INTERACTIONS: ENERGY/ENVIRONMENT

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Contents

Summary

The main environmental problems faced by humanity today and the contribution of energy as the cause of such problems are discussed. Each of these problems, namely urban air pollution, indoor pollution, acid rain, greenhouse warming, and coastal and marine degradation are presented. One section addresses the major causes of the environmental problems, particularly electricity production, transportation, and industry. The potential conflict between energy use—essential for development—and environmental degradation is outlined.

1. Introduction

The environment in which we live changes continuously due to “natural causes” over which we have little control. The seasons of the year are the most evident of these changes, primarily in geographical locations at high latitudes (north and south). There are many other variations, such as the inclination of the earth’s axis, sunspots on the surface of the sun and those with their origin in the earth itself, such as volcanic eruptions, earthquakes, typhoons, floods, and forest fires. Life on earth has shown a surprising resilience in withstanding changes in the environment, and humanity in particular has adapted well to changing climate since the last glaciation some 10,000 years ago, when most of the northern hemisphere was covered by ice and snow. All the natural changes in our environment, except natural disasters, occurred slowly over long periods of time, typically centuries.

Until recently, humanity's actions have been of negligible importance in changing the environment, except perhaps in denuding large forest areas in Europe, China, and Central and South America. After the Industrial Revolution at the end of the eighteenth century, however, and particularly in the twentieth century, anthropogenic aggression towards the environment has become more important due to population growth and the enormous increase in personal consumption, mainly in the industrialized countries. What characterizes these environmental changes caused by humanity is that they take place in a short period of time (typically decades). As a result, many new problems or areas of interest in the environmental field have become the object of study and great concern, mainly the ones indicated in Table 1.

Environmental problems	**Source**	**Primary affected groups**
Urban air pollution	Energy (industry and transportation)	Urban population
Indoor air pollution	Energy (cooking)	Rural poor
Acid rain	Energy (fossil-fuel burning)	All
Ozone depletion	Industry	All
Greenhouse warming and climate change	Energy (fossil-fuel burning)	All
Availability and quality of fresh water	Population increase, agrilture	All
Coastal and marine degradation	Transportation and energy	All
Deforestation and desertification	Population increase, agriculture, energy	Rural poor
Toxic chemicals and hazardous wastes	Industry and nuclear energy	All

Source: Goldemberg, J., Energy, *Environment and Development*, London, Earthscan, 1996.

Table 1. Main environmental problems

The impact on the environment can be attributed to the production of undesirable gases and other pollutants such as carbon dioxide (CO_2), methane (CH_4), sulfur dioxide (SO_2), nitrous oxide (NO_2), particulates, and metals such as lead (Pb), cadmium (Cd), and mercury (HS). Broadly speaking, all these problems have a multitude of causes, including population increase, the growth and changing patterns of industry, transportation, agriculture, and even tourism. The way energy is produced and used, however, is at the root of many of these causes. For example, air pollution and acid rain are largely due to the burning of fossil fuels and urban transportation. Greenhouse warming and climate change are caused mainly by the burning of fossil fuels. Deforestation and land degradation are due, in part, to the use of fuelwood for cooking .

			Portion of Human Disruption Caused by:			
Affected quantity	**Natural baseline**	**Human disruption index**	**Industrial energy***	**Traditional energy****	**Agriculture**	**Manufacturing, other**
Lead flow	25 000 tons/yr	15	63% fossil fuel burning including additives	Small	Small	37% metals processing, manufacturing, refuse burning
Oil flow to oceans	500 000 tons/yr	10	60% of oil harvesting, processing, transport	Small	Small	40% disposal of oil wastes
Cadmium flow	1 000 tons/yr	8	13% fossil fuel burning	5% burning traditional fuels	12% agricultural burning	70% metals processing, manufacturing, refuse burning
SO_2 flow	50 million tons/yr	1.4	85% fossil fuel burning	1% burning traditional fuels	1% agricultural burning	13% smelting, refuse burning
Methane stock	800 parts per billion	1.1	18% fossil fuel harvesting and processing	5% burning traditional fuels	65% rice paddies, domestic animals, land clearing	12% landfills
Mercury flow	25 000 tons/yr	0.7	20% fossil fuel burning	1% burning traditional fuels	2% agricultural burning	77% metals processing, manufacturing, refuse burning
Nitrous oxide flow	10 million tons/yr	0.4	12% fossil fuel burning	8% burning traditional fuels	80% fertilizer, land clearing, aquifer disruption	small
Particle flow	500 million tons/yr	0.25	35% fossil fuel burning	10% burning traditional fuels	40% fertilizer, land clearing, aquifer disruption	15% smelting, non agricultural land clearing, refuse burning
CO_2 flow	280 parts per million	0.25	75% fossil fuel burning	3% net deforestation for fuelwood	15% net deforestation for land clearing	7% net deforestation for lumber, cement manufacturing

Notes: * Industrial energy refers to commercial energy sources: coal, oil, gas, hydro, nuclear
** Traditional energy are non-commercial energy sources such as fuelwood, charcoal, agriculture residues and others.
Source: Holdren, J. P., Energy in Transition, *Scientific American*,, 263, (3), pp. 156–63, (1990).

Table 2. Human impact on the global environment: portion attributable to energy supply.

Such factors are also an important cause of the loss of biodiversity. In some other environmental situations, energy does not play a dominant role but, nevertheless, is important in an indirect way, as in coastal and marine degradation which is due in part to oil spills. In the case of environmental hazards and disasters, the role of nuclear energy is paramount as clearly demonstrated by the Chernobyl 1 nuclear accident.

Table 2 shows what portion of the human impact is attributable to energy supply, along with agriculture, traditional energy, manufacturing, and other causes. A *human disruption index* is given in this table and is designed as the ratio of human-generated flow to the natural flow of pollutants which is the baseline.

A human disruption index of 1 means that human actions equal the natural baseline that occurs without anthropogenic action. As can be seen in Table 2, the flow of lead, oil, cadmium, sulfur dioxide, and methane is higher than 1, which indicates the seriousness of the problem.

Despite these alarming signals, energy consumption is an essential ingredient of development, as one can see by plotting a variety of environmental quality indicators for countries, such as urban concentrations of particulate matter and sulfur dioxide (SO_2), total deforestation, and carbon dioxide emissions per capita as a function of energy consumption per capita (see Figure 1).

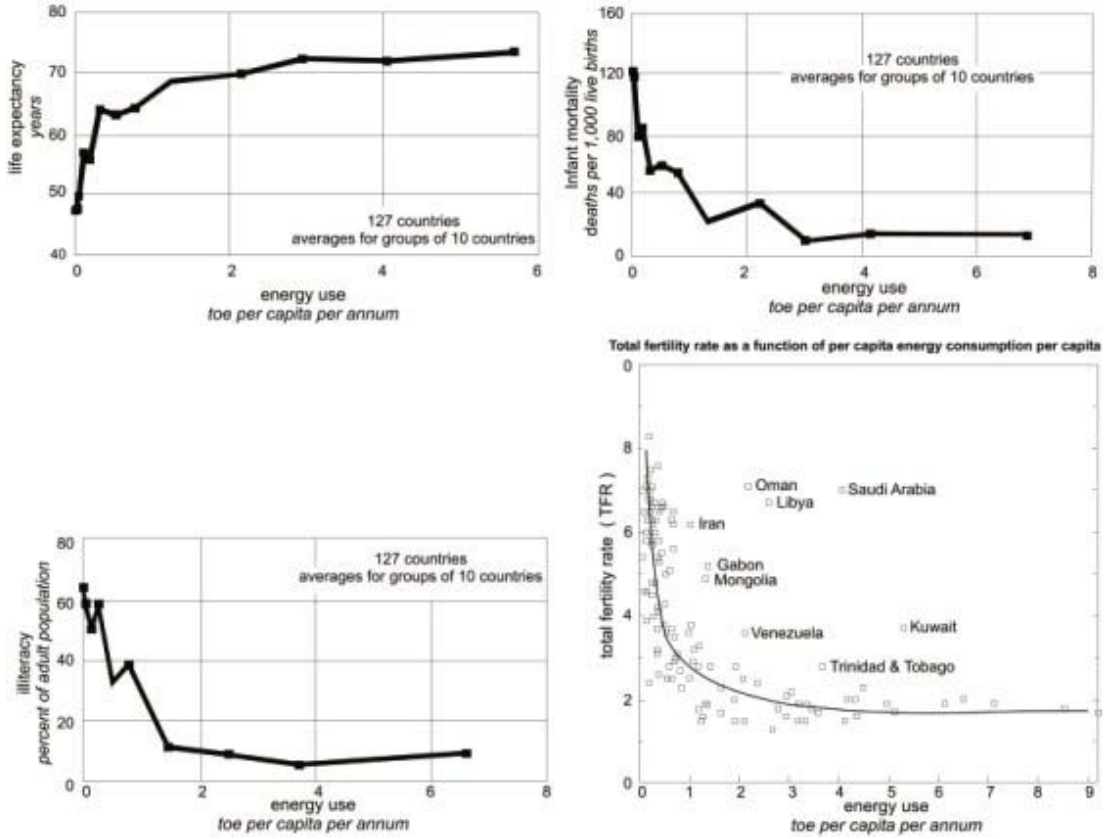

Figure 1. Social indicators as a function of energy consumption

In Figure 1, we used per capita income as a proxy for energy consumption per capita. This approach glosses over differences in income within each country, which are often considerable.

In the majority of the developing countries, where commercial energy consumption per capita is below 1 ton of oil equivalent (TOE) per year, illiteracy, infant mortality, and the total fertility rate are high, while life expectancy is low. Surpassing the 1 TOE/capita barrier seems, therefore, an important instrument for development and social change. A low level of energy consumption is not, of course, the only cause of poverty and underdevelopment, but it is a good proxy for many of their causes, such as poor education, bad health care, and the hardship imposed on women and children. As commercial energy consumption per capita increases to values of above 2 TOE (or higher) per year, social conditions improve considerably. Average consumption per capita in OECD countries, in 1990, was about 5 TOE per year.

2. The Major Environmental Problems

The environmental problems most closely related to energy consumption are:

- urban air pollution
- indoor air pollution
- acid rain
- greenhouse warming and climate change
- coastal and marine degradation.

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Biographical Sketch

Professor José Goldemberg earned his Ph.D. in Physical Science from Universidade de São Paulo, of which he is former Rector and Full Professor. He has served as the President of the Brazilian Association for the Advancement of Science and as the Secretary of State for Science and Technology, Secretary of the Environment and Minister of State for Education of the Federal Government of Brazil until August 1992. He has authored many technical papers and books on nuclear physics, the environment, and energy.