 14 times the present rate. This is obviously not sustainable.

5.4 Preserving the Global Environmental Quality at Least Cost

Many of the environmental problems arise from the fact that the environmental costs and consequences are not borne fully by those who cause them. They are external to their benefit/cost calculations. If the costs of environmental emissions and impacts are borne by those who cause them, they would cause less of emissions. They would take the necessary steps and additional effort and additional expenditure would be made and enviromental stress reduced. The costs of curtailing undesirable emissions varies from one economic activity to another as also from one place to another. Thus, curtailing carbon emissions from a power plant costs a different amount than curtailing carbon emissions from an automobile. The cost of the latter may vary from country to country depending on the type of automobiles used, how well they are maintained, in what traffic conditions they are used, etc., Regulations that stipulate emission standards for various activities are somewhat unsatisfactory. Firstly, even when everyone emits within the permissible limit, the ambient air or water quality may deteriorate, if the number of emitters cannot be controlled. Secondly, it is difficult to impose physical limits on different industries and firms to reflect their marginal cost of abatement.

It would be most efficient to use the market mechanism to decide who does what and how. Tradeable emission rights provides a way of maintaining ambient air or water quality at a desired level with, at least theoretically, least cost.

If each country is allotted a fair share of the global atmospheric carrying capacity sink for CO^2 emissions, then those, who want to emit more must buy emission rights from those who emit below their share. Developing countries with surplus emission rights would be better advised not to sell them but only lease them out on annual basis as the worth of these will be much higher in future. One may have a long term lease agreement with prices pegged to some benchmark level such as mean rental values of contracts completed in the previous year. Leasing and futures market will help make the system more efficient. Individual countries will compare whether it cost more to buy rights or to take control measures.

Such a system would minimize global costs of emission controls.

5.5 Fair Allocation of Emission Rights

How should emission rights be allocated to different countries? What is a fair allocation?

It should be on a per capita basis as that treats all human beings as equal. This is morally appealing. However, the developed countries would argue that this amounts to rewarding developing countries who do not control their population. It can be on the basis of population of some year in the past e.g. as in 1985 as taken in Table 4.3. An allocation based on area of the country is also not a good allocation as that would reward those who have appropriated (unjustly ?) a larger part of an important global resource, namely, land. All these suggest the difficulty of arriving at a just principle of allocation. Any agreement whatsoever would have an implicit allocation. Thus, allocation is unavoidable and it is better to make it explicit.

This may be illustrated with a specific example, say, of carbon emissions.

In 1987, the total emission of CO_2 caused by human activities was about 8.6 billion tons in terms of its carbon content, but the atmospheric total increased by only about 3.7 billion tons. Thus, the natural processes are able to absorb some 4.9 billion tons. If we want to maintain the level of atmospheric carbon at its present value of some 740 billion tons, then emissions from human activities must be restricted to 4.9 billion tons a year.

When the World Resources Institute (WRI) report "World Resources 1990-91" describes "net" contribution of each country to global Carbon accumulation, it implicitly allocates shares to different countries. The "net" emissions of WRI are not "net" of sinks such as forests developed by the country through its own human activities, but it is net of nature's absorptive capacity (the 4.9 billion tons referred to above) and the country's share in it.

To arrive at net emissions, the WRI report scales down the gross emission by the global net to gross ratio (i.e. by 3.7/8.6). Thus, implicitly, the WRI report allocates each country the global absorptive capacity of 4.9 billion tons, a share in proportion to its own gross pollution rate. Thus, the developed countries get a much larger share. This procedure rewards the culprit and punishes the well behaved. This cannot be acceptable to developing countries. The WRI report does not seem to be aware that it is making this allocation.

5.6 Environmental Priorities - Local vs. Global Problems

A system of fairly allocated tradeable emission rights provides the developing countries the freedom to set their own priorities. For many developing countries local problems are of great significance for the welfare of their citizens. Problems of urban air and water pollution which lead to increased morbidity and mortality, degradation of common property resources in the villages depriving the poorest segment of society their access to fodder, fuel and other products that provide additional incomes, have a higher priority. With limited resources - and the poor countries are always short of resources - it may be better to deal with these problems than spend money to contain carbon emissions.

For example, 45 per cent of the population in developing countries have no access to safe water. Provision of access to safe water will lead to reduction in infant mortality. Cleaning up urban air and water pollution, provision of safe water and sanitation facilities have such obviously beneficial impacts on the health and welfare that developing countries should give these tasks a much higher priority than reducing greenhouse gas emissions such as methane.

Yet, it would be prudent for developing countries to carefully balance future value of emissions rights and present benefits when evaluating alternative techniques of production. A well developed system of tradeable rights and future markets will provide the information needed to arrive at decisions which make long term sense.

5.7 Specific Actions

The broad approach to policy described above, will only provide for efficient implementation of specific policy actions. Possible actions available to promote sustainable development include reduction in emissions through better development such as creation of carbon sinks through afforestation, use of renewable resources to reduce use of fossil fuels and appropriate economic policies to promote adoption of these measures. We deal with some of these below:

Forests : It is necessary not only to halt deforestation but also afforest already deforested lands. The role of forests in removing CO_2 from atmosphere and halting soil erosion is well known. Trees not only absorb carbondioxide but many other emissions as well. In addition, they halt soil erosion.

Afforestation on a substantial scale is possible, both in developing as well as in developed countries. This will increase global sinks of carbon dioxide.

However, after some time (say 100 years), when most of the possible afforestation has taken place, and stock of wood products that sequesters carbon for a long term has reached to a level of saturation, this sink is no more available. Thus, this is a solution for short and medium term only.

Afforestation in third countries raise some issues of rights and obligation. These are discussed in box 5.1.

Alternative fuel substitution : Natural gas is far cleaner compared to fuelwood, coal and oil. Fortunately, many developing countries have natural gas resources some of which are yet untapped. In some countries, significant amount of gas is flared. If help is given to halt this flaring by suitable development of natural gas markets, it will not only reduce carbon dioxide emissions but also make use of locally available, precious and relatively cleaner energy resources to substitute dirty fuels, such as wood, coal and oil in power, transport, industries and household sectors. Moreover, this would reduce imports of petroleum and petroleum products. If gas is used in transport sector using compressed natural gas (CNG) technology, considerable amount of concentrations of particulates, carbon monoxide and hydrocarbons can be reduced especially in the urban environment. Some of these emissions in urban environment lead to many health problems.

There are some 25 developing countries, who have adequate gas resources to satisfy their needs equivalent to current crude imports upto 2010 and beyond.

Energy efficiency: A considerable amount of energy consumption could be avoided through energy management and energy efficient technologies. This is true of developing as well as developed countries. These efficiency measures are known for almost all sectors including power, industry, transport, domestic and commercial sectors. Though many of these are economically attractive options, there are often institutional obstacles to introducing these measures and they are not treated at par with energy supply options. One of the problems is the differences in the discount rates acceptable to the users and to the supply utilities.

Since 1985, the progress in efficiency improvement has slowed down considerably and world-wide use of oil and electricity has considerably increased. This may be due to availability of cheaper oil since then. It should be emphasised that the planned efficiency targets, such as cars that give 27 miles per gallon in the USA by 2000, are nowhere near the goals that ought to be set even to make a dent in the problem.

Increased efficiencies cannot solve the problems that have been created by inappropriate life styles. Any life style which cannot be followed by all, must be considered inappropriate, if it is recognised that we have only one world and some of the people cannot be banished into the "third world" for ever. However, it has been shown by Goldenberg et al (1988) that European lifestyle can be maintained by all using energy-efficient technologies. Thus, it is necessary to revive and maintain interest in energy-efficient way of life.

Renewable Sources of Energy: Technologies to harness renewable energy sources such as photovoltaic, solar thermal, passive solar, wind and wave energy have been already examined in the context of wide varieties of end-uses, local situations within countries and across countries. Some of them are presently considered expensive compared to the conventional energy sources, since environmental costs for the conventional energy sources are not internalised in these comparisons. These comparisons need to be reviewed again against the backdrop of local pollution and global impacts of green house effects. However, environmental impacts of renewable energy technology also need to be considered carefully. They are often simplistically assumed to be benign while they are not always so. The environmental impacts should be viewed for a sizable contribution, such as per GW (or TWh), by each type of technology; conventional as well as renewables. On such a scale solar thermal technology may have thermal pollution; photovoltaics may involve toxic chemicals; wind energy, in addition to involving noise pollution may also require non-renewable materials such as steel, aluminium, and cement, and could lead to changes in wind patterns and may affect birds; and so on. Nonetheless, renewable energy sources for appropriate uses and situations will constitute important alternatives to reduce environmental stress. One has to keep in mind that renewable energy options are being talked about for two decades but despite a number of efforts around the world, they have not yet entered the energy supply statistics. (Had they provided more than 1% energy they would have.).

Appropriate Pricing: Road transportation is an important contributor of SO_x, NO_x, HC, CO and CO_2 emissions. Hard decisions are expected from the developed countries, which account for more than 85% of use of transportation energy. USA alone accounts for 44% gasolene consumption, 37.3% of world's total vehicles (177 millions) and 38% of CO_2 emissions from vehicles in the world. Moreover, 11 million cars are purchased every year in the USA. When looked at US gasolene consumption per vehicle over time, one might get a feeling of progress. However a comparison with other countries is more relevant here to obtain insights into what is possible as can be seen in Figure 5.1. For example, some studies that have looked only at the USA have failed to draw attention to the possible role of raising gasolene prices and provision of mass transit as some of the major policy alternatives to curb gasolene consumption in the USA. The countries of Western Europe where gasolene prices are 3 to 5 times the US price, use less than half the gasolene per capita per year. In the absence of a pricing policy, it is not surprising that despite the improvements in vehicle efficiencies, consumption in the USA grew by more than 40% during 1974-1988. (Mackenzie J.J. and M.P. Walsh 1990). It shows that increasing energy efficiency will not solve the problem, unless it is also coupled with other hard decisions concerning lifestyles and pricing.

5.8 Concluding Observations

We have seen that unless dramatic new technologies become available, the present consumption patterns of the rich are not sustainable. They require a disproportionately large share of the earth's resources and put a similarly large burden on the global carrying capacity. As more and more people become rich and emulate

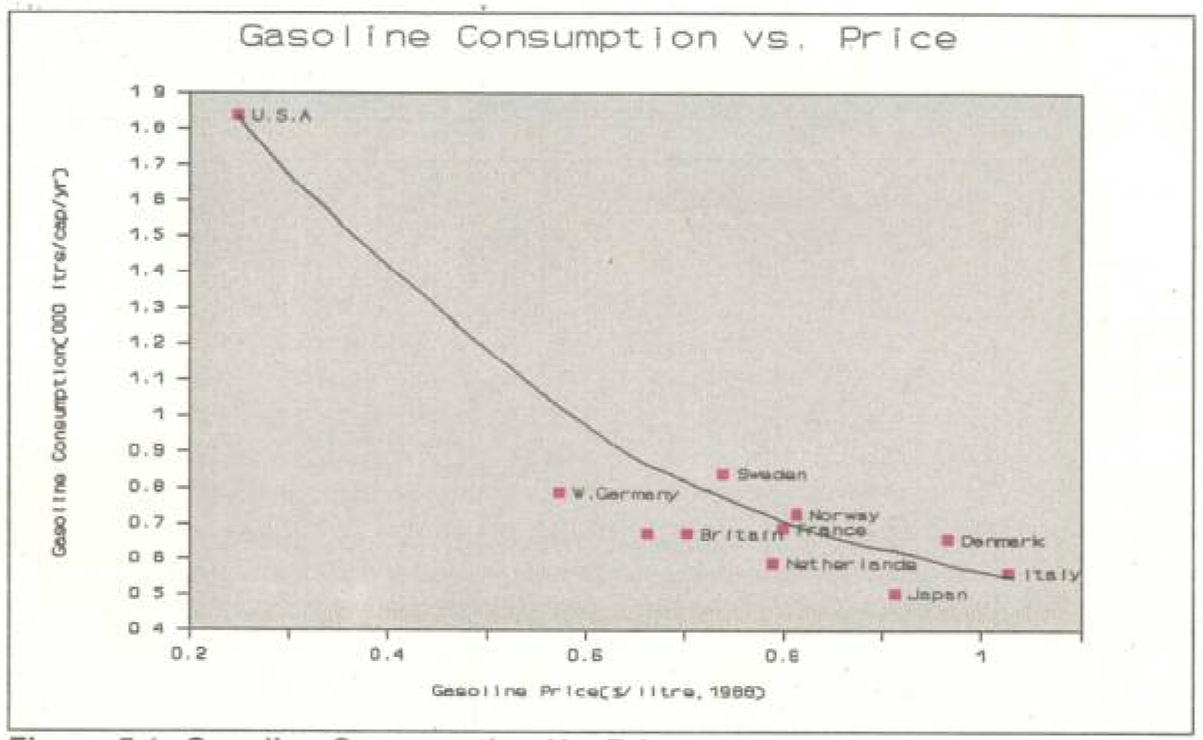


Figure 5.1: Gasoline Consumption Vs. Price

this lifestyle the burden on earth would be unbearable.

At the same time, growing population in many low income low growth economies pose a different set of problems that may lead to degradation of land and forests. But more importantly they make it more difficult to reach a sustainable state in the future.

There are many things we can do to reduce if not eliminate the danger to earth's ecology. But we need to act and act together if we are to be successful. If we act well and wisely and with charity, this is an opportunity we can seize to green the earth. For Earth's sake let us do that.

Box 5.1

Afforestation in Third Countries - For Whose Benefit?
Is it AID? Is it DFI?, Is it a LOAN?

Afforestation in Third World countries, usually developing ones, by the industrial nations has been advanced as a solution to global warming. It would be an especially attractive scheme, if and when tradeable emission rights are established. While on the one hand, it is approvingly described as an interesting scheme to "reverse the greenhouse effect"[1], an "international compensation project"[2] and creation of "carbon sink forests"[3], it is also criticized as using the third world as a "sink for the West's dirt"[4]. If appropriately handled, it could pave a way for new opportunities for greening the earth, if not, it could lead to "environmental colonialism".

Such creation of forests in third countries raise a number of questions: Who pays for the cost of planting? Who bears the opportunity cost of land? To whom does the forest belong? To whom does the right to the CO_2 sink belong?

Clear answers and understanding of these and related issues is needed to arrive at an understanding on how desirable are such programmes and under what conditions.

The answers to the questions raised above depend upon whether it is aid, direct foreign investment, a loan, or just a lease or sale of asset by the recipient country?

Aid : In this case, the donor country pays for the costs of afforestation and apart from monitoring that the aid money is spent for the purpose for which it is given, forgets about it. It has no further claim on the fruits or the CO_2 sink arising out of the creation of the forest. There are no problems of ownerships of forests and associated products.

Loan : This is also similar to the case of aid excepting that the donor country expects repayment with interest. It has no claim as the products or the CO_2 sink.

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[1] Anon 1989, Plant Trees, Conserve Energy to Counter Greenhouse Effect, in Our Planet, March 1989, United Nations Environment Programme, Nairobi.

[2] John Pezzey 1989, Economic Analysis of Sustainable Growth and Sustainable Development, Environment Department Working Paper No.15, March 1989, The World Bank, Washington.

[3] Robert Goodland et at 1990, Tropical Moist Forest Management: The Urgent Transition to Sustainability, paper presented at a Seminar on Economics of the Sustainable Use of Forest Resources, April 1990, Centre for Science and Environment, New Delhi, Mimeo.

[4] Agarwal Anil and Sunita Narain (1991), "Global Warming in an Unequal World: A case of environmental colonialism", Centre for Science and Environment, New Delhi.

Box 5.1 (Contd.)

Direct Foreign Investment : This situation is somewhat complex. Here the receiving country is exporting every year its land services, the value of which may be higher because of its greater climatic suitability to grow forests than in the investing country. The receiving country foregoes other uses of this land (opportunity costs) and that is its contribution to the creation of the forests. If it is seen as a joint venture, the two countries should share in the products and rights depending on the values of their relative contributions. Alternatively, it can be viewed as fully foreign owned investment for which the land has been rented out by the recipient country. In either case, an appropriate rental value for land needs to be fixed up. A fair agreement could be as follows:

- The investing country pays for all costs of plantation and maintenance.
- It pays a rent for land every year and the rent should be periodically revised.
- The rental rate for any year should be linked to the marginal cost of greenhouse gas remission in the world that year as well as the opportunity costs of the land and the growth of forest stock whichever is higher. If a scheme of tradeable emission rights is operated, then these values are easily obtained.
- Once appropriate rent is paid, the forest products and rights can belong to the investor.

Whatever scheme is being followed should be made explicit to avoid misunderstanding. Any fair arrangements that increases the area under forests through cooperation arrived at without coercion can only increase the welfare of mankind. But any commercial arrangements thrust upon helpless developing countries under the guise of aid will smell of environmental colonialism and may be counterproductive in the long run.

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