A MANUAL FOR A COURSE ON THE ENVIRONMENTAL ASPECTS OF INDUSTRIAL DEVELOPMENT

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Volume II: Environmental Issues, Impact and Assessment of Development

VOLUME TWO

Environmental Issues, Impact, and Assessment of Development

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Volume Two

ENVIRONMENTAL ISSUES, IMPACT AND ASSESSMENT OF DEVELOPMENT

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"Environmental Management in Industry"[a]

by

Jack B. Carmichael

The goal of industrial development has been adopted throughout the developing countries as a major solution to the problems of poverty and underdevelopment. However, industrialization has often resulted in the generation of un-utilized waste and the release of these untreated wastes has affected the environment in many ways.

A legitimate question is often raised in the developing countries: How can an economically and socially advantageous industrial development programme also be tailored to protect the natural environment and to maintain a desirable human environment? Countries on the threshold of economic development do not wish to forego industrialization for the sake of the environment. However, they can plan industrial development in such a way as to avoid environmental disruptions that may cause serious hazards to human health or the contamination or depletion of natural resources. Each country must decide, in the light of its own geographical, economic and political circumstances, the role of environmental policy in development planning.

Consideration of the effects of industrial development on the environment entails a technological assessment of these effects. As there is an increased scientific understanding of the environmental disruptions associated with given industrial practices, there will be a greater appreciation among political leaders of environmental problems, the technologies available to solve these problems and their costs.

The minimum that is required includes:

(a) a survey of environmental problems associated with existing industry in the country; and

(b) a simple but adequate process of estimating environmental impact of new industry.

[a]A paper presented to the Interregional Symposium of Environmental Quality in the Policy and Planning of Developing Countries, Geneva, 26 July - 1 August 1977; International Centre for Industrial Studies, UNIDO.

In the cases of both (a) and (b), effects of effluent discharge upon the environment and the status of conditions within the plant and effects on workers' health are required.

To illustrate the importance of the environmental survey of existing industry, let us begin with case histories from both developed and developing countries. The first example is a case in which flagrant disregard for proper working conditions and manufacturing procedures resulted in 70 cases of chemical poisoning and a water pollution disaster of major proportions. This is the case of the Kepone disaster in the United States in which a plant operated by Life Sciences Product Company produced a pesticide called Kepone for Allied Chemical. Kepone is used sparingly in the United States against ants and roaches. Overseas it enjoys much wider use against vegetable and fruit pests. Because of shoddy manufacturing practices, including pesticide dust inches deep on floors and equipment including the employee lunch area, 70 of the firms 150 employees developed symptoms of Kepone toxicity including tremors, slurring of speech, chest and joint pain, liver damage and testicular damage that has left several of the men sterile. Additionally, effluent from the plant caused the closure of the city sewage treatment plant and contaminated a large reach of the James River. The River, an important oyster growing area, was closed to finishing in December 1975 and has remained closed. In October 1976, the US Justice Department informed Allied Chemical that it must pay for the costs incurred by the Environmental Protection Agency in surveying the pollution incident. So far, the expenses have exceeded $1m. The company will also be responsible for the costs of cleaning up the James River which may include dredging. Allied Chemical was fined $13.2m. in October 1976 by a Federal Judge for discharging Kepone into the James River. Several suits against Allied and Life Sciences by former plant workers claiming injury from unsafe plant conditions are still pending. Also pending are claims by James River fishermen against Allied for loss of income due to the closing of the River to fishing and oystering. In January 1977, a Federal Judge accepted Allied Chemicals' offer to put up $8m. to help correct problems caused by the Kepone manufacturing operation. This was subtracted from the fine levied in 1976 leaving a $5m. penalty. The environmental health problems described above occurred during a period of only 16 months of manufacturing of Kepone by Life Sciences.

Another dramatic pollution case study occurred in the United States in February of 1977. The Environmental Protection Agency laboratory in Corryville, Ohio, measured high levels of carbontetrachloride in the raw water taken from the Ohio River for Cincinnati drinking water. Concentrations measured in the samples indicated that a batch of approximately 70 tons of carbontetrachloride was discharged in the River. Carbontetrachloride is a known carcinogen to rats, mice, and hampsters and strongly suspected human carcinogen. The impact of the carbontetrachloride on the population of Cincinnati was mitigated by the fortunate circumstance that the waterworks had started treating the city's

water with activated carbon on 3 February for taste and odour problems. The actual impact of the carbontetrachloride on the health of those exposed to it would be very difficult to determine. After the incident, an evaluation team from the EPA visited the FMC Corporation, a manufacturer of carbontetrachloride on the Kanawha, a tributary of the Ohio. The team discovered that a recent carbontetrachloride spill had occurred although FMC claimed a spill of 6,000 pounds, much smaller than the alleged 70 ton spill. However, the EPA discovered that this plant had a history of 20 previous carbontetrachloride spills and that the maintenance of the carbontetrachloride facility at the plant was so poor as to virtually ensure future spills. EPA then sought and received a temporary restraining order shutting the facility down. The Director of the Ohio River Valley Sanitary Authority reported that "People are mad about this and they are going to stay mad for a while".

Case histories of severe pollution are not limited to the developed countries. In 1974, UNIDO carried out an environmental survey of an integrated iron and steel plant in country A. The plant is a severe polluter of air and water and there are severe environmental health problems within the plant. The iron and steel works is a severe air polluter because there is no air pollution control equipment, the coke ovens are charged using cars of old design and production exceeds the rated capacity of the plant. About 12 tons of SO_2 per day are emitted from the power plant into the atmosphere along with heavy smoke. Copious brown fumes of iron oxide are emitted from the plant. No air pollution monitoring data are available but people who live in the direction of the prevailing winds complain about the bad smell of the gases and the soiling of clothes and buildings from soot and brown dust. Liquid effluent discharges into the river (average floor of 300 cubic metres per second) have killed all fish life for distances up to 50 kilometers downstream from the plant.

Another major air pollution problem occurs in the working environment inside the steel plant. Serious air pollution occurs in the production of casting during a process of shake-out in which the sand is shaken loose from the casings. This is done in an open space and the dust collector is inadequate to collect the fine, very try SIO_2 particles. As a result, an average of 7 workers working at the shake-out are absent each year from 3 to 12 months because of the lung disease silicosis.

In 1975, UNIDO carried out an environmental survey of a dye manufacturing industry in country B. This company produces some 80 dyestuffs and several intermediates including aluminium chloride, sulphuric acid and anthraquinone. The highly coloured effluents with pH ranging from 1 to 4 are discharged direct into a nearby river. The Government has investigated the firm and requested that a plan for effluent treatment be developed. A major problem in this company is poor working conditions. As a result of poor production techniques in various batch processes, all kinds of liquids are split leaving the floors and equipment wet.

In addition to this bad housekeeping, workers are constantly in contact with the products especially because the equipment including filter processes is loaded and unloaded by hand. The medical director of the firm reported that of a production and maintenance work force of 1,200, about 300-400 workers at any one time suffer from dermatitis owing to exposure to the chemicals.

Severe problems due to mercury discharge were discovered by UNIDO in industries located in countries C and D. Both are chlorine-caustic soda plants. In the industry in country C, one ton of mercury is lost per year. Hydrogen is manufactured in the process and about one-third is used in the manufacture of hydrochloric acid. The excess hydrogen could be used in the manufacture of hydrochloric acid. The excess hydrogen could be used in the hardening of edible oils but the mercury content is prohibitive. The possibility of pollution of the bay by mercury discharges has not been considered at all. The chlorine-caustic soda plant in country D is presently discharging 4 to 5 tons per year of mercury into the Mediterranean. Nearby there is a company which is producing salt for domestic consumption. Presently the company is using raw material from salt beds but the beds are nearly exhausted. The company had planned to take sea water for future salt production near the discharge point of the effluents from the chlorine caustic soda plant. This would have meant substantial mercury contamination of the salt. This potential environmental health disaster was averted when UNIDO learnt of the circumstances during a survey of industrial waste discharges in the area.

In order to discover and document major sources of problems to the environment and workers' health, a developing country may wish to consider an industrial survey each 2-3 years. Such a survey would uncover clear and present dangers. Cost estimates could then be developed for means of alleviating these environmental dangers.

UNIDO has developed a methodology of environmental analysis for existing plants that could be utilized in such a survey. The methodology is as follows:

1. Survey environmental effects with the plant.

   (a) Working conditions: do any health hazards exist within the factory?

   (b) Document hazardous materials and processes in the plant;

   (c) How many workers are affected? What is the nature and magnitude of each health effect?

   (d) How much time is lost?

(e) What economic loss results from time lost?

(f) Interview workmen to determine state of health.

2. Identify and characterize effluents leaving the plant.

(a) Physical analyses: try to obtain data on temperature flow and on suspended solids; screen analysis (air);

(b) Chemical analysis - BOD, COD, toxic substances;

(c) Specify wastes per day and per ton of finished product;

(d) Describe treatment processes including dilutions and mixing of waste streams.

3. Determine effects that plant effluents have on the external environment.

(a) Gather any relevant air and water pollution monitoring data. For the example of a stream, try to obtain data on water quality upstream as well as downstream from the discharge point;

(b) Impact of the discharge on the ecology. What have been the effects of the air or water pollutants on plants and animals? For the example of heavy air pollution, have there been noticeable declines in the production of any crops since the factory has been established? How have discharges of water pollutants changed the ecology of the receiving stream?

(c) What has been the impact of the discharge on downstream users of the water? Elimination of fishing owing to water pollution, for example, would have a substantial downstream effect which should be evaluated;

(d) Health effects: ascertain by discussion with physicans and members of the community;

(e) What socio-cultural effects have occurred? The expected benefits will come from the salaries and wages paid out to the work force. Social costs include all negative effects on people owing to the presence of the factory;

(f) Economic costs of pollution from damages external to the plant. One example is the value of reduction of the fish catch owing to water pollution discharges.

4. Determine economics of pollution control at the factory.

(a) What are the overall economics of the plant operations? Can this plant bear the costs of pollution control?

(b) Can this factory contribute to pollution control by waste reduction practices within the plant? Are there waste streams that could be processed for waste recovery, for example? Can the economic costs and benefits be estimated for waste recovery or reuse of certain waste waters?

5. Establish the legal implications of the pollution problem at the factory.

(a) What pertinent legislation exists at the local or federal government level?

(b) If, for example, water pollution control legislation exists, is it enforced? By whom and how does the enforcement occur?

In addition to a periodic survey of operating conditions of existing industry, a simple environmental impact analysis will help assure that major environmental damage does not occur from new projects. If the pre-project environmental analysis is begun early enough, alternatives can be considered before important irrevocable decisions have been made. As an example, a river basin survey would be conducted prior to making economic development decisions. The survey would determine the present ecological condition of the river, land use patterns, human settlements, water uses, the present level of water quality and the capacity of the river to absorb wastes. Utilizing this information, a decision could be reached on the site location, production capacity and effluent treatment required for a proposed new industry, such as a pulp and paper mill.

The most direct and easiest approach to the environmental analysis of a project is to use a set of check-list questions or statements that guide the analysis towards the key problem areas. Guidelines of this sort have been developed by the World Bank. The various sorts of information that should be obtained and evaluated are listed under major project and environmental categories.

General methodology for environmental assessment[1/]

A. Linkages between the environment and the resources under development.

1. The current state of the eco-system at the site should be reported, along with expected project effects upon important eco-system components;

1/ Adapted from Environment, Health and Human Ecologic Considerations in Economic Development Projects (Washington, D.C., World Bank, 1974).

2. When applicable, alternatives to the project or possible future amendments to the project should be discussed with the intent of minimizing adverse environmental effects.

B. Project design and construction

1. Short-term effects are the major concern under this category. The objective is a well-designed project and consolidated construction plans that will protect the flora and fauna and prevent erosion;

2. Proper considerations should be given to the health and safety of workers during project construction. Health screening of the work force and periodic examinations are suggested.

C. Operations

1. Prior to the project approval and construction, there should be assurance that the operations of the completed project will be adequately managed. The operations phase of the environmental analysis should include a plan with provisions for:

   (a) Raw materials management;

   (b) Wastes management;

   (c) Installation and maintenance of environmental controls and safeguards;

   (d) Monitoring for environmental effects of plant operations;

   (e) Occupational health and safety.

D. Socio-cultural factors

This analysis should deal broadly with short-run construction effects and long-run project operation effects on people.

1. Project effects on persons indigenous to the area must be considered:

   (a) If relocation of people is necessary, a comprehensive plan must be prepared;

   (b) Any social disruptions to the indigenous people from noise, air or water pollution should be identified.

2. Project effects upon the work force. The socio-cultural needs of the construction and operational work force should be considered where appropriate. This is especially important if workers live at the project site.

E. Health effects

1. Proper consideration for health should include a sufficient knowledge of endemic disease vectors, and controls should be introduced where the development of a project may cause the spread and increased influence of a disease;

2. Health care services for workers during project construction and operation should be described. Any occupational health and safety programme should be presented;

3. Any potential for creation of new health hazards, such as introduction of new pests or diseases, should be recognized.

F. Long-term considerations

1. Indirect effects that might occur as a result of the project are an important long-term consideration. If, for example, a project will attract large numbers of people to the area over a long period of time, this should be recognized and reported. Such an indirect effect will eventually require the provision of an urban infrastructure with the need for health care and other services;

2. Possible regional development effects may be a long-term consequence of the project, either through project expansion or the establishment of other related development projects. These may have important environmental consequences for the region;

3. Possible occurrences of catastrophes and their consequences for the project should be evaluated as part of the section.

In conclusion, consider an actual water quality survey of a river in country E prior to taking a decision on locating a large pulp and paper mill on the river. The following terms of reference were established for the survey:

(1) A chemical, physical and biological analysis of river water and water life were carried out from the proposed site to the mouth of the river 160 kilometers away;

(2) A survey of vegetation on the river shores was undertaken;

(3) A census was carried out on those wild life which were dependent on the river for water;

(4) The present pattern of human consumption of the water was determined along with estimates of present and future requirements for such uses;

(5) Other projected water needs presently contemplated in the development of the water shed were considered.

60 kilometers downstream from the site of the proposed pulp and paper mill is the site of a large proposed sugar factory. In considering the allowable water pollution load from the paper mill, country officials were constrained to consider the raw water requirements of the sugar plant. They concluded that secondary treatment of the paper mill waste to remove 85 per cent of the BOD would be sufficient to allow the stream to recover completely by self purification so that river water at the site of the sugar plant would be of high quality.

"Human Population Growth"[a]

by

Russell F. Christman[b]

No topic has ever been more important to the current inhabitants of the earth nor more difficult to approach because of deeply held personal beliefs than the need for population control. Beginning with Malthus' warning in 1816 that human populations grow inherently faster than does their ability to produce food, and continuing through the more current recommendations of international study commissions, advice has been repeatedly given and dismissed as "interesting, perhaps, but not sufficiently important" to move ordinary people to change life-long habits. A wide range of "expert" opinion has been heard regarding the severity of the population threat. Not all the voices that have been raised, however, have been in favor of population control.

Some experts view the population problem as nothing but a mirage. They hold that growth is good and that a growing economy is always a healthy one; that man is resourceful, has always adapted to social and environmental changes in the past and will continue to do so in the future. Unfortunately, this view is not consistent with the observable facts. Certain countries (Taiwan, for example) have slow growth rates and slow economies; others (such as Japan) have slow growth rates and excellent economies; and others (particularly India) have enormous growth rates in the face of abject poverty.

Others admit that a real problem exists, but maintain that it is a solvable problem. Such ideologically diverse groups as the Marxists and the Roman Catholics share this view, but hold it for different reasons. The Marxists consider that we do not have a food production problem, but only a food distribution problem. The facts simply do not support this position. Much of the world is currently hungry - perhaps as many as 20 million deaths each year are attributable to starvation. If the world's food production were spread evenly among the earth's present inhabitants, it

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[a]From: The Natural Environment: Wastes and Control. Revised Edition. Pacific Palisades, California: Goodyear Publishing Company, 1974. Pp. 244. By R. F. CHRISTMAN, et al.

[b]R. F. CHRISTMAN, Dept. of Environmental Sciences & Engineering, University of North Carolina at Chapel Hill

is questionable whether any individual would be well nourished. The Catholic view places great confidence in the ability of technology to solve the food shortage through the increased application of fertilizer and pesticides to farmland. Most agricultural experts, however, are not so optimistic. Others who place great faith in scientific research believe that, although the population problem is deadly serious, it can probably be resolved through developing new hybrid grains that will greatly increase farm yields, (the "Green Revolution") and through increased farming of the sea.

Finally, there are those who contend that it is already too late to prevent global disaster. Regardless of new solutions, the world's population is increasing too rapidly to prevent the eventual onslaught of pestilence, famine, and social disorder before any critical breakthrough could be implemented.

Human population control for planet earth is inevitable in one form or another, and nothing is more demonstrable in the animal world than the natural control of population.[1] We may continue our present course of action and expand our numbers to the finite carrying capacity of the physical environment. This would ultimately mean emigration to other planets and a margin of safety reduced to such precarious levels that a change of climate or an occasional famine would permit nature to control our numbers - effectively, but tragically. Alternatively, we may decide in the future to control our numbers with a wider safety margin and a broader selection of styles of life for those who do walk the earth and coexist with the things they eat. A nice feature of this alternative is the extra time it would give us to reach a more accurate understanding of the earth's carrying capacity in relation to how we live. And if it took us a long time to come to understand our environment, while we tried to control our numbers, many millions of deaths from starvation and deprivation might be avoided.

A HISTORY OF HUMAN POPULATION GROWTH

Early data on man's population increase are speculative at best, since sufficient historical information is available only after 1650 A.D. Estimates of population size and density prior to that time must be based on the archeological record and what can be gleaned from studies of primitive cultures that exist today. Demographers calculate that the total human population at the time of Christ was slightly larger than the present population of the United States, or approximately 200 to 300 million, and that this number doubled by the middle of the seventeenth century. However, it took only 200 years for that number to double again, resulting in a global population of around 1.0 billion by 1850 A.D., and only another 80 years to reach 2.0 billion, by the late 1920s. This increase is graphically described in Figure 10-1, from which it is clear that both the rate of in-

crease and the total number of individuals are accelerating rapidly. We are now expecting 4.0 billion inhabitants by the mid-1970s (a 45-year doubling time), when the rate of increase will produce another doubling in only 35 years. Although the history of population growth is interesting, the important point is that the time required for enormous changes in the numbers of human beings (doubling from 4.0 billion to 8.0 billion, and so on) is now so short that vast increases in population lie well within

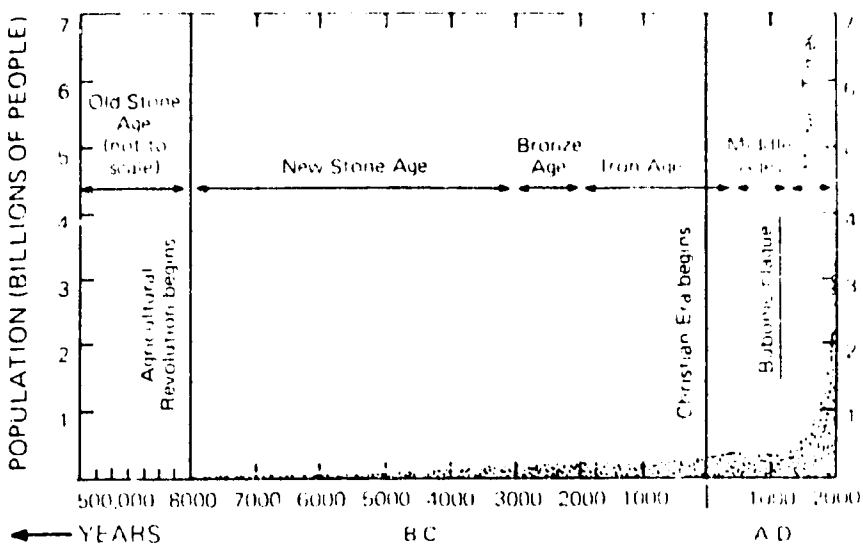

Figure 10-1 Human Population Growth on a Linear Scale
Adapted from POPULATION BULLETIN, vol 18, no 1

the time required to devise and implement the means of controlling them. Even if we elected right now to control the earth's human population, we would have to plan for an ultimate population substantially larger than the present number.

Focusing on broad periods of time and global growth patterns tends to mask important subpatterns in local population fluctuations. In man's history, regional populations have risen and fallen as a consequence of changes in climate, wars, famines, and discoveries, although the overall result has been an explosive increase. The natural biological characteristics of Homo sapiens have had much to do with man's current population "success."[2] First, as a species, man is rarely specialized in his diet, permitting him to adapt to sudden changes in food sources. Second, he is an intelligent and resourceful being, which, when combined with his opportunistic diet, assured him of a high probability of survival in spite of the elements and tended to maximize his territorial expansion. Third, he is socially oriented and has a great propensity for storing his learning and passing it on to younger generations. In fact, most of the habitable prehistoric world may have been occupied by early man (erectus-sapiens) and divided into hunting-gathering territories as long as 2 or 3 million years ago.[3] Advanced knowledge in weaponry and in the use

of fire allowed these early populations to flourish at the expense of the wild game food sources. This period of human development has been referred to as the "cultural revolution" and ultimately led to a depletion of food resources (known as "Pleistocene Overkill"), which momentarily slowed population growth rates. Perhaps 50,000 to 300,000 years ago, early man learned that his numbers could be more safely supported by adopting a primary consumer role and growing his food in managed agricultural settings instead of chasing it on the hoof.

Freedom from the daily search for food gave man the time for other pursuits, and his inventive nature responded by developing metal tools, dividing labor, and creating a more sophisticated social structure. Thus the "agricultural revolution" was the second major level on the human population growth curve as depicted on a log-log scale in Figure 10-2. This new freedom from

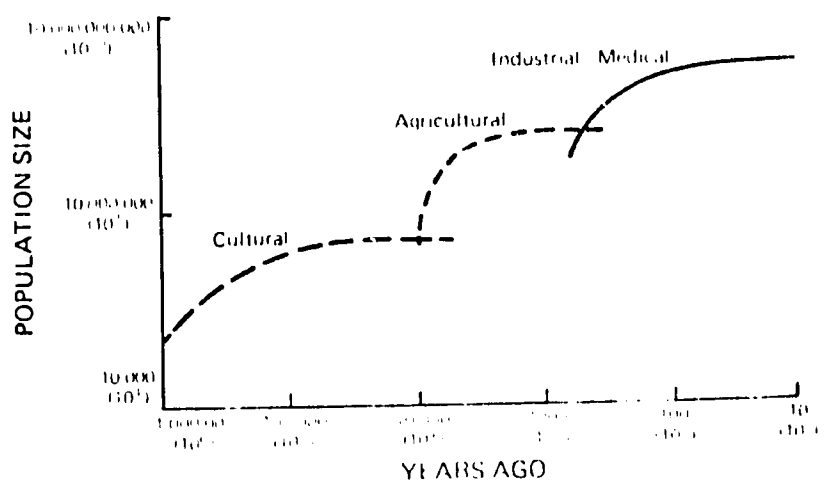

Figure 10-2. Human Population Growth on a Log Log Scale
Adapted from Deevey. THE HUMAN POPULATION. Copyright © 1960 by Scientific American Inc

chasing one's dinner did not include immunity, however, from the often tragic impact of famine and disease. As the Ehrlichs have stated:[4]

> Civilizations grew, flourished and disintegrated; periods of good and bad weather occurred; and those apocalyptic horsemen, pestilence, famine and war took their toll. Although the global trend . . . was one of accelerating increase, a great many local population explosions and crashes are concealed in that trend. For example, bubonic plague (Black Death) killed an estimated 25 percent of the inhabitants of Europe between 1348 and 1350. From 1348 to 1379 England's total population was reduced by almost 50 percent. . . . Many cities lost half or more of their inhabitants in the second half of the fourteenth century.

According to Boughey, the global outbreak of influenza in 1919 is conservatively estimated to have killed many more (10 to 15 million) than actually died in the battles of World War I. More recently the Asian "flu" form of influenza virus is thought to have killed 9 million people during the 1967 to 1968 period. The threat of infectious and contagious disease is aggravated by the increased close contact among people in modern city life. On the other hand, immunization programs are easier to administer in organized urban settings, and advances in our ability to control contagious diseases tend to lessen the threat of epidemics. Wars have often had dramatic effects on the populations of those territories involved but have had apparently no significant effect on world population growth. Bates has pointed out that the 300 years following 1650 were a period of almost continuous warfare for the human community, and, at the same time world population growth reached its first significant proportions.[5] The United States has lost about 1.0 million people in all of its wars, and at present growth rates that number is replaced in about 4 months. The destructive potential of modern thermonuclear warfare, however, casts a different light on war's effectiveness to control population growth.

Robert Malthus recognized in 1816 that human population growth has a potential for increase greater than the increase that actually occurs because of limited resources. He believed that the checks on population growth that keep the potential from being realized can be reduced to war, disease, and famine. At present, it does not appear that war (short of nuclear disaster) and disease (short of highly virulent forms of bronchial disease) can be relied on as effective checks on population growth.

Famines are another matter. The Ehrlichs have stated:[6]

> One study, by Cornelius Walford, lists more than 200 famines in Great Britain alone between 10 and 1846 A.D. Another counts 1,828 Chinese famines in the 2019 years preceding 1911, a rate of almost one a year. Some of these famines, and similar ones in India, have been known to result in many millions of deaths. Even in this century famine has killed many. . . . perhaps 5-10 million deaths have been attributable to starvation in Russia (1918-1922, 1932-1934) . . . 4 million deaths in China (1920-1921) and 2-4 million deaths in West Bengal, India (1943).

Today we are faced with enormous demands on the world's food resources. There are not only more people to be fed and more to be planned for than ever before, but individual demand is accelerating because of expectations of affluence. Unlike any previous period in history, those who are hungry and impoverished are more painfully aware, thanks to improved methods of communication, of the life styles of the more fortunate sectors of the global community, and they certainly cannot be scorned for wanting to live the same way. In addition, even in the more well-to-do sectors, social pressures often demand increased personal

affluence. Before discussing the implications of these pressures on population growth, we must examine some facts and figures on population growth rates.

POPULATION ARITHMETIC

Birth rates are usually expressed as the number of births per thousand members of the population per year. They are calculated by dividing the number of live births in a year by the population (expressed in thousands) at the midpoint of that year.

Example:

The population of the United States at the midpoint of 1969 (July 1) was estimated as 203,100,000, or

$$\frac{203,100,000}{1000} = 203,100 \text{ thousands}$$

If the number of live births for the year ending September 30 was 3,534,000 then the birth rate for the year 1969 was

$$\frac{3,534,000}{203,100} = 17.4 \text{ births per thousand.}$$ [7]

Death rates are calculated similarly. Additions to a population can also come from immigration, and subtractions from emigration. These must be considered as well in calculating overall growth rates. In general, for any nation or territory,

Growth Rate = (Birth Rate + Immigration Rate) - (Death Rate + Emigration Rate).

The equation is simplified when applied to the growth rate of the planet, since immigration and emigration rates are zero. Population data for countries ranging from high growth rates to low growth rates are shown in Table 10-1. A more extensive list of countries would reveal a relative scarcity of birth rates in the twenties and thirties per thousand and, as Boughey has pointed out, this is not fortuitous. Those nations that have adopted population control measures tend to have birth rates below 20 and those that have not have rates remaining in the forties and fifties per thousand. There is no in-between.

When all available statistics on birth and death rates since 1750 are analyzed, several important trends appear. First, the crude birth rate (not corrected for population age structures) remained at about 40 for all nations until around the turn of the twentieth century, when it began to fall (to 20 or fewer) for the more advanced, industrialized nations. The less advanced, underdeveloped (or developing) nations still tend to have birth rates near 40 per thousand. Second, for all nations there has been a

dramatic reduction in death rates from the low to mid-thirties per thousand in 1850 to 15 or fewer in the 1950s (Figure 10-3). This decrease in death rate is the most important single cause of the current population explosion. It began in the industrialized nations when man began to understand disease and improve sanitation. World War II caused recent advances in medical research in antibiotics and in controlling disease vectors with DDT and other pesticides to be exported to all corners of the earth. Dramatic declines in the death rates of underdeveloped nations followed - plummeting in some cases from as high as 40 per thousand to a low of 5 or 6 per thousand within a 20-year period. Finally, in the more advanced nations, birth rates have generally declined during the late industrialization period. This phenomenon, called the "demographic transition," which slows overall growth rates, occurred in Europe around the turn of the century and more recently in North America.

TABLE 10-1

Population Data for Selected Countries

COUNTRY	POPULATION— mid-1971 (in millions)	BIRTH RATE per 1000	DEATH RATE per 1000	GROWTH RATE (%)
Sudan	16.1	48.9	18.4	2.8
Japan	104.7	19.2	6.6	1.1
Colombia	21.8	44.6	10.6	3.2
Algeria	14.8	49.1	16.9	3.5
India	550.3	42.8	16.7	2.2
Guatemala	5.4	39.0	15.0	3.1
Mexico	50.8	43.4	9.9	3.2
Australia	12.7	21.7	8.7	1.9
United Kingdom	55.6	16.2	11.6	0.4
United States	207.1	17.3	9.3	1.1
Sweden	8.1	14.1	10.2	0.8
Belgium	9.7	14.5	12.4	0.5

From 1972 United Nations Statistical Yearbook

It is hazardous to compare overall population growth rates for different countries calculated from crude birth and death rate data because of the significant influence of population age structure on short-term population growth. For instance, identical death rates for two countries are comparable only when the mortality is occurring in the same age group in each population. Real populations vary considerably in age and sex distribution, life expectancy and marriage ages, as well as in the specific mortality and natality of each age group.[8] Developed nations have experienced declining birth and death rates and tend to have more uniform age structures than those whose birth rates remain high. In the latter case, decreased infant mortality in addition to lowered overall death rates have further inflated the population of the younger age groups. The potential for explosive population increases is realized when these large blocks of young people move upward in the age structure and reach their reproductive years. This is the case in most underdeveloped countries of the world, where as much as 40 to 50 percent of the total population is under 15 years of age (creating a high dependency load). As Paul Ehrlich has pointed out, even if we were making great

progress in reducing birth rates in these countries (and we are not), 30 years would pass before population growth would be slowed down.

The present world population is around 3.7 billion. Its major regional contributions are listed in Table 10-2. It is clear from inspecting the data in this table that the majority of the world's present population lives in underdeveloped regions and that this proportion of the total is increasing rapidly. At present world growth rates we may exceed 7.0 billion by 2006.

RECENT TRENDS IN THE UNITED STATES

The population of the United States is still growing although the rate has slowed. Some have suggested that the United States has reached zero population growth because of a considerable decline in birth rates since the 1960s. These notions tend to be reinforced by occasional news items reporting even further recent decreases in birth rates. It is simply untrue, however,

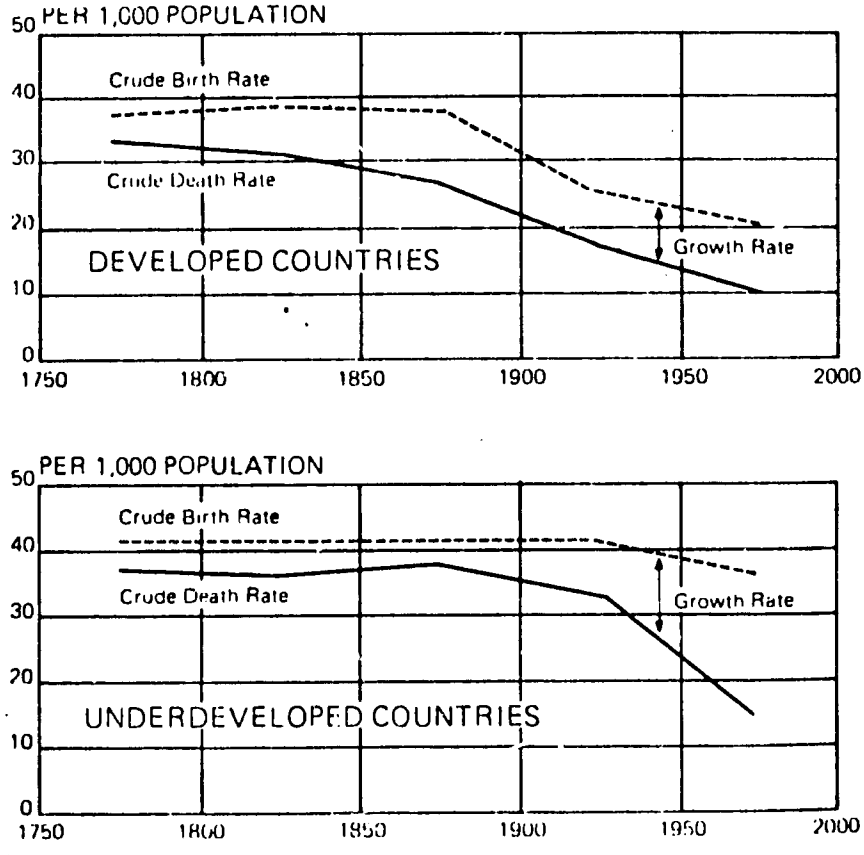

Figure 10-3. Birth and Death Rates in Developed and Underdeveloped Nations
Adapted from A CONCISE SUMMARY OF THE WORLD POPULATION SITUATION IN 1971 (New York: United Nations, 1971)

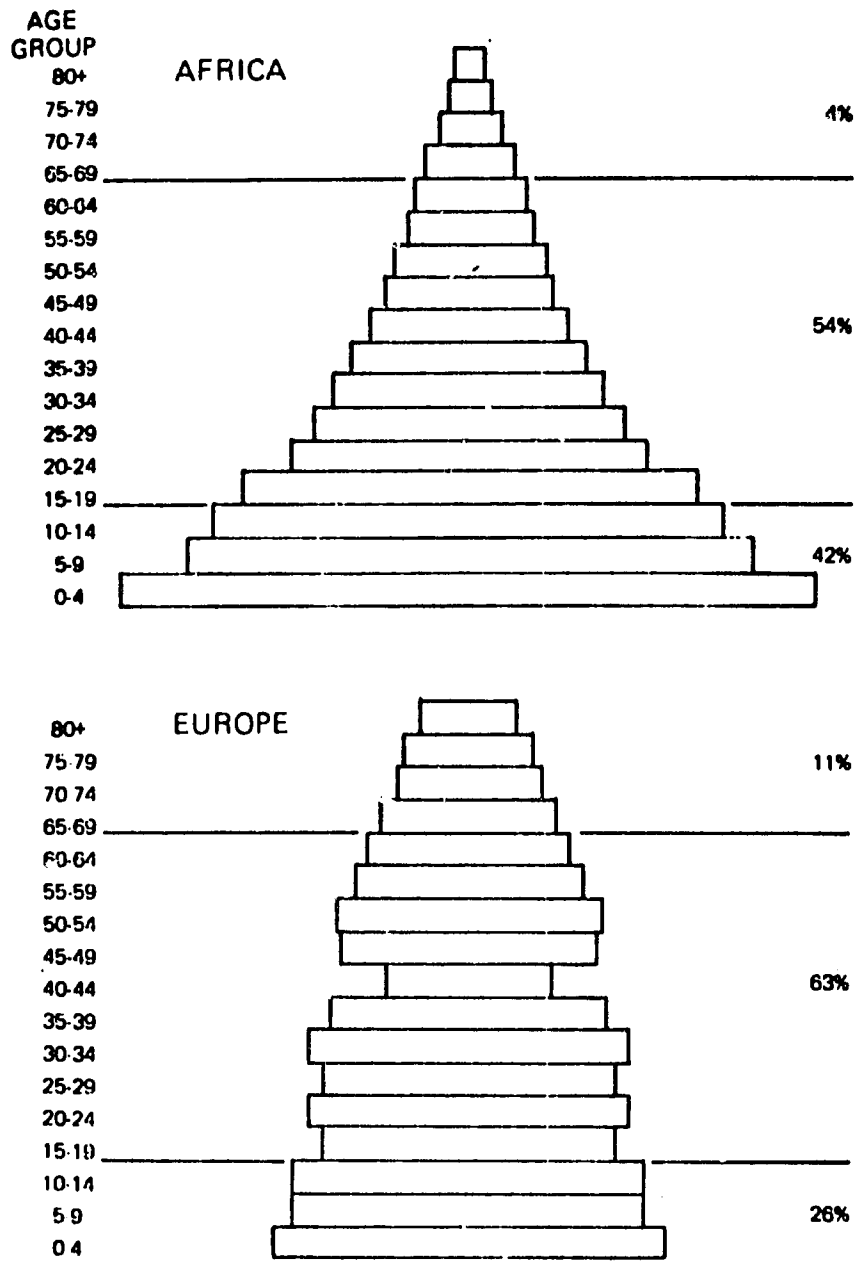

Figure 10-4. Age Structures in Growing and Stable Populations
Adapted from "Population Trends in Developing Countries," FINANCE AND DEVELOPMENT QUARTERLY, International Monetary Fund and World Bank, vol 8, no 4.

to state that the United States has, in 1974, reached a zero-growth plateau; our population was estimated at 203 million in mid-1969, 207 million in mid-1971, and most recently passed 210 million in March of 1974.[9] In 1972 alone, 1,630,000 individuals were added to the U.S. population. What has happened is a remarkable decrease in the birth rate since the 1960s, and a concurrent decrease in the fertility rate. The fertility rate is a better index of birth trends because it measures the births per thousand women in their reproductive years (ages 14 to 44). The fertility rate in the United States fell from the 120s at the turn of the century to a low of 75 during the depression years, 1932 to 1936. From then until the late 1950s, the fertility rate rose again to about 120, but has steadily fallen since. In March of 1974, a record low was reached of 67 births per thousand, and indications are that it is still falling.[10] This fertility rate is at or below what would be required just to maintain our population. Replacement fertility, or 2.11 births per woman, is the rate that will just replace parents when they die. Why this rate is not exactly 2.0 is due to the fact that our population is not precisely divided 50-50 into males and females. Why then have we not reached zero population growth?

The reason is that these low numbers are rates, that is, births per thousand women. The rates say nothing about the actual numbers of women, and there are significantly more women entering their reproductive years because of the post-World War II baby boom: 40.2 million in 1967, 42.3 million in 1970, and 46.9 million estimated for 1975. Furthermore, the subgroup of

TABLE 10-2

Present Status of Population in Major Regions

REGION	POPULATION—MID-1971* ESTIMATES (IN MILLIONS)	GROWTH RATE (%)	YEARS TO DOUBLE	PERCENT OF PRESENT POPULATION†	PERCENT OF YEAR 2000 POPULATION‡
Africa	354	2.6	27	10	13
Asia	2104	2.3	30	56	58
North America	230	1.3	54	6	5
Latin America	291	2.9	24	8	10
Europe	466	0.8	88	13	9
USSR	245	1.1	64	7	5
Oceania	19.8	2.1	33	0.05	0.05
WORLD (Total)	3706	2.0	35	–	–

*1965-71 average rates
†Does not sum to 100 percent because of rounding
‡Based on United Nations "medium" estimate for year 2000 for each country and for total world population of 6.5 billion

From 1972 United Nations Statistical Yearbook, World Summary.

women aged 20 to 29 bear most of the children, and the numbers of these will continue to increase through 1980, as shown in Table 10-3. If the trend toward decreased fertility continues, or even holds constant, and if the death rate does not change, we may well reach a no-growth plateau before the turn of the twenty-

TABLE 10-3

Estimated Numbers of Women in the 20-29 Age Group in the United States

YEAR	NUMBERS (in millions)
1968	14.3
1975	18.3
1980	20.0

From POPULATION, RESOURCES AND ENVIRONMENT: ISSUES IN HUMAN ECOLOGY, by Paul and Anne Ehrlich. San Francisco: W. H. Freeman, 1970, p.31

first century. Reaching this plateau is important even though the United States will represent only 5 percent of the world's population at that time. To persuade other countries to control their populations, it will be helpful to have controlled ours first.

POPULATION PRESSURES ON FOOD AND MINERALS

It would be valuable to know how many people the earth can support. Estimates have varied from somewhat fewer than we have now (4 billion) to several times the present number (30 billion). The simple truth is that we do not know the limits of our biosphere. Our continued population growth in the face of this ignorance is something like the foolhardy man who accelerates a car down a highway at night, his headlights turned off, having good reason to believe that something is blocking the road ahead.

It does seem clear that the ultimate safe number of the earth's inhabitants will depend heavily on the style in which they choose to live. There are currently tremendous variations in the quality and styles of life among the earth's inhabitants. The most demanding of these styles in relation to the use of resources and the generation of waste products is that adopted by the United States. We constitute roughly 6 percent of the world's population but use over one-half of the world's resources in satisfying our desires for automobiles, electricity, recreational pursuits, and other amenities. This consumption may reach 80 percent of total world consumption by 1980.[11]

It is difficult to speak of material or even of political self-sufficiency when the United States is so highly dependent on foreign supplies for most of its industrial raw materials. The U.S. consumer received warning of his dependence on foreign supplies during the 1973 to 1974 fuel crisis. Energy is not the only substance we may run short of, and ironically, we may be closer to self-sufficiency in relation to energy because of our nuclear technology and enormous coal reserves than we are in relation to basic minerals (Tables 10-4 and 10-5). At current rates of use, known supplies of lead, zinc, copper, and tin will be exhausted before the year 2000, even with no additonal population growth.[12] Nickel, cobalt, manganese, and molybdenum will last another century, and chromium and iron another 2000 years.

TABLE 10-4

Consumption of Minerals in the United States

MINERAL	U.S. CONSUMPTION AS % OF WORLD PRODUCTION (1972)	U.S. IMPORTS 1950	U.S. IMPORTS 1960	% OF U.S. CONSUMPTION 1971	% OF U.S. CONSUMPTION 1972
Manganese Ore	12	95	122	98	95
Iron Ore	15	8	32	35	28
Copper	27	36	34	17	18
Zinc	24	48	50	56	52
Tin	30	104	66	71	77
Lead	38	44	36	19	26
Molybdenum	23	1	–	2	–

Adapted from *Mining and Minerals Policy* (1973), Part Two Appendices

Clearly, we are not out of the woods with "crises" and shortages; we are actually just entering them. Known reserves of minerals often do not include low-grade deposits that are presently uneconomical to mine and process, and of course they do not include estimates for new discoveries. In trying to decide just how much growth we can permit, we must allow for some reduced intensity in life style and for an increase in recycling efforts (Table 10-6). Just how much sacrifice we will be willing to make is uncertain, but it seems obvious that known resources are simply insufficient to permit even the present world population of 3.7 billion to live at current U.S. standards. If this could be done it would require "75 times as much iron as is now extracted annually, 100 times as much copper, 200 times as much lead, 75 times as much zinc, and 250 times as much tin," as Ehrlich has noted.[13] The increase in pollution load, waste by-products, and heat, in addition to extra energy demands, would be enormous.

Mankind faces a more basic but related problem--to supply food for his growing numbers. In 1967, the Panel on World Food Supply of the President's Science Advisory Committee issued a 3-volume report containing a description of the world's food problem, including nutritional requirements and recommendations for alleviating shortages in the next two decades.[14] This study estimated that in underdeveloped nations, or two-thirds of the world, 20 percent of the individuals are currently undernourished and 60 percent are malnourished. These and other studies estimate that between 1 and 2 billion people of the present population of 3.7 billion are not receiving an adequate diet. How many are actually starving is unknown, since data tend to be unreliable where the problem is severe, but it is estimated that 500 million (0.5 billion) people are either chronically hungry or starving. The Panel further reported that the current world average for caloric need is around 2300 calories per person per day. This requirement, when compared to the estimated (United Nations FAO estimate) 2400 calories per person per day currently

available at the world market place, makes the margin between supply and need quite precarious. The problem is further aggravated beyond what the margin implies by the uneven distribution of food.

All practical solutions to this problem will require rapid implementation of effective international population control programs, the production of more food, and improvements in our ability to distribute it. World food production must be increased by at least half again as much as current production, if we are to feed the estimated 1985 population even at the insufficient 1965 levels.[15]

The simplest way to produce more food is to put more land under the plow, although this is not as easy as it would seem. In the United States, we already use some 300 million acres of our 350-million acre total. The remaining land is not our best and is being eaten into by urban sprawl at the rate of 1.0 million acres per year. On a global basis, there is probably 2 to 3 times as much arable land as has been either cultivated at some time during the last few decades or has been harvested in any given year. Unfortunately, most of this land (over 4 billion acres) lies in the tropics, where our present agricultural production technology is inadequate, at least for the humid and subhumid tropics. The President's Science Advisory Committee suggested that developing this land should be a long-range project to be met through increased research on new varieties of plants and new methods of fertilization. Furthermore, this land, if it could be made to produce food, is geographically removed from the location of present and future food needs. The report summary states: "The very large disparity between population size and potentially arable land in Asia, on the one hand, and South America, North America and Africa on the other, suggests that very large-scale intercontinental migrations, such as characterized most of the nineteenth century, might well become important again in times to come."[16]

Table 10-5

Supply of Selected Minerals

MINERAL	U.S. RESERVES AS % OF WORLD RESERVES (1972)	YEARS OF SUPPLY AT PRESENT RATE OF CONSUMPTION
Antimony	2	95
Cadmium	29	74
Copper	24	53
Iron	4	40
Lead	35	62
Titanium	20	100
Tungsten	6	26
Uranium	32	21
Zinc	23	60

Adapted from *Mining and Minerals Policy (1973)*, Part Two, Appendices

TABLE 10-6

Recycling of Selected Minerals in the United States

MINERAL	RECYCLING AS % OF ANNUAL U.S. CONSUMPTION (19[illegible])
Copper	20
Iron	33
Nickel	34
Platinum	2.[illegible]
Potash	0
Manganese	1
Lead	35
Zinc	5

*Platinum group metals include: ruthenium, rhodium, palladium, osmium, iridium, and platinum.

Adapted from *Mining and Minerals Policy* (1973), Part Two, Appendix.

If the imminent food problem is not to be met by introducing new farmlands, it will have to be met by increasing yields on present land and by more efficiently using available food by reducing waste and spoilage. The problems with this proposal are still enormous. The people and institutions of Asia are not accustomed to thinking of farming as a business, and there are limits to the effectiveness of directly transferring agricultural technology to underdeveloped nations. Instead, adaptive research, or developing new varieties of plants, should be carried out in Asian fields, for example, and not flown in from Iowa. Training programs, fertilizer and capital will be required on massive scales; to bring fertilizer applications in India alone up to the per capita level of Japan or the Netherlands will take one-half the world output.[17] An economic investment on the order of $12 billion above the 1965 base would be needed to raise Indian food production even 4 percent.[18] Obviously, these proposals imply unparalleled peacetime cooperation between developed and underdeveloped nations.

Increasing farm yields in the underdeveloped nations through applying agricultural techniques and improving fertilizers is half od what is referred to as the "Green Revolution"--growing more food to stay ahead of the population explosion. The other half is developing new high-yield strains of food crops (rice, wheat, and sorghum), which hold significant promise for increased food production. Early results have been encouraging in Asia, where over 34 million acres have been planted within 5 years of introduction. In 1968, the Indian wheat harvest was 35 percent above record, and the Pakistani crop was 37 percent higher than ever before.[19] Some biologists are still skeptical, claiming that these "miracle crops" may ultimately attract miracle pests and that early harvest gains were actually due to better regional weather. They contend further that risks are being taken by converting substantial acreage to these new plant hybrids, thereby hazarding unknown susceptibilities to plant disease and pests and escalating pesticide requirements. Furthermore, it is still unknown whether these plants will grow throughout Asia, and whether similar plants can be developed for South America and Africa.

Probably the best that can be said for the Green Revolution is that the extra food it may generate (if these programs work) will give us a little extra time to develop effective patterns of international cooperation for controlling human population growth.

THE HUMAN CHALLENGE

It is difficult to avoid pessimism about the future well-being of the millions of needy individuals in the underdeveloped nations when one considers the physical dimensions of the problem and the efficacy of governmental and political action. Nor can we afford the sanguinous notion that whatever happens to the poorer countries will not seriously affect our own lives. The political implications of rising pressures on resources are staggering. Even if the United States made no further advances in its "standard of living," someone would have to explain to a burgeoning group of have-not nations why they cannot live as we do, and why they should continue to supply us with the raw materials of our comfort. In the past, the United States has enjoyed a relatively luxurious position in regard to technological development and food production, but much of this well-being has come at the ecological expense of the rest of the world. Our present food surpluses, which used to be dealt with as "charitable" contributions to the foreign needy, are now for sale on world markets where those with money are all too eager to buy. Continued escalation of food prices in the United States is unavoidable because exporting our food surplus will become increasingly necessary to pay for energy and other resources we cannot produce ourselves (Table 10-5). Even the industrial technology and capital we send abroad may be worsening the problem if the biosphere will not permit the present world community to live at Western levels of consumption.[20] Our science and technology are far from providing an early solution and are in fact still trying to describe the problem adequately.

We are learning that previous efforts to help may have been counterproductive. Clearly, the underdeveloped nations will profit most from managing their own resources and controlling their own futures, but they will be unable to do this under the economic thumb of massive Western industrial empires. At the same time, these nations urgently need help from the West in the form of training, guidance, materials, and economic underwriting. The great challenge of the immediate future, then, comes down to the question of how to help the hungry masses without destroying their social structures, value systems, and sense of dignity. Maintaining national boundaries or preserving any particular governmental form becomes a less significant issue when contrasted with the tremendous challenge of ensuring human survival.

Can we restructure national aims? Can we separate foreign aid from the special interests of business? Can we distribute the fruits of industrializaton without further industrialization?

Can we commit ourselves to a concept of growth based more on the quality of life than on economic "root, hog, or die" prosperity measures? If we could settle these questions wisely, we might end up exerting some genuine leadership toward reaching humanitarian goals and be able to display meaningful, nondestructive ambitions to the underdeveloped nations of the world instead of displaying the automobile, the transistor radio, the electric carving knife, and other so-called achievements of advanced society. But, as in the case of population control, we will first have to demonstrate our good faith by restructuring our own value system in order to be credible to the rest of the world.

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Man and His Environment[a]

by

Ansley J. Coale[b]

The way our economy is organized is an essential cause, if not the essential cause, of air and water pollution, and of the ugly and sometimes destructive accumulation of trash. I believe it is also an important element in such dangerous human ecological interventions as changes in the biosphere resulting from the wholesale use of inorganic fertilizers, of the accumulation in various dangerous places such as the fatty tissue of fish and birds and mammals of incredibly stable insecticides. We can properly attribute such adverse effects to a combination of a high level of economic activity and the use of harmful technological practices that are inconsistent with such a high level.

The economist would say that harmful practices have occurred because of a disregard of what he would call externalities. An externality is defined as a consequence (good or bad) that does not enter the calculations of gain or loss by the person who undertakes an economic activity. It is typically a cost (or a benefit) of an activity that accrues to someone else. A fence erected in a suburban neighborhood for privacy also affords a measure of privacy to the neighbor--a cost or a benefit depending on how he feels about privacy versus keeping track of what goes on next door. Air pollution created by an industrial plant is a classic case of an externality; the operator of a factory producing noxious smoke imposes costs on everyone downwind, and pays none of these costs himself--they do not affect his balance sheet at all. This, I believe, is the basic economic factor that has a degrading effect on the environment: we have in general permitted economic activities without assessing the operator for their adverse effects. There has been no attempt to evaluate--and to charge for--externalities. As Boulding says, we pay people for the goods they produce, but do not make them pay for the bads.

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[b]The author is director of the Office of Population Research at Princeton University, Princeton, New Jersey 08540. This article is adapted from a talk given 19 March 1970 at a symposium devoted to "Man and Environment" at the University of North Carolina, Chapel Hill.

To put the same point more simply: environmental deterioration has arisen to a large extent because we have treated pure air, pure water, and the disposal of waste as if they were free. They cannot be treated as free in a modern, urban, industrial society.

There are a number of different kinds of policies that would prevent, or at least reduce, the harmful side effects of some of our economic activities, either by preventing or reducing the volume of the harmful activity, or by inducing a change in technique. Other policies might involve curative rather than preventive steps, such as cleaning up trash along the highways, if we cannot prevent people from depositing it there.

Among the possibilities are steps that would make externalities internal. An example that I find appealing, although it is perhaps not widely practical, is to require users of flowing water to take in the water downstream of their operation and discharge it upstream. A more general measure is to require the recycling of air or water used in industrial processes, rather than permitting the free use of fresh water and clean air, combined with the unmonitored discharge of exhaust products.

Public authorities can charge for unfavorable external effects by imposing a tax on operations that are harmful to the environment. The purpose of such taxes is to reduce the volume of adverse effects by inducing a shift in technique or by reducing the volume of production by causing a rise in price. Also, the tax receipts could be used to pay for mitigating the effect. An example of a desirable tax is one imposed to minimize the use of disposable cans and bottles for soft drinks and beer. Not long ago the majority of manufacturers produced these commodities in containers that were to be returned. The producer offered a modest price for returning bottles as an inducement. It has proven cheaper to use disposable glass bottles and cans; recently aluminum cans have rapidly increased in popularity, substituting a container that lasts indefinitely for the tin cans that would sooner or later rust away. Everyone is familiar with the resultant clutter on beaches, in parks, and along the highways. If a tax of 10 cents per unit were imposed on each disposable container, it would clearly be cheaper to go back to returnables. If some manufacturers found it advantageous to pay the 10-cent tax, the receipts could be used to pay for cleaning up highways and beaches.

Another approach that would induce people to give up economic activities with harmful effects on others is to make individuals and corporations financially liable for any damage caused by their operations. The resultant litigation would be an unwarranted windfall for lawyers, but financial liability might be a very potent factor in reducing pollution.

There is general agreement that our knowledge of what affects the environment is wholly inadequate. Because of inade-

quate monitoring and measurement, we do not know what is happening to the atmosphere or the biosphere; we need research to keep track of what is going on as well as to develop the techniques that will produce the goods we want with fewer of the bads we do not want.

An Economist's Review of Resource Exhaustion

One of the questions most frequently raised about the environmental effects of modern life is the rapid and rising rate of extraction of raw materials. Are we running out of resources?

I would first like to note that the distinction between renewable and nonrenewable resources is not a clear one. There are, of course, instances of nonrenewable resources in the form of concentrated sources of energy, such as the fossil fuels. These are reservoirs of reduced carbon embodying radiant energy from the sun that accumulated over many thousands of years. When these fuels are used, the energy that is released is to a large extent radiated into space, and we have no way of reclaiming it. The geological processes that are constantly renewing the fossil deposits of carbon are so slow compared to the rate at which we are burning the fuels that the designation "nonrenewable" is appropriate.

On the other hand, when we think of our resources of such useful materials as the metallic elements of iron, copper, nickel, lead, and so forth, we should realize that spaceship Earth has the same amount of each element as it had a million years ago, and will have the same amount a million years from now. All we do with these resources is to move them around. The energy we use is lost, but the minerals we find useful are still with us. It does not pay to recycle these minerals (that is to use them repeatedly by reclaiming scrap) because the deposits of minerals in the ground or in the ocean are still such a cheap source. It must be noted that the mining of fresh ore is cheaper than the use of scrap in part because miners are not charged for their "externalities." If harmful by-products of mining could not be discharged into streams, if mine tailings were regulated, and erosion-producing or even unesthetic practices forbidden, minerals would be more expensive and recycling more attractive. In the production of any metallic element, the easier sources are exploited first. As mining gets more difficult, the ore gets more expensive, and recycling becomes more nearly competitive. It seems wholly probable that the technology of recycling will be improved.

The surprising fact is that raw materials are not at the moment very costly, and moreover their cost relative to the cost of finished goods has not been increasing. The gross national product in the United States is more than $4500 per capita and the raw materials component per capita is less than $100. The price of raw materials relative to the price of finished goods is

no higher now than at the beginning of the century, and if we were running out of raw materials, they would surely be rising in relative expensiveness. A prominent exception is saw lumber, which is substantially more expensive relative to the cost of finished wooden products than it used to be.

The reason that the future of our resource situation always seems so bleak and the past seems quite comfortable is that we can readily construct a plausible sounding estimate of the future demand for a particular raw material, but cannot form such a plausible picture of the future supply. To estimate the future demand, we need merely note the recent trends in the per capita consumption of whatever it is we are concerned about, utilize whatever plausible projection of population we are prepared to accept, multiply the two together and project an astonishingly high rate of usage 50 years in the future. If this demand does not seem overwhelming, we need only make a projection 100 years in the future. What we cannot so readily foresee is the discovery of new sources and of new techniques of extraction, and, in particular, the substitution of other raw materials or the substitution of other raw materials or the substitution of other industrial processes which change the demand away from the raw material we are considering. Hence it can always be made to appear that in the future we are going to run out of any given material, but that at present we never have.

It is possible to set plausible limits to the stores of fossil fuels that we are likely to discover, and with the very rapid rise in the use of these fuels they will surely become more expensive in some not too distant time. It should be noted, however, that we will not suddenly "run out" of fossil fuels. Long before the last drop of oil is used, oil will have become much more expensive. If gasoline were $5 or $10 a gallon, we would utilize it much more sparingly, with small economical automobile engines, or perhaps the substitution of some non-petroleum-based fuel altogether. In fact, the principal user of our petroleum deposits may be the petrochemical industries. I have given this special attention to fossil fuels because there is no substitute in prospect for such fuels in small mobile units such as automobiles. On the other hand, the supply of overall energy seems to pose no problem. There seems to be ample fissionable material to supply rising energy needs for many centuries, if breeding reactors are perfected. If fusion proves a practical source, the supply of energy can properly be considered limitless.

Another aspect of the relation of the United States economy to resources that is much publicized today is the fact that we are consuming such a large fraction of the current annual extraction of raw materials in the world. A much quoted figure is the 6 percent of the world's population is using 30 percent of the resources. It is concluded from figures such as these that we are robbing the low-income countries of the world of the basis of their future prosperity--that we are using up not only our resources, but theirs as well. Most economists would find this a

very erroneous picture of the effect of our demand for the raw materials extracted in the less developed parts of the world. The spokesmen for the less developed countries themselves constantly complain about the adverse terms of trade that they face on world markets. The principal source of their concern is the low price of raw materrials and the high price of finished goods. The most effective forms of assistance that the developed countries (including the United States) give to the less developed countries are the purchases they make from the less developed countries in international trade. A developing country needs receipts from exports in order to finance the purchase of the things they need for economic development. For example, in order to industrialize, a nonindustrialized country must for a long time purchase capital equipment from more advanced countries, and the funds for such purchases come from exports--principally of raw materials. Economists in the developing countries feel that the demand for raw materials is inadequate. Perhaps the most important adverse effect of slowing down the growth of the gross national product in the United States would be that it would diminish the demand for primary products that we would otherwise import from the less developed countries. After all, if a developing country wants to retain its raw materials at home, it can always place an embargo on their export. However, it would be a policy very damaging to economic progress of that very country.

Note that the effect of our high demand for raw materials is a different matter from the desirability of the domestic control of mineral resources within the developing countries. Selling oil on the world market provides immense economic advantages to a developing country. Whether foreign interests should be represented in the extraction of raw materials is another question.

Population Growth in the United States

I shall begin a discussion of population with a brief description of recent, current, and future population trends in the United States. Our population today is a little over 200 million, having increased by slightly more than 50 percent since 1940. I think it is likely to increase by nearly 50 percent again in the 30 years before the end of the century.

This rate of increase cannot continue long. If it endured throughout the next century, the population would reach a billion shortly before the year 2100. Within six or seven more centuries we would reach one person per square foot of land area in the United States, and after about 1500 years our descendants would outweigh the earth if they continued to increase by 50 percent every 30 years. We can even calculate that, at that rate of increase, our descendants would, in a few thousand years, form a sphere of flesh whose radius would, neglecting relativity, expand at the velocity of light.

Every demographer knows that we cannot continue a positive rate of increase indefinitely. The inexorable arithmetic of compound interest leads us to absurd conditions within a calculable period of time. Logically we must, and in fact we will, have a rate of growth very close to zero in the long run. The average rate of incease of mankind from the inception of the species until the present is zero to many decimal places. If we agree that 10,000 years from now we can have no more than one person per square foot, and that the population of the world will at a minimum exceed that of Richmond, Virginia, we can say that the average annual growth of population will be within one per thousand of zero.

The only questions about attaining a zero rate of increase for any population is when and how such a rate is attained. A zero rate of increase implies a balance between the average birth and death rates, so the choice of how to attain a zero rate of increase is a choice between low birth and death rates that are approximately equal. The average growth rate very near to zero during mankind's past history has been attained with high birth and death rates--with an average duration of life that until recently was no more than 30 or 35 years. I have no difficulty in deciding that I would prefer a zero rate of growth with low rather than high birth and death rates, or with an average duration of life in excess of 70 years, as has been achieved in all of the more advanced countries of the world, rather than the life that is "nasty, brutish, and short." The remaining question then is <u>when</u> should our population growth level off.

A popular answer today is "immediately." In fact a zero rate of increase in the United States starting immediately is not feasible and I believe not desirable. The reason is the age composition of the population that our past history of birth and death rates has left to us. We have an especially young population now because of the postwar baby boom. One consequence is that our death rate is much lower than it would be in a population that had long had low fertility. That is, because our population is young, a high proportion of it is concentrated in ages where the risk of mortality is small. Therefore, if we were to attain a zero growth rate immediately, it would be necessary to cut the birth rate about in half. For the next 15 or 20 years, women would have to bear children at a rate that would produce only a little over one child per completed family. At the end of that time we would have a very peculiar age distribution with a great shortage of young people. The attendant social and economic disruptions represent too large a cost to pay for the advantages that we might derive from reducing growth to zero right away.

In fact, a more reasonable goal would be to reduce fertility as soon as possible to a level where couples produced just enough children to insure that each generation exactly replaced itself. If this goal (early attainment of fertility at a replacement level) were reached immediately, our population would increase 35

to 40 percent before it stabilized. The reason that fertility at the mere replacement level would produce such a large increase in population is again the age distribution we have today. There are many more people today under 20 than 20 to 40, and when the relatively numerous children have moved into the childbearing ages, they will greatly outnumber the persons now at those ages, and when the current population under age 20 moves into the old ages, they will be far more numerous than the people now at the old ages. Thus to move the population to replacement would be to insure approximately that the number of children under 20 will be about the same as it is today, but that the number above that age will be substantially higher. The net effect is the increase of 35 to 40 percent mentioned just above. It is the built-in growth in our age composition that led me to state earlier that I think an increase in the order of 50 percent of the U.S. population is not unlikely.

A sensible choice in reducing our growth rate to zero then is between early or late attainment of fertility at the replacement level. Is there any reason that we should not attempt to attain a fertility at replacement as soon as possible? My own opinion is that an early move in that direction is desirable, but for the sake of completeness, I must point out that there is a non-negligible cost associated with attaining a stationary population--the population that will exist with fertility at replacement after the age distribution left over from the past has worked out its transitory consequences.

A stationary population with the mortality levels that we have already attained has a much older age distribution than any the United States has ever experienced. It has more people over 60 than under 15, and half the population would be over 37 rather than over 27, as is the case today. It would be an age distribution much like that of a health resort.

Moreover, if we view the age pyramid in the conventional way, with the number of males and females being drawn out as in the branches of a Christmas tree (age representing altitude of the tree) the pyramid for the stationary population is virtually vertical until age 50 because of the small number of deaths under the favorable mortality conditions we have attained. In contrast, the age distribution of the United States to date has always tapered more or less sharply with increasing age. The stationary population with its vertical sides would no longer conform in age composition to the shape of the social structure--to the pyramid of privilege and responsibility. In a growing population, the age pyramid does conform, so there is a rough consonance of shape between diminishing numbers at higher ages and the smaller number of high positions relative to low positions. In a stationary population there would no longer be a reasonable expectation of advancement as a person moves through life. I have indicated that sooner or later we must have a stationary population, so that sooner or later we must adjust to such an age composition. I am pointing to this disadvantage to show that

there is a choice between moving more gradually to a stationary population at the expense of a larger ultimate population size in order to continue to enjoy for a longer time the more desirable age distribution of a growing population.

Connection between Population and Pollution

The connection between the current growth in our population and the deterioration of our environment of which we have all become aware is largely an indirect one. The problem has arisen because we are permitting the production of bads (pollution, or negative externalities) along with goods. There seems little doubt that the rapid increase in the production of goods has been responsible for the rapid increase in the production of bads, since we have made no effective effort to prevent the latter from accompanying the former. But per capita increase in producton has been more important than population growth. It has been calculated that if we were to duplicate the total production of electricity in the United States in 1940 in a population enjoying the 1969 per capita usage of energy, the population could be only 25 million rather than 132 million people there were in 1940. Population has increased by 50 percent, but per capita use of electricity has been multiplied several times. A similar statement can even be made about the crowding of our national parks. The population has increased by about 50 percent in the last 30 years--attendance in national parks has increased by more than 400 percent.

A wealthy industrial urban population of 100 million persons would have most of the population problems we do. In fact, Sydney, Australia, has problems of air and water pollution and of traffic jams, even though the total population of Australia is about 12 million in an area 80 percent as big as the United States. Australia is actually more urbanized than the United States, in spite of its relatively small population and large overall area.

If we have the will and intelligence to devise and apply proper policies, we can improve our environment and can do so either with the current population of 200 million, or with the population that we will probably have in another 50 years of 300 million. On the other hand, if we ignore environmental problems and continue to treat pure air and water and the disposal of trash as if they were free, and if we pay no attention to the effects of the techniques that we employ upon the balance of nature, we will be in trouble whether our population grows or not. There is no doubt that slower population growth would make it easier to improve our environment, but not much easier.

Policies That Would Affect the Growth of Population

We must, at some time, achieve a zero rate of population, and the balance should surely be achieved at low birth and death

rates rather than at high rates. If, as at present, only about 5 percent of women remain single at the end of the childbearing span, and if 96 percent of women survive to the mean age of childbearing, and if finally the sex ratio at birth remains about 105 males for every 100 females, married couples must have an average of about 2.25 children to replace themselves. What kinds of policies might be designed to assure such a level of fertility or, more generally, to produce the fertility level that is at the moment socially desirable?

I begin with a set of policies that are consistent with general democratic and humanitarian principles, although a minority of the population would oppose them on religious grounds. These are policies that would, through education and the provision of clinical services, try to make it possible for every conception to be the result of a deliberate choice, and for every choice to be an informed one, based on an adequate knowledge of the consequences of bearing different numbers of children at different times. A component of such a set of policies would be the development of more effective means of contraception to reduce the number of accidental pregnancies occurring to couples who are trying to avoid conception. These are policies that call for a substantial government role and I think that an effective government program in these areas is already overdue. I personally believe that education in the consequences of childbearing and in the techniques of avoiding pregnancy, combined with the provision of contraceptive services, should be supplemented by the provision of safe and skillful abortion upon request. It is clear that the public consensus in favor of abortion is not nearly as clear-cut as that in favor of contraception, and I know that the extent and the strength of the moral objection to induced abortion is much greater. Nevertheless, I am persuaded by experience in Japan and eastern Europe that the advantages of abortion provided under good medical auspices to cause the early termination of unwanted pregnancies are very important to the women affected, as is evident in the fact that when medically safe abortion has been made available at low cost, the number of abortions has initially been as great or greater than the number of live births. Later there is a typical tendency for women to resort to contraception rather than repeated abortions.

The reason I favor abortion is that such a high proportion of births that occur today are unwanted, and because a large number of desperate pregnant women (probably more than a half a million annually) resort to clandestine abortions today, with high rates of serious complications. In contrast, early abortion, under skilled medical auspices, is less dangerous than tonsillectomy, and substantially less dangerous than carrying a child to full term.

In recent years the number of births that were unwanted in the United States constituted about 20 percent of the total (an unwanted birth was defined as one in which the woman said that conception occurred either as a result of a failure of contraception or in the absence of contraception but without the intent to

become pregnant as soon as possible, when at the time the conception occurred the husband or wife or both did not want another child then or later). The rate at which women are having children today would lead to a completed family size of slightly under three children. If all unwanted births were eliminated, the number of children born per married woman would be about 2.4 or 2.5 on average. This is very little above replacement, and when allowance is made for the likely possibility that women understated the proportion of births that were unwanted, it is probable that the elimination of unwanted births would bring a fertility at or below replacement.

If it is true that the elimination of unwanted pregnancies would reduce fertility very nearly to replacement, it must be conceded that this outcome is fortuitous. It is highly unlikely that over a substantial period of time the free choice by each couple of the number of children they want would lead exactly to the socially desirable level of fertility. The erratic behavior of fertility in America and in other advanced industrialized countries in the last 30 or 40 years is ample evidence that when fertility is voluntarily controlled, the level of fertility is subject to major fluctuations, and I see no logical reason to expect that on average people would voluntarily choose a number of children that would keep the long-run average a little above two per couple. In other words, we must acknowledge the probable necessity of instituting policies that would influence the number of children people want. However, there is no need for haste in formulating such policy, since, as I have indicated, improved contraceptive services combined with a liberal provision of abortion would probably move our fertility at present quite close to replacement, and a gradual increase in population during the next generation would not be a major addition to the problems we already face.

Policies intended to affect people's preferences for children should be designed within the framework of our democratic traditions. They should be designed, for example, to encourage diversity and permit freedom of choice. An average of 2.25 children does not require that 75 percent of couples have two children and 25 percent three, although that would produce the desired average. Another possibility is a nearly even division of family size among zero, one-, two-, three-, four-, and five-child families. The ideal policy would affect the decision at the margin and not try to impose a uniform pattern on all. I do not think that people who prefer to have more than the average number of children should be subject to ridicule or abuse.

It is particularly difficult to frame acceptable policies influencing the number of children that people want. While it is still true that so many large families result from unwanted pregnancies, the unwanted child that is the most recent birth in a large family already faces many deprivations. The psychological disadvantages of the unwanted child cause some of our most serious social problems. In addition to these psychological disad-

vantages, the unwanted child in a large impoverished family faces an inadequate diet, much below average chances for schooling, and generally inferior opportunities. I hardly think it a wise or humane policy to handicap him further by imposing a financial burden on his parents as a result of his birth.

When unwanted births have become negligible in number, we could imagine trying to design a policy in which the couple is asked to pay some part of the "externalities" that an additional birth imposes on society. In the meantime, I suggest as a desirable supplement to better contraception and free access to abortion the extension of more nearly equal opportunities in education and employment for women, so that activities outside of the home become a more powerful competitor to a larger family. We should start now devoting careful attention to formulation of policies in this area--policies that could increase fertility when it fell too low as well as policies to induce people to want fewer children.

Some aspects of the deterioration of our environment appear to be critical and call for prompt action. We need to start now to frame and apply actions that would arrest the careless destruction of the world in which we live. We also need policies to reduce promptly the incidence of unwanted births. In the long run we shall also need ways to influence the number of births people want. To design policies consistent with our most cherished social and political values will not be easy, and it is fortunate that there is no valid reason for hasty action.

The Strategy of Ecosystem Development[a]

by

Eugene P. Odum[b]

The principles of ecological succession bear importantly on the relationships between man and nature. The framework of successional theory needs to be examined as a basis for resolving man's present environmental crisis. Most ideas pertaining to the development of ecological systems are based on descriptive data obtained by observing changes in biotic communities over long periods, or on highly theoretical assumptions; very few of the generally accepted hypotheses have been tested experimentally. Some of the confusion, vagueness, and lack of experimental work in this area stems from the tendency of ecologists to regard "succession" as a single straightforward idea; in actual fact, it entails an interacting complex of processes, some of which counteract one another.

As viewed here, ecological succession involves the development of ecosystems; it has many parallels in the developmental biology of organisms, and also in the development of human society. The ecosystem, or ecological system, is considered to be a unit of biological organization made up of all of the organisms in a given area (that is, "community") interacting with the physical environment so that a flow of energy leads to characteristic trophic structure and material cycles within the system. It is the purpose of this article to summarize, in the form of a tabular model, components and stages of development at the ecosystem level as a means of emphasizing those aspects of ecological succession that can be accepted on the basis of present knowledge, those that require more study, and those that have special relevance to human ecology.

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Definition of Succession

Ecological succession may be defined in terms of the following three parameters (1). (i) It is an orderly process of community development that is reasonably directional and, therefore, predictable. (ii) It results from modification of the physical environment by the community; that is, succession is community-controlled even though the physical environment determines the pattern, the rate of change, and often sets limits as to how far development can go. (iii) It culminates in a stabilized ecosystem in which maximum biomass (or high information content) and symbiotic function between organisms are maintained per unit of available energy flow. In a word, the "strategy" of succession as a short-term process is basically the same as the "strategy" of long-term evolutionary development of the biosphere--namely, increased control of, or homeostasis with, the physical environment in the sense of achieving maximum protection from its perturbations. As I illustrate below, the strategy of "maximum protection" (that is, trying to achieve maximum support of complex biomass structure) often conflicts with man's goal of "maximum production" (trying to obtain the highest possible yield). Recognition of the ecological basis for this conflict is, I believe, a first step in establishing rational land-use policies.

The earlier descriptive studies of succession on sand dunes, grasslands, forests, marine shores, or other sites, and more recent functional considerations, have led to the basic theory contained in the definition given above. H. T. Odum and Pinkerton (2), building on Lotka's (3) "law of maximum energy in biological systems," were the first to point out that succession involves a fundamental shift in energy flows as increasing energy is relegated to maintenance. Margalef (4) has recently documented this bioenergetic basis for succession and has extended the concept.

Changes that occur in major structural and functional characteristics of a developing ecosystem are listed in Table 1. Twenty-four attributes of ecological systems are grouped, for convenience of discussion, under six headings. Trends are emphasized by contrasting the situation in early and late development. The degree of absolute change, the rate of change, and the time required to reach a steady state may vary not only with different climatic and physiographic situations but also with different ecosystem attributes in the same physical environment. Where good data are available, rate-of-change curves are usually convex, with changes occurring most rapidly at the beginning, but bimodal or cyclic patterns may also occur.

Bioenergetics of Ecosystem Development

Attributes 1 through 5 in Table 1 represent the bioenergetics of the ecosystem. In the early stages of ecological succession, or in "young nature," so to speak, the rate of primary production or total (gross) photosynthesis (P) exceeds the rate of

community respiration (R), so that the P/R ratio is greater than 1. In the special case of organic pollution, the P/R ratio is typically less than 1. In both cases, however, the theory is that P/R approaches 1 as succession occurs. In other words, energy fixed tends to be balanced by the energy cost of maintenance (that is, total community respiration) in the mature or "climax" ecosystem. The P/R ratio, therefore, should be an excellent functional index of the relative maturity of the system.

So long as P exceeds R, organic matter and biomass (B) will accumulate in the system (Table 1, item 6), with the result that ratio P/B will tend to decrease or, conversely, the B/P, B/R, or B/E ratios (where E = P + R) will increase (Table 1, items 2 and 3). Theoretically, then, the amount of standing-crop biomass supported by the available energy flow (E) increases to a maximum in the mature or climax stages (Table 1, item 3). As a consequence, the net community production, or yield, in an annual cycle is large in young nature and small or zero in mature nature (Table 1, item 4).

Comparison of Succession in a Laboratory Microcosm and a Forest

One can readily observe bioenergetic changes by initiating succession in experimental laboratory microecosystems. Aquatic microecosystems, derived from various types of outdoor systems, such as ponds, have been cultured by Beyers (5), and certain of these mixed cultures are easily replicated and maintain themselves in the climax state indefinitely on defined media in a flask with only light input (6). If samples from the climax system are inoculated into fresh media, succession occurs, the mature system developing in less than 100 days. In Fig. 1 the general pattern of a 100-day autotrophic succession in a microcosm based on data of Cooke (7) is compared with a hypothetical model of a 100-year forest succession as presented by Kira and Shidei (8).

During the first 40 to 60 days in a typical microcosm experiment, daytime net production (P) exceeds nighttime respiration (R), so that biomass (B) accumulates in the system (9). After an early "bloom" at about 30 days, both rates decline, and they become approximately equal at 60 to 80 days. The B/P ratio, in terms of grams of carbon supported per gram of daily carbon production, increases from less than 20 to more than 100 as the steady state is reached. Not only are autotrophic and heterotrophic metabolism balanced in the climax, but a large organic structure is supported by small daily production and respiratory rates.

While direct projection from the small laboratory microecosystem to open nature may not be entirely valid, there is evidence that the same basic trends that are seen in the laboratory are characteristic of succession on land and in large bodies of

water. Seasonal successions also often follow the same pattern, an early seasonal bloom characterized by rapid growth of a few dominant species being followed by the development later in the season of high B/P ratios, increased diversity, and a relatively steady, if temporary, state in terms of P and R (4). Open systems may not experience a decline, at maturity, in total or gross productivity, as the space-limited microcosms do, but the general pattern of bioenergetic change in the latter seems to mimic nature quite well.

These trends are not, as might at first seem to be the case, contrary to the classical limnological teaching which describes lakes as progressing in time from the less productive (oligotrophic) to the more productive (eutrophic) state. Table 1, as already emphasized, refers to changes which are brought about by biological processes within the ecosystem in question. Eutrophication, whether natural or cultural, results when nutrients are imported into the lake from outside the lake--that is, from the watershed. This is equivalent to adding nutrients to the laboratory microecosystem or fertilizing a field; the system is pushed back, in successional terms, to a younger or "bloom" state. Recent studies on lake sediments (10), as well as theoretical considerations (11), have indicated that lakes can and do progress to a more oligotrophic condition when the nutrient input from the watershed slows or ceases. Thus, there is hope that the troublesome cultural eutrophication of our waters can be reversed if the inflow of nutrients from the watershed can be greatly reduced. Most of all, however, this situation emphasizes that it is the entire drainage or catchment basin, not just the lake or stream, that must be considered the ecosystem unit if we are to deal successfully with our water pollution problems. Ecosystematic study of entire landscape catchment units is a major goal of the American plan for the proposed International Biological Program. Despite the obvious logic of such a proposal, it is proving surprisingly difficult to get tradition-bound scientists and granting agencies to look beyond their specialties toward the support of functional studies of large units of the landscape.

Food Chains and Food Webs

As the ecosystem develops, subtle changes in the network pattern of food chains may be expected. The manner in which organisms are linked together through food tends to be relatively simple and linear in the very early stages of succession, as a consequence of low diversity. Furthermore, heterotrophic utilization of net production occurs predominantly by way of grazing food chains--that is, plant-herbivore-carnivore sequences. In contrast, food chains become complex webs in mature stages, with the bulk of biological energy flow following detritus pathways (Table 1, item 5). In a mature forest, for example, less than 10 percent of annual net production is consumed (that is, grazed) in the living state (12); most is utilized as dead matter (detritus) through delayed and complex pathways involving as yet little

understood animal-microorganism interactions. The time involved in an uninterrupted succession allows for increasingly intimate associations and reciprocal adaptations between plants and animals, which lead to the development of many mechanisms that

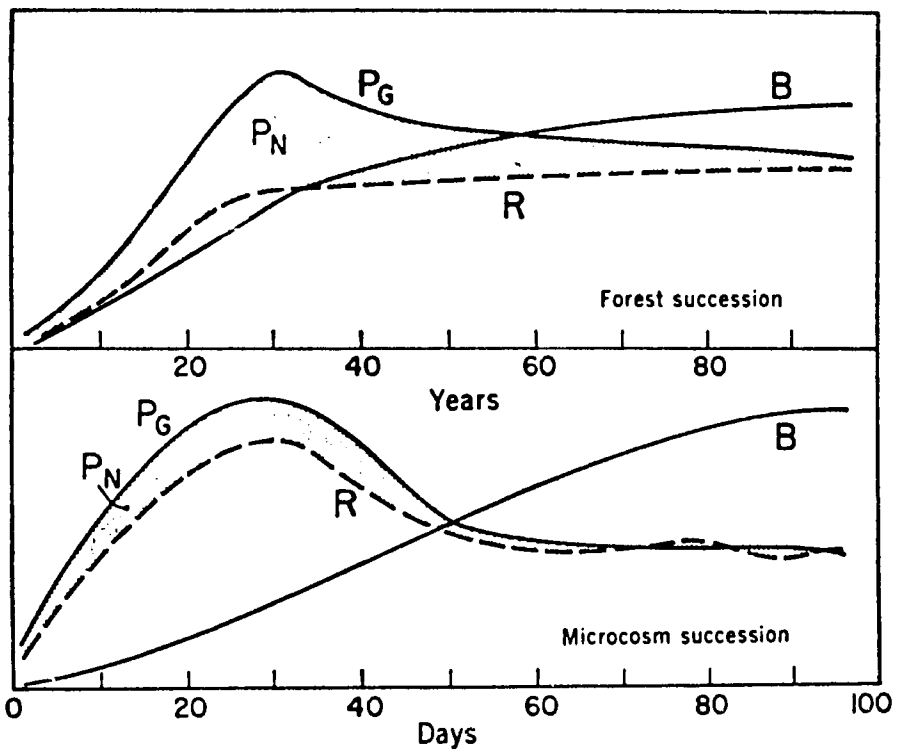

Fig. 1. Comparison of the energetics of succession in a forest and a laboratory microcosm. P_G, gross production; P_N, net production; R, total community respiration; B, total biomass.

reduce grazing--such as the development of indigestible supporting tissues (cellulose, lignin, and so on), feedback control between plants and herbivores (13), and increasing predatory pressure on herbivores (14). Such mechanisms enable the biological community to maintain the large and complex organic structure that mitigates perturbations of the physical environment. Severe stress or rapid changes brought about by outside forces can, of course, rob the system of these protective mechanisms and allow irruptive, cancerous growths of certain species to occur, as man too often finds to his sorrow. An example of a stress-induced pest irruption occurred at Brookhaven National Laboratory, where oaks became vulnerable to aphids when translocation of sugars and amino acids was impaired by continuing gamma irradiation (15).

Radionuclide tracers are providing a means of charting food chains in the intact outdoor ecosystem to a degree that will permit analysis within the concepts of network or matrix algebra. For example, we have recently been able to map, by use of a radiophosphorus tracer, the open, relatively linear food linkage between plants and insects in an early old-field successional stage (16).

Diversity and Succession

Perhaps the most controversial of the successional trends pertain to the complex and much discussed subject of diversity (17). It is important to distinguish between different kinds of diversity indices, since they may not follow parallel trends in the same gradient or developmental series. Four components of diversity are listed in Table 1, items 8 through 11.

The variety of species, expressed as a species-number ratio or a species-area ratio, tends to increase during the early stages of community development. A second component of species diversity is what has been called equitability, or evenness (18), in the apportionment of individuals among the species. For example, two systems each containing 10 species and 100 individuals have the same diversity in terms of species-number ratio but could have widely different equitabilities depending on the apportionment of the 100 individuals among the 10 species--for example, 91-1-1-1-1-1-1-1-1-1 at one extreme or 10 individuals per species at the other. The Shannon formula,

$$-\Sigma \frac{ni}{N} \log_2 \frac{ni}{N}$$

where ni is the number of individuals in each species and N is the total number of individuals, is widely used as a diversity index because it combines the variety and equitability components in one approximation. But, like all such lumping parameters, Shannon's formula may obscure the behavior of these two rather different aspects of diversity. For example, in our most recent field experiments, an acute stress from insecticide reduced the number of species of insects relative to the number of individuals but increased the evenness in the relative abundances of the surviving species (19). Thus, in this case the "variety" and "evenness" components would tend to cancel each other in Shannon's formula.

While an increase in the variety of species together with reduced dominance by any one species or small group of species (that is, increased evenness) can be accepted as a general probability during succession (20), there are other community changes that may work against these trends. An increase in the size of organisms, an increase in the length and complexity of life histories, and an increase in interspecific competition that may result in competitive exclusion of species (Table 1, items 12-14) are trends that may reduce the number of species that can live in a given area. In the bloom stage of succession organisms tend to be small and to have simple life histories and rapid rates of reproduction. Changes in size appear to be a consequence of, or an adaptation to, a shift in nutrients from inorganic to organic (Table 1, item 7). In a mineral nutrient-rich environment, small size is of selective advantage, especially to autotrophs, because of the greater surface-to-volume ratio. As the ecosystem develops, however, inorganic nutrients tend to become more and more

tied up in the biomass (that is, to become intrabiotic), so that the selective advantage shifts to larger organisms (either larger individuals of the same species or larger species, or both) which have greater storage capacities and more complex life histories, thus are adapted to exploiting seasonal or periodic releases of nutrients or other resources. The question of whether the seemingly direct relationship between organism size and stability is the result of positive feedback or is merely fortuitous remains unanswered (21).

Thus, whether or not species diversity continues to increase during succession will depend on whether the increase in potential niches resulting from increased biomass, stratification (Table 1, item 9), and other consequences of biological organization exceeds the countereffects of increasing size and competition. No one has yet been able to catalogue all the species in any sizable area, much less follow total species diversity in a successional series. Data are so far available only for segments of the community (trees, birds, and so on). Margalef (4) postulates that diversity will tend to peak during the early or middle stages of succession and then decline in the climax. In a study of bird populations along a successional gradient we found a bimodal pattern (22); the number of species increased during the early stages of old-field succession, declined during the early forest stages, and then increased again in the mature forest.

Species variety, equitability, and stratification are only three aspects of diversity which change during succession. Perhaps an even more important trend is an increase in the diversity of organic compounds, not only of those within the biomass but also of those excreted and secreted into the media (air, soil, water) as by-products of the increasing community metabolism. An increase in such "biochemical diversity" (Table 1, item 10) is illustrated by the increase in the variety of plant pigments along a successional gradient in aquatic situations, as described by Margalef (4, 23). Biochemical diversity within populations, or within systems as a whole, has not yet been systematically studied to the degree the subject of species diversity has been. Consequently, few generalizations can be made, except that it seems safe to say that, as succession progresses, organic extrametabolities probably serve increasingly important functions as regulators which stabilize the growth and composition of the ecosystem. Such metabolites may, in fact, be extremely important in preventing populations from overshooting the equilibrial density, thus in reducing oscillations as the system develops stability.

The cause-and-effect relationship between diversity and stability is not clear and needs to be investigated from many angles. If it can be shown that biotic diversity does indeed enhance physical stability in the ecosystem, or is the result of it, then we would have an important guide for conservation practice. Preservation of hedgerows, woodlots, noneconomic species, noneutrophicated waters, and other biotic variety in man's landscape could then be justified on scientific as well as esthetic

grounds, even though such preservation often must result in some reduction in the production of food or other immediate consumer needs. In other words, is variety only the spice of life, or is it a necessity for the long life of the total ecosystem comprising man and nature?

Nutrient Cycling

An important trend in successional development is the closing or "tightening" of the biogeochemical cycling of major nutrients, such as nitrogen, phosphorus, and calcium (Table 1, items 15-17). Mature systems, as compared to developing ones, have a greater capacity to entrap and hold nutrients for cycling within the system. For example, Bormann and Likens (24) have estimated that only 8 kilograms per hectare out of a total pool of exchangeable calcium of 365 kilograms per hectare is lost per year in stream outflow from a North Temperate watershed covered with a mature forest. Of this, about 3 kilograms per hectare is replaced by rainfall, leaving only 5 kilograms to be obtained from weathering of the underlying rocks in order for the system to maintain mineral balance. Reducing the volume of the vegetation, or otherwise setting the succession back to a younger state, results in increased water yield by way of stream outflow (25), but this greater outflow is accompanied by greater losses of nutrients, which may also produce downstream eutrophication. Unless there is a compensating increase in the rate of weathering, the exchangeable pool of nutrients suffers gradual depletion (not to mention possible effects on soil structure resulting from erosion). High fertility in "young systems" which have open nutrient cycles cannot be maintained without compensating inputs of new nutrients; examples of such practice are the continuous-flow culture of algae, or intensive agriculture where large amounts of fertilizer are imported into the system each year.

Because rates of leaching increase in a latitudinal gradient from the poles to the equator, the role of the biotic community in nutrient retention is especially important in the high-rainfall areas of the subtropical and tropical latitudes, including not only land areas but also estuaries. Theoretically, as one goes equatorward, a larger percentage of the available nutrient pool is tied up in the biomass and a correspondingly lower percentage is in the soil or sediment. This theory, however, needs testing, since data to show such a geographical trend are incomplete. It is perhaps significant that conventional North Temperate row-type agriculture, which represents a very youthful type of ecosystem, is successful in the humid tropics only if carried out in a system of "shifting agriculture" in which the crops alternate with periods of natural vegetative redevelopment. Tree culture and the semiaquatic culture of rice provide much better nutrient retention and consequently have a longer life expectancy on a given site in these warmer latitudes.

Table 1. A tabular model of ecological succession: trends to be expected in the development of ecosystems.

	Ecosystem attributes	Developmental stages	Mature stages
	Community energetics		
1.	Gross production/community respiration (P/R ratio)	Greater or less than 1	Approaches 1
2.	Gross production/standing crop biomass (P/B ratio)	High	Low
3.	Biomass supported/unit energy flow (B/E ratio)	Low	High
4.	Net community production (yield)	High	Low
5.	Food chains	Linear, predominantly grazing	Weblike, predominantly detritus
	Community structure		
6.	Total organic matter	Small	Large
7.	Inorganic nutrients	Extrabiotic	Intrabiotic
8.	Species diversity--variety component	Low	High
9.	Species diversity--equitability component	Low	High
10.	Biochemical diversity	Low	High
11.	Stratification and spatial heterogeneity (pattern diversity)	Poorly organized	Well-organized
	Life history		
12.	Niche specialization	Broad	Narrow
13.	Size of organism	Small	Large
14.	Life cycles	Short, simple	Long, complex
	Nutrient cycling		
15.	Mineral cycles	Open	Closed
16.	Nutrient exchange rate, between organisms and environment	Rapid	Slow
17.	Role of detritus in nutrient regeneration	Unimportant	Important
	Selection pressure		
18.	Growth form	For rapid growth ("r-selection")	For feedback control ("K-selection")
19.	Production	Quantity	Quality
	Overall homeostasis		
20.	Internal symbiosis	Undeveloped	Developed
21.	Nutrient conservation	Poor	Good
22.	Stability (resistance to external perturbations)	Poor	Good
23.	Entropy	High	Low
24.	Information	Low	High

Selection Pressure: Quantity versus Quality

MacArthur and Wilson (26) have reviewed stages of colonization of islands which provide direct parallels with stages in ecological succession on continents. Species with high rates of reproduction and growth, they find, are more likely to survive in the early uncrowded stages of island colonization. In contrast, selection pressure favors species with lower growth potential but better capabilities for competitive survival under the equilibrium density of late stages. Using the terminology of growth equations, where r is the intrinsic rate of increase and K is the upper asymptote or equilibrium population size, we may say that "r selection" predominates in early colonization, with "K selection" prevailing as more and more species and individuals attempt to colonize (Table 1, item 18). The same sort of thing is even seen within the species in certain "cyclic" northern insects in which "active" genetic strains found at low densities are replaced at high densities by "sluggish" strains that are adapted to crowding (27).

Genetic changes involving the whole biota may be presumed to accompany the successional gradient, since, as described above, quantity production characterizes the young ecosystem while quality production and feedback control are the trademarks of the mature system (Table 1, item 19). Selection at the ecosystem level may be primarily interspecific, since species replacement is a characteristic of successional series or seres. However, in most well-studied seres there seem to be a few early successional species that are able to persist through to late stages. Whether genetic changes contribute to adaptation in such species has not been determined, so far as I know, but studies on population genetics of Drosophila suggest that changes in genetic composition could be important in population regulation (28). Certainly, the human population, if it survives beyond its present rapid growth stage, is destined to be more and more affected by such selection pressures as adaptation to crowding becomes essential.

Overall Homeostasis

This brief review of ecosystem development emphasizes the complex nature of processes that interact. While one may well question whether all the trends described are characteristic of all types of ecosystems, there can be little doubt that the net result of community actions is symbiosis, nutrient conservation, stability, a decrease in entropy, and an increase in information (Table 1, items 20-24). The overall strategy is, as I stated at the beginning of this article, directed toward achieving as large and diverse an organic structure as is possible within the limits set by the available energy input and the prevailing physical conditions of existence (soil, water, climate, and so on). As tudies of biotic communities become more functional and sophisticated, one is impressed with the importance of mutualism, parasitism, predation, commensalism, and other forms of symbiosis. Partnership between unrelated species is often noteworthy

(for example, that between coral coelenterates and algae, or between mycorrhizae and trees). In many cases, at least, biotic control of grazing, population density, and nutrient cycling provide the chief positive-feedback mechanisms that contribute to stability in the mature system by preventing overshoots and destructive oscillations. The intriguing queston is, Do mature ecosystems age, as organisms do? In other words, after a long period of relative stability or "adulthood," do ecosystems again develop unbalanced metabolism and become more vulnerable to diseases and other perturbations?

Relevance of Ecosystem Development Theory to Human Ecology

Figure 1 depicts a basic conflict between the strategies of man and of nature. The "bloom-type" relationships, as exhibited by the 30-day microcosm or the 30-year forest, illustrate man's present idea of how nature should be directed. For example, the goal of agriculture or intensive forestry, as now generally practiced, is to achieve high rates of production of readily harvestable products with little standing crop left to accumulate on the landscape--in other words, a high P/B efficiency. Nature's strategy, on the other hand, as seen in the outcome of the successional process, is directed toward the reverse efficiency--a high B/P ratio, as is depicted by the relationship at the right in Fig. 1. Man has generally been preoccupied with obtaining as much "production" from the landscape as possible, by developing and maintaining early successional types of ecosystems, usually monocultures. But, of course, man does not live by food and fiber alone; he also needs a balanced CO_2-O_2 atmosphere, the climatic buffer provided by oceans and masses of vegetation, and clean (that is, unproductive) water for cultural and industrial uses. Many essential life-cycle resources, not to mention recreational and esthetic needs, are best provided man by the less "productive" landscapes. In other words, the landscape is not just a supply depot but is also the oikos--the home--in which we must live. Until recently mankind has more or less taken for granted the gas-exchange, water-purification, nutrient-cycling, and other protective functions of self-maintaining ecosystems, chiefly because neither his numbers nor his environmental manipulations have been great enough to affect regional and global balances. Now, of course, it is painfully evident that such balances are being affected, often detrimentally. The "one problem, one solution approach" is no longer adequate and must be replaced by some form of ecosystem analysis that considers man as a part of, not apart from, the environment.

The most pleasant and certainly the safest landscape to live in is one containing a variety of crops, forests, lakes, streams, roadsides, marshes, seashores, and "waste places"--in other words, a mixture of communities of different ecological ages. As individuals we more or less instinctively surround our houses with protective, nonedible cover (trees, shrubs, grass) at the same time that we strive to coax extra bushels from our corn-

field. We all consider the cornfield a "good thing," of course, but most of us would not want to live there, and it would certainly be suicidal to cover the whole land area of the biosphere with cornfields, since the boom and bust oscillation in such a situation would be severe.

The basic problem facing organized society today boils down to determining in some objective manner when we are getting "too much of a good thing." This is a completely new challenge to mankind because, up until now, he has had to be concerned largely with too little rather than too much. Thus, concrete is a "good thing," but not if half the world is covered with it. Insecticides are "good things," but not when used, as they now are, in an indiscriminate and wholesale manner. Likewise, water impoundments have proved to be very useful man-made additions to the landscape, but obviously we don't want the whole country inundated! Vast manmade lakes solve some problems, at least temporarily, but yield comparative little food or fiber, and, because of high evaporative losses, they may not even be the best device for storing water; it might better be stored in the watershed, or underground in aquafers. Also, the cost of building large dams is a drain on already overtaxed revenues. Although as individuals we readily recognize that we can have too many dams or other large-scale environmental changes, governments are so fragmented and lacking in systems-analysis capabilities that there is no effective mechanism whereby negative feedback signals can be received and acted on before there has been a serious overshoot. Thus, today there are governmental agencies, spurred on by popular and political enthusiam for dams, that are putting on the drawing boards plans for damming every river and stream in North America!

Table 2. Contrasting characteristics of young and mature-type ecosystems.

Young	Mature
Production	Protection
Growth	Stability
Quantity	Quality

Society needs, and must find as quickly as possible, a way to deal with the landscape as a whole, so that manipulative skills (that is, technology) will not run too far ahead of our understanding of the impact of change. Recently a national ecological center outside of government and a coalition of governmental agencies have been proposed as two possible steps in the establishment of a political control mechanism for dealing with major environmental questions. The soil conservation movement in America is an excellent example of a program dedicated to the

consideration of the whole farm or the whole watershed as an ecological unit. Soil conservation is well understood and supported by the public. However, soil conservation organizations have remained too exclusively farm-oriented, and have not yet risen to the challenge of the urban-rural landscape, where lie today's most serious problems, We do, then, have potential mechanisms in American society that could speak for the ecosystem as a whole, but none of them are really operational (29).

The general relevance of ecosystem development theory to landscape planning can, perhaps, be emphasized by the "mini-model" of Table 2, which contrasts the characteristics of young and mature-type ecosystems in more general terms than those provided by Table 1. It is mathematically impossible to obtain a maximum for more than one thing at a time, so one cannot have both extremes at the same time and place. Since all six characteristics listed in Table 2 are desirable in the aggregate, two possible solutions to the dilemma immediately suggest themselves. We can compromise so as to provide moderate quality and moderate yield on all the landscape, or we can deliberately plan to compartmentalize the landscape so as to simultaneously maintain highly productive and predominantly protective types as separate units subject to different management strategies (strategies ranging, for example, from intensive cropping on the one hand to wilderness management on the other). If ecosystem development theory is valid and applicable to planning, then the so-called multiple-use strategy, about which we hear so much, will work only through one or both of these approaches, because, in most cases, the projected multiple uses conflict with one another. It is appropriate, then, to examine some examples of the compromise and the compartmental strategies.

Pulse Stability

A more or less regular but acute physical perturbation imposed from without can maintain an ecosystem at some intermediate point in the developmental sequence, resulting in, so to speak, a compromise between youth and maturity. What I would term "fluctuating water level ecosystems are good examples. Estuaries, and intertidal zones in general, are maintained in an early, relatively fertile stage by the tides, which provide the energy for rapid nutrient cycling. Likewise, freshwater marshes, such as the Florida Everglades, are held at an early successional stage by the seasonal fluctuations in water levels. The dry-season drawdown speeds up aerobic decomposition of accumulated organic matter, releasing nutrients that, on reflooding, support a wet-season bloom in productivity. The life histories of many organisms are intimately coupled to this periodicity. The wood stork, for example, breeds when the water levels are falling and the small fish on which it feeds become concentrated and easy to catch in the drying pools. If the water level remains high during the usual dry season or fails to rise in the wet season, the stork will not nest (30). Stabilizing water levels in the Ever-

glades by means of dikes, locks, and impoundments, as is now advocated by some, would, in my opinion, destroy rather than preserve the Everglades as we now know them just as surely as complete drainage would. Without periodic drawdowns and fires, the shallow basins would fill up with organic matter and succession would proceed from the present pond-and-prairie conditon toward a scrub or swamp forest.

It is strange that man does not readily recognize the importance of recurrent changes in water level in a natural situation such as the Everglades when similar pulses are the basis for some of his most enduring food culture systems (31). Alternate filling and draining of ponds has been a standard procedure in fish culture for centuries in Europe and the Orient. The flooding, draining, and soil-aeration procedure in rice culture is another example. The rice paddy is thus the cultivated analogue of the natural marsh or the intertidal ecosystem.

Fire is another physical factor whose periodicity has been of vital importance to man and nature over the centuries. Whole biotas, such as those of the African grasslands and the California chaparral, have become adapted to periodic fires producing what ecologists often call "fire climaxes" (32). Man uses fire deliberately to maintain such climaxes or to set back succession to some desired point. In the southeastern coastal plain, for example, light fires of moderate frequency can maintain a pine forest against the encroachment of older successional stages which, at the present time at least, are considered economically less desirable. The fire-controlled forest yields less wood than a tree farm does (that is, young trees, all of about the same age, planted in rows and harvested on a short rotation schedule), but it provides a greater protective cover for the landscape, wood of higher quality, and a home for game birds (quail, wild turkey, and so on) which could not survive in a tree farm. The fire climax, then, is an example of a compromise between production simplicity and protection diversity.

It should be emphasized that pulse stability works only if there is a complete community (including not only plants but animals and microorganisms) adapted to the particular intensity and frequency of the perturbation. Adaptation--operation of the selection process --requires times measurable on the evolutionary scale. Most physical stresses introduced by man are too sudden, too violent, or too arrhythmic for adaptation to occur at the ecosystem level, so severe oscillation rather than stability results. In many cases, at least, modification of naturally adapted ecosystems for cultural purposes would seem preferable to complete redesign.

Prospects for a Detritus Agriculture

As indicated above, heterotrophic utilization of primary production in mature ecosystems involves largely a delayed con-

sumption of detritus. There is no reason why man cannot make greater use of detritus and thus obtain food or other products from the more protective type of ecosystem. Again, this would represent a compromise, since the short-term yield could not be as great as the yield obtained by direct exploitation of the grazing food chain. A detritus agriculture, however, would have some compensating advantages. Present agricultural strategy is based on selection for rapid growth and edibility in food plants, which, of course, make them vulnerable to attack by insects and disease. Consequently, the more we select for succulence and growth, the more effort we must invest in the chemical control of pests; this effort, in turn, increases the likelihood of our poisoning useful organisms, not to mention ourselves. Why not also practice the reverse strategy--that is, select plants which are essentially unpalatable, or which produce their own systemic insecticides while they are growing, and then convert the net production into edible products by microbial and chemical enrichment in food factories? We could then devote our biochemical genius to the enrichment process instead of fouling up our living space with chemical poisons! The production of silage by fermentation of low-grade fodder is an example of such a procedure already in widespread use. The cultivation of detritus-eating fishes in the Orient is another example.

By tapping the detritus food chain man can also obtain an appreciable harvest from many natural systems without greatly modifying them or destroying their protective and esthetic value. Oyster culture in estuaries is a good example. In Japan, raft and long-line culture of oysters has proved to be a very practical way to harvest the natural microbial products of estuaries and shallow bays. Furukawa (33) reports that the yield of cultured oysters in the Hiroshima Prefecture has increased tenfold since 1950, and that the yield of oysters (some 240,000 tons of meat) from this one district alone in 1965 was ten times the yield of natural oysters from the entire country. Such oyster culture is feasible along the entire Atlantic and Gulf coasts of the United States. A large investment in the culture of oysters and other seafoods would also provide the best possible deterrent against pollution, since the first threat of damage to the pollution-sensitive oyster industry would be immediately translated into political action!

The Compartment Model

Successful though they often are, compromise systems are not suitable nor desirable for the whole landscape. More emphasis needs to be placed on compartmentalization, so that growth-type, steady-state, and intermediate-type ecosystems can be linked with urban and industrial areas for mutual benefit. Knowing the transfer coefficients that define the flow of energy and the movement of materials and organisms (including man) between compartments, it should be possible to determine, through analog-computer manipulation, rational limits for the size and capacity

of each compartment. We might start, for example, with a simplified model, shown in Fig. 2, consisting of four compartments of equal area, partitioned according to the basic biotic-function criterion--that is, according to whether the area is (i) productive, (ii) protective, (iii) a compromise between (i) and (ii) or (iv), urban-industrial. By continually refining the transfer coefficients on the basis of real world situations, and by increasing and decreasing the size and capacity of each compartment through computer simulation, it would be possible to determine objectively the limits that must eventually be imposed on each compartment in order to maintain regional and global balances in the exchange of vital energy and of materials. A systems-analysis procedure provides at least one approach to the solution of the basic dilemma posed by the question "How do we determine when we are getting too much of a good thing?" Also it provides a means of evaluating the energy drains imposed on ecosystems by pollution, radiation, harvest, and other stresses (34).

Implementing any kind of compartmentalization plan, of course, would require procedures for zoning the landscape and restricting the use of some land and water areas. While the principle of zoning in cities is universally accepted, the procedures now followed do not work very well because zoning restrictions are too easily overturned by short-term economic and population pressures. Zoning the landscape would require a whole new order of thinking. Greater use of legal measures providing for tax relief, restrictions on use, scenic easements, and public ownership will be required if appreciable land and water areas are to be held in the "protective" categories. Several states (for example, New Jersey and California), where pollution and population pressure are beginning to hurt, have made a start in this direction by enacting "open space" legislation designed to get as much unoccupied land as possible into a "protective" status so that future uses can be planned on a rational and scientific basis. The United States as a whole is fortunate in that large areas of the country are in national forests, parks, wildlife refuges, and so on. The fact that such areas, as well as the bordering oceans, are not quickly exploitable gives us time for the accelerated ecological study and programming needed to determine what proportions of different types of landscape provide a safe balance between man and nature. The open oceans, for example, should forever be allowed to remain protective rather than productive territory, if Alfred Redfield's (35) assumptions are correct. Redfield views the oceans, the major part of the hydrosphere, as the biosphere's governor, which slows down and controls the rate of decomposition and nutrient regeneration, thereby creating and maintaining the highly aerobic terrestrial environment to which the higher forms of life, such as man, are adapted. Eutrophication of the ocean in a last-ditch effort to feed the populations of the land could well have an adverse effect on the oxygen reservoir in the atmosphere.

Until we can determine more precisely how far we may safely go in expanding intensive agriculture and urban sprawl at the

expense of the protective landscape, it will be good insurance to hold inviolate as much of the latter as possible. Thus, the preservation of natural areas is not a peripheral luxury for society but a capital investment from which we expect to draw interest. Also, it may well be that restrictions in the use of land and water are our only practical means of avoiding overpopulation or too great an exploitation of resources, or both. Interestingly enough, restriction of land use is the analogue of a natural behavioral control mechanism known as "territoriality" by which many species of animals avoid crowding and social stress (36).

Since the legal and economic problems pertaining to zoning and compartmentalization are likely to be thorny, I urge law schools to establish departments, or institutes, of "landscape

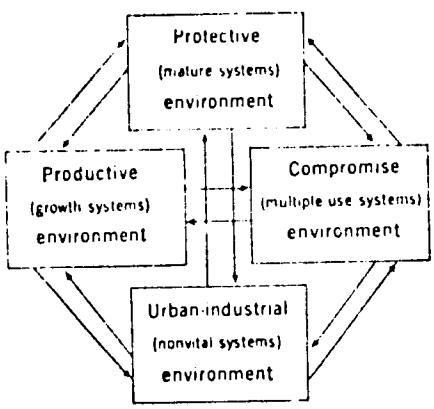

Fig. 2. Compartment model of the basic kinds of environment required by man, partitioned according to ecosystem development and life-cycle resource criteria.

law" and to start training "landscape lawyers" who will be capable not only of clarifying existing procedures but also of drawing up new enabling legislation for consideration by state and national governing bodies. At present, society is concerned--and rightly so-- with human rights, but environmental rights are equally vital. The "one man one vote" idea is important, but so also is a "one man one hectare" proposition.

Education, as always, must play a role in increasing man's awareness of his dependence on the natural environment. Perhaps we need to start teaching the principles of ecosystem in the third grade. A grammar school primer on man and his environment could logically consist of four chapters, one for each of the four essential kinds of environment, shown diagrammatically in Fig. 2.

Of the many books and articles that are being written these days about man's environmental crisis, I would like to cite two that go beyond "crying out in alarm" to suggestions for bringing about a reorientation of the goals of society. Garrett Hardin, in a recent article in Science (37), points out that, since the optimum population density is less than the maximum, there is no

strictly technical solution to the problem of pollution caused by overpopulation; a solution, he suggests, can only be achieved through moral and legal means of "mutual coercion, mutually agreed upon by the majority of people." Earl F. Murphy, in a book entitled Governing Nature (38), emphasizes that the regulatory approach alone is not enough to protect life-cycle resources, such as air and water, that cannot be allowed to deteriorate. He discusses permit systems, effluent charges, receptor levies, assessment, and cost-internalizing procedures as economic incentives for achieveing Hardin's "mutually agreed upon coercion."

It goes without saying that the tabular model for ecosystem development which I have presented here has many parallels in the development of human society itself. In the pioneer society, as in the pioneer ecosystem, high birth rates, rapid growth, high economic profits, and exploitation of accessible and unused resources are advantageous, but, as the saturation level is approached, these drives must be shifted to considerations of symbiosis (that is, "civil rights," "law and order," "education," and "culture"), birth control, and the recycling of resources. A balance between youth and maturity in the socio-environmental system is, therefore, the really basic goal that must be achieved if man as a species is to successfully pass through the present rapid-growth stage, to which he is clearly well adapted, to the ultimate equilibrium-density stage, of which he as yet shows little understanding and to which he now shows little tendency to adapt.

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The World Bank, Industrial Development, and the Environment

by

The World Bank

Washington, D. C.

Introduction

The World Bank Group--the single largest economic development institution in the world--follows a policy that calls for every project proposed to it for financing in developing countries to be examined for its environmental implications and to have appropriate safeguard measures incorporated. Industrial projects undergo a searching evaluation of their pollution potential; that story, in brief, is presented below following a description of the World Bank Group as an institution.

THE WORLD BANK GROUP AND POLLUTION CONTROL IN DEVELOPING COUNTRIES

The World Bank Group provides financial and technical help for the development of poor countries.

The Group consists of the World Bank (International Bank for Reconstruction and Development), IDA (International Development Association) and IFC (International Finance Corporation).

The Bank and IDA are now lending more than $3,400 million a year to help raise the standard of living in developing countries. This is well over one-fourth of the total from all official sources outside the developing countries themselves. The IFC has the same purpose, but its role is more specialized; helping to stimulate growth in the private sector, particularly industry. It is now investing nearly $150 million a year.

Both the Bank and IDA have expanded rapidly in the last five years as shown in the following tables:

Table 1: Bank and IDA lending to current borrowers[1] 1964-73
(US$ millions. Fiscal years.)

Number of Countries in ( )	Average 1964-68	Average 1969-73	1973
Bank only (33)	$ 516	$ 1,154	$ 1,241
IDA only (25)	16	205	384
Bank/IDA (35)			
Bank	223	629	810
IDA	251	582	973
Totals	$ 1,006	$ 2,570	$ 3,408

[1]Member countries which have borrowed since fiscal 1968 or which are included in the fiscal 1974 lending program.

Table 2: Bank and IDA lending to current borrowers by principal sectors, 1964-73
(US$ millions. Fiscal years.)

	1964-68		1969-73		1973	
	Amount	%	Amount	%	Amount	%
Agriculture	$ 124	12	$ 518	20	$ 938	28
Education	31	3	145	6	276	8
Industry[1]	120	12	364	14	377	11
Population Planning	-	-	13	1	22	1
Public Utilities[2]	346	34	706	27	849	25
Tourism	-	-	16	1	-	-
Transportation	293	29	651	25	682	20
Urban Projects[3]	-	-	10	-	36	1
Non-project[4]	91	9	146	6	229	7
Totals	$1,006		$2,570		$3,408	

[1]Including development finance companies.

[2]Communications, power, water supply and sewerage.

[3]Specifically to help with the "urbanization" problem.

[4]Industrial imports, reconstruction and rehabilitation, technical assistance, project preparation, planning.

In fiscal 1973, the Bank provided more than twice as much and IDA nearly four times as much financial help to developing countries as in any year before 1969. These funds are helping to support a wide variety of projects, large and small, public and private chiefly in the following fields: agriculture, education, electric power, industry, population planning, tourism, transportation, telecommunications, urban development, water supply and sewerage.

The Bank Group has also committed itself to helping its 122 member countries with their many intractable development problems, including questions of income distribution, rural poverty, unemployment, excessive population growth, rapid urbanization and, of late, environmental rehabilitation.

Although legally and financially distinct, the Bank, IDA, and IFC are a closely integrated unit. Using funds from different sources and lending on different terms and arrangements, they have become a highly flexible instrument for giving both financial and technical assistance to developing member countries at virtually all stages of economic and social growth. Together, they constitute a true development institution.

On a global scale, the World Bank was the first institution to be established with the explicit purpose of helping less developed countries raise their living standards.

Along with the International Monetary Fund (IMF), the Bank was founded in 1944 at a United Nations Monetary and Financial Conference of 44 governments at Bretton Woods, New Hampshire, U.S.A. It began operations in June 1946. Membership in the Bank is open to all members of the IMF, and 122 have joined. The Bank is owned and controlled by its member governments.

The Bank's charter spells out certain basic rules which govern its operations. It must lend only for productive purposes, and only if there are reasonable prospects of repayment. Each loan must be guaranteed by the government concerned. Except in "special circumstances," loans must be for specific projects. The Bank must assure itself that the necessary funds are unavailable from other sources on reasonable terms. The use of loans cannot be restricted to purchases in any particular member country or countries. And the Bank's decisions must be based only on economic considerations.

A unique feature of the Bank as an intergovernmental organization is the fact that it relies mainly on private investors for its financial resources. Most of the money it lends comes from the Bank's own borrowings in various capital markets. Although a total of $25,197 million of its authorized capital of $27,000 million has been subscribed, members pay in only 10%. The remaining 90% serves as a guarantee of the Bank's debt. It can be used only if required to meet obligations to investors in Bank securities.

Thus, investors who might otherwise never become involved in the financing of projects in developing countries are contributing to their economic growth. The Bank has borrowed a cumulative total of $15,764 million, of which $8,882 million is outstanding in 15 different currencies.

Since the Bank obtains most of its funds on commercial terms, it must charge its own borrowers a commensurate rate of interest. On average, Bank loans are repaid over about 20 years, and the current rate of interest is 8 percent. Table 1 shows how Bank loans are used along with IDA credits, on unusually favorable terms, to help meet the needs of many of the poorest countries.

Aside from borrowings, paid-in capital subscriptions and charges on its loans, the Bank has two other principal sources of funds it can lend. Most important is the flow of repayments on previous loans. These have amounted to $5,316 million. In addition, it often sells portions of its loans to other investors, chiefly commercial banks, and uses these funds to make additional loans. By this means, it has been able to raise $2,500 million.

The Bank earns a profit on its operations, but it has never paid a dividend, since all shareholders agree that earnings should be used to help developing countries. Part of the Bank's net earnings have been placed in reserves which strengthen its ability to borrow and most of which are also available for lending. Beginning in 1964, the balance each year has been given to IDA, increasing its ability to help the poorest countries. These grants to IDA have totaled $705 million, and net earnings applied to reserves have amounted to $1,750 million.

IDA

Unlike the Bank, IDA gets virtually all of its funds in the form of contributions. This makes it possible for the Bank Group to help countries that are too poor to borrow from the Bank at all, and to ease the average terms of lending to others that can afford to borrow only a part of their legitimate needs on conventional terms.

Nearly all IDA "credits," as they are called, have been for a period of 50 years, without interest except for a small charge to cover administrative costs. Repayment of principal does not begin until after 10 years of grace.

The need for lending to many poor countries on much easier terms than the Bank alone could give became apparent during the 1950s. On the initiative of the United States, endorsed by other members of the Bank and by the United National General Assembly, IDA was established in 1960 to help meet this need. It was made an affiliate of the Bank, to be administered in accordance with the Bank's own standards of efficiency.

All members of the Bank are eligible for membership in IDA, and 112 have joined. Nineteen of the wealthier members have contributed 87% of all funds that have been available for the Association's use, or $6,094 million. Out of its net earnings, the Bank has contributed $705 million, or 10%, including $3 million earmarked for agricultural research grants. About $78 million has been contributed or otherwise made available by developing countries.

The annual amount IDA can lend has increased by more than 400% over the last five years. During the period 1964-68, the Association was able to lend an average of only $267 million a year. In fiscal 1973 its credits totaled nearly $1,360 million.

These funds are carefully rationed for use in the poorer countries. There are four main criteria that a country must meet in order to borrow from IDA:

1. It must be very poor. The "poverty ceiling" varies from time to time, depending on circumstances; it is now roughly $375 a year of income per capita.

2. It must have sufficient economic, financial and political stability to warrant long term development lending.

3. It must have an unusually difficult balance of payments problem, and little prospect of earning enough foreign exchange to justify borrowing all it needs on conventional terms.

4. It must have a genuine commitment to development, reflected in its policies.

About 70 countries would now be eligible under the first criterion. They include nearly four fifths of the population of the 96 countries that are current borrowers from the Bank, IDA or both. About 70% of them live in Asia, 24% in Africa, 3% in Europe (Turkey), and 4% in Latin America and the Caribbean area.

Under the second criterion, four of these countries have not been in a position to borrow from either the Bank or IDA. For various reasons related to other criteria, another six have borrowed from the Bank but not from IDA. Twenty five of the poorest have borrowed only from IDA. And a "blend" of Bank loans and IDA credits has been provided to another 35.

To the poorer countries, the importance of IDA as an integral part of the Bank Group can be seen in the record of lending, as shown in Table 1. Without funds on IDA terms, any significant help to the group of 25 very poor countries might well have been impossible. Without the ability to reduce the average debt burden by combining its loans with a rising volume of IDA credits, the Bank could not have increased its own support to the 35 "blend" countries to the degree it has.

Thus the scope and flexibility of Bank Group help to the poorest of the poor depend upon the volume of IDA's resources. This is determined chiefly by the level of contributions agreed to from time to time by the wealthier member countries. The amount from this source is now about $800 million a year.

Operating Methods

Whether large or small, every project financed by the Bank or IDA is considered in the light of the country's total needs, capabilities and policies. This is essential from the point of view of the Bank and IDA, to assure the most efficient use of their own resources. It is even more important to the people of the borrowing country, whose hope for a better standard of life depends upon the efficient mobilization and allocation of all resources available.

The first step in response to each country's request for assistance, therefore, is the conduct of a comprehensive study of its economy. The resulting "country economic report" is used by both the Government and the Bank, and is kept up-to-date. It provides a basis for the Bank's own decisions on both financial and technical assistance. It often serves also as a planning tool for the Government, and as a basic document for the use of other national and international lending agencies.

The report describes and analyzes the entire economy and the country's development policies, organization and principal problems. On the basis of objective analysis, it outlines a general order of development priorities among the various sectors. Whenever necessary, the country study is supplemented by more detailed analyses of individual sectors and relationships between them, which help to throw light on the relative importance of alternative projects in achieving the country's development goals.

Chiefly on the basis of the economic report, and after consultation with the Government, a program of Bank/IDA operations in the country is drawn up for a five-year period. This is reviewed and revised annually. It takes into account the likely availability of other external finance, as well as the country's own resources. The program provides a framework for concrete proposals for action to help the country carry out an agreed strategy of development. Each individual project is then considered within this framework.

There is no "application form" for Bank or IDA financing. Sometimes a formal request is made by letter, perhaps to the President of the Bank. Sometimes Bank staff members or missions identify specific project possibilities, discuss them with the Government and, in some cases, help with the detailed work required to describe and document them. More often, project proposals arise out of the joint efforts of Government and Bank

staff members in their search for solutions to common problems. No matter how a proposal originates, however, the project is subjected to careful analysis, including its environmental aspects, and a detailed agreement is worked out with the borrower before a loan or credit is approved.

Assume, for example, that technical staffs of the Government and the Bank agree that improvements in the road system are a priority need for attainment of the country's development goals. Often in such a case, the Bank will recommend that consulting engineers be hired to draw up detailed plans. After this preparatory work is completed, the Bank will send a staff mission to make a thorough appraisal of all aspects of the project.

When agreement is reached on details of the proposed project and on financing requirements, a formal loan or credit agreement is negotiated. If this is satisfactory, the President presents the proposal to the Executive Directors, who represent all member countries, for their approval.

The approval of a loan does not end the Bank's involvement, nor does the borrower walk away with cash in his pocket. In most cases, the borrower seeks bids, on the basis of international competition, for the goods and services required. The Bank releases money only as needed to meet verified expenditures on the project. Goods and services paid for by Bank loans or IDA credits may be obtained from any member country or Switzerland. The Bank pays in whatever currency is required, and the borrower repays in the currency used by the Bank.

Bank involvement continues throughout the life of the project. The borrower provides periodic progress reports and Bank staff members visit the site from time to time, helping to anticipate and overcome difficulties and to assure that the project's intended benefits to the country are realized. This close supervision is facilitated by the fact that the borrowing country is a part owner of the Bank and shares in the control of its policies and operations. As a cooperative multinational institution, the object of the Bank is to see that each project is carried out at the least possible cost and that it makes its full contribution to the country's development.

Table 2 shows how much has been lent to the current borrowers for different purposes during the last 10 years, and how the emphasis has been changing. Shifts in the geographical distribution of lending are reflected in Table 3 as follows:

Table 3: Bank and IDA lending to current borrowers by region, 1964-73 (US$ millions. Fiscal years.)

	1964-68 Amount	%	1969-73 Amount	%	1973 Amount	%
Eastern Africa	$ 71	7	$ 214	8	$ 342	10
Western Africa	60	6	178	7	177	5
Asia	387	38	866	34	1,292	38
Europe, Middle East, No. Africa	178	18	606	24	913	27
Latin America, Caribbean	310	31	706	27	685	20
Totals	$1,006		$2,570		$3,408	

IFC

The International Finance Corporation (IFC), established in 1956, is the member of the World Bank Group that encourages the growth of productive private enterprise in the developing countries, especially in the industrial sector.

Membership in IFC is open to all governments which are members of the World Bank, on June 30, 1973, the Corporation had 98 member countries.

IFC has total resources of approximately $616 million. That amount is made up of the Corporation's capital of $107 million, subscribed by its member countries, accumulated earnings of some $76 million, ability to borrow up to $428 million from the World Bank and a $5 million loan from the Netherlands. These resources are augmented through repayments on IFC loans, which as of June 30, 1973, totaled $66 million, and sales by IFC of its own investments to other investors.

IFC can offer other resources to local and foreign entrepreneurs, sponsors, technical partners and similar investors associated with its projects. For example, the Corporation has expert knowledge on financial, legal, technical and related aspects of private enterprise in developing countries. IFC can also draw on the World Bank's wide experience, as well as on its own contracts with financial institutions, business concerns, economic development agencies and governmental organizations.

The Corporation encourages private enterprise in the developing countries principally by itself investing in projects that either establish new businesses, or expand, modernize or diversify existing businesses.

Besides making its own investments IFC can recruit capital from other sources, local and foreign, and obtain managerial and technical support for a project.

As of June 30, 1973, IFC had made 285 commitments totaling $848 million to 203 private enterprises, located in 51 developing countries. Other investors had invested approximately $3,372 million in these projects--making a total of over $4,200 million.

In addition to making its own direct investments IFC invests in regional and local development finance companies which, in turn, make smaller investments in the private sector in the developing countries that it is practicable for IFC itself to do.

The World Bank Group and the Environment

As stated earlier, the basic function of the World Bank Group is to prepare and finance projects for economic development in the developing countries of the world.

That purpose is paramount today; it will remain so tomorrow. It is also the policy of the Bank Group that careful and studied attention must be given, in the planning and execution of its development projects, for the consequences to the environment and to the health and welfare of affected peoples.

Though the Bank Group had, prior to 1971, concerned itself with the environmental implications of its developmental activities, no systematic procedure existed to identify and examine those effects. More importantly, methods to prevent or mitigate adverse environmental consequences had not, in all instances, been devised.

Such an unsystematic approach was clearly seen as inadequate in light of scientific data that has come to light in recent years about the specific and collective effects of unplanned development on environmental systems; and, the rapid growth of control technologies.

In late 1970, the post of Environmental Adviser was established and given a strong mandate to review and evaluate every investment project from the standpoint of its potential effects on the environment. That solo post has now grown into an Office of Environmental Affairs which oversees the Bank Group's environmental activities, including especially, ensuring that projects proposed for financing are examined for their ecological, health, and sociocultural effects, and appropriate measures taken to prevent or mitigate seriously adverse consequences.

Important to this task has been the Bank Group's handbook, Environmental, Health, and Human Ecologic Considerations in Economic Development Projects. Prepared for use by its own staff

the handbook has found widespread use throughout the developing world, including government planners, borrowing entities, engineering and construction firms, consultant organizations, universities, etc. As environmental considerations have more and more become a fixed part of Bank Group operations, these guidelines and criteria now cover many different kinds of project possibilities and settings and are used in the evaluation of environmental impacts of virtually all projects.

Experience in environmental evaluations within the Bank Group has given rise to a series of operations which are now being followed for each project believed to have significant environmental/health/human ecologic impacts.

In brief these include:

- In-house study of the proposed project utilizing the Bank Group's technical staff.

- On-site "environmental reconnaissance" to determine likely impact of the project; the problems, if any, likely to result; recommendations for preventing or mitigating such problems; or recommendations for in-depth studies of particular environmental responses.

- In-depth studies are the subject of multi-disciplinary investigations conducted under terms of reference carefully tailored to the conditions and requirements surrounding the particular project, or component thereof.

- Projects of such a nature that their environmental impacts are of unique importance to a regional or global audience, and wherein singularly unique and important environmental values are involved must, of necessity, be the object of comprehensive and detailed studies to determine how or if the project can proceed.

- Projects for which environmental safeguards or controls are to be included are examined during the construction and pre-operation stages to determine their adequacy and sufficiency in light of any changes which may have occurred subsequent to final appraisal.

- Projects in operation are examined periodically to determine the continuing adequacy of environmental safeguards, and the need, if any, for new or improved controls.

- Projects involving important ecological systems are subjected to "environmental post-audits" at appropriate points in their implementation to determine the accuracy of the pre-project impact assessment, and the actual consequences for such systems.

In each and every project subjected to one or more of the steps cited above, the environmental safeguards which may be indicated are the object of cost/benefit analysis. Efforts are continuing to develop a more suitable methodology for identifying and quantifying the diseconomies, social and opportunity costs, and benefits to be anticipated. The difficulties experienced in this regard are many, and are the subject of increased research.

The environmental studies seen as being requisite to financing a project are, in most instances, financed by the borrowing entity, in much the same manner as other aspects of project preparation, such as engineering, geology, marketing, etc. In some cases involving poor countries, the Bank Group may finance the required studies. Increasingly, the borrowing entity is encouraged to make the necessary studies, while the Bank Group reserves the right to approve the terms of reference and the qualifications of those employed in their conduct. The Bank Group does assist, where appropriate, in preparing the terms of reference and in defining the disciplines to be used in the studies. In some instances, the Bank Group will conduct the required studies being financed by the borrower. In any event, findings of environmental studies are shared jointly with the borrower, member country government, and the Bank Group.

Thus, while no formal "impact statement" on the environmental consequences of a development project is strictly required, the Bank Group does require that major adverse effects be avoided or mitigated and as indicated, has established systematic procedures for accomplishing this. To date, all projects requiring safeguard measures have been successfully negotiated with the borrower and member country.

Industrial Projects

The guidelines for industrial projects given in the Bank Group's handbook follow a progesssion of check points designed to accomplish two main purposes: the prevention of deterioration of natural resources so that they can continue to provide the basis for further and sustained economic development; and, the provision of adequate warning of the side effects of project development which may incur costs not identified in ordinary review procedures.

The first purpose, protection of the resource base for future development, aims to identify opportunities in project design which will facilitate the full utilization and renewal of resources where possible or, the conversion of resource sites to alternate subsequent uses where renewal is not possible. The guidelines also seek avoidance of depletion and destruction in the sense of leaving areas with no future uses or in a condition to do harm to other related resources.

The second purpose, to call attention to undesirable side effects, aims to bring external effects or social costs not ordinarily calculated into the overall project evaluation. In this case, the rate of return on the project and the economic return to society may be different so that the total expected costs have to be weighed against total expected benefits.

The objectives require a compilation of information in a frame of reference of sufficient breadth of scope and time to identify the relevant context for project evaluation. Nine different steps are outlined; they serve to link the particular project first to the natural resource origin of the raw material to be handled and finally to its eventual resting place in a disposal area. The steps call attention to the place of the project being appraised in the context of the cycle from extraction to disposition.

A second feature limits the concern of the analyst. In order to incorporate environmental considerations into the concerns of economics, the environment has to be treated as an economic entity. It must be demonstrated to have scarcity, priorities, and alternatives for action. Without an awareness of these three characteristics, environmental evaluation reduces to assertions which cannot be handled through economic analysis. Whether or not these economic characteristics of the environment are quantitatively expressed is not the only issue. Analysis can proceed as long as there is a sense of scarcity, priorities and alternatives.

Environmental considerations have often been excluded from economic analysis because they could not be handled with current analytical tools. The development of necessary concepts is still in the early stages and the criteria articulated here are minimally necessary to proceed.

The state of the art of incorporating environmental criteria is not only complicated by conceptual difficulties, but also by an absence or relative paucity of both the data necessary to assess effects and the dynamic predictive models which employ the data. Thus, the need to make difficult judgments, in order to assess the risk of uncertainty of prediction as well as weigh the costs and benefits. The difficulty is compounded by the fact that many environmental judgments do not have to deal with the imperatives of survival, but with differences in values of substance and timing. Thus, poor men may value jobs more than aesthetics and may be willing to make short term gains now and hope to repair the damage later. The guidelines point the way to making these choices consciously, but they cannot make the choices themselves. They are guides rather than absolute prohibitions or assertions of certain fact.

Environmental Guidelines*

The environmental guidelines for project appraisal include a broad array of concerns designed to assess costs leading to impairment of future productivity of a country's natural resource base and the side effects of investments. As indicated in the nine steps of analysis (presented below) the impact of investments on the human envirionment requires a systematic and integrated view of projects which links them to materials flow within production processes and throughout the economy and society. This widening of the scope of concern is justified because incremental change in particular cases has led to a broader impact.

Proceeding through the nine steps from natural resource linkage to optimization calls attention to the interrelation of choice of process with recycling and reuse potential, of plant location with urbanization issues, of waste management with process design, and other such connections which make the integrated project design sensitive to environmental needs.

There will be considerable variation of opportunity to make an integrated appraisal for there is variation in the degree and timing involvement by the economic development institution. There will be variation in economics, natural conditions, and interests in the issues addressed. Over time, it is increasingly likely that the full range of interests expressed here, and perhaps others, will play a significant role. The following outline of environmentally sensitive target areas in current industrial projects lending is intended to call attention to relevant factors.

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*Excerpts from Chapter 9, Guidelines for Estimating Industrial Environmental Impact of the World Bank 1973 publication Environmental, Health and Human Ecologic Considerations in Economic Development Projects.

PROJECT
DESIGN

ENVIRONMENTAL GUIDELINES

1	2	3	4	5	6	7	8
Natural Resource Linkage	Process	Site Assim. Capacity	Waste Manage-ment	Operations	Social Aspects	Health Aspects	Final Resting Place

DAMAGE ESTIMATES

CARRYING CAPACITY

TIMING

RESPONSE
to
GUIDELINES

COST AVOIDANCE

PRIORITIES

BENEFIT MEASURES

INTEGRATED
PROJECT DESIGN

Figure 1: OPTIMIZATION PROCEDURE

Step 1. Natural Resource Linkage: This step includes environmental considerations from the original extraction of the ore or other resource to the time it enters the projected plant. If the material is an import the linkage may start with its arrival in the country. The natural resources would include (a) all organic material such as liquid, solid, and gas fossil fuels and other organics not used for fuel including crude oil; (b) all inorganic ores leading to the fields of fertilizer, ceramics and cements, and other basic chemicals; (c) all metallic ores whether complex or native metal; and (d) all primary and reusable materials including agricultural and marine products for food and industry.

An example of this linkage can be seen in a decision to fund a naphtha cracker to produce feedstock for polyethylene. The linkage would begin with the drilling of a well or with the arrival of the crude at the seaport, go through the refining process to separate the naphtha fraction by distillation, and then follow on to the actual building of the cracker, the project under consideration. The particular problems to be considered in this linkage would be oil spillage, oil storage and transportation, and the refinery operations. The refinery would produce a range of gases, liquids, and solids, of which the naphtha feedstock would be only a small part. Plans for the full range of waste materials should be formulated at the same time.

Step 2. Process: This step includes the decisions on basic processes to be used in the projected plant, the source(s) of energy for power and heat, and the supply of air and water. The environmental aspects of any projected plant start with the decision to use a particular process. An environmentally sensitive decision includes a consideration of by-products and wastes and their abilities to be either reused or assimilated. The source of energy considers available materials in the area besides the traditional supplies, whether there be waste gases or liquids, or perhaps tree bark or other solids with potential heat content.

Air and water can be thought of as chemical inputs to the system, their purity after use to be considered as carefully as before use. To ensure more complete materials utilization, the raw materials in each step can be chosen from the possibilities in the area including by-products and wastes which might be available but often are excluded by a centralized designing source. The selection of the process or processes can be made from a collection of all these facts.

Copper extraction suggests an example of an environmentally sensitive decision. Although most copper is extracted from its ore by smelting and then electrolytic refining, there are aternatives. Depending on the particular ore to be processed, there are roast and leach techniques or just leaching itself. The leaching approach avoids the formation of sulfur dioxide and instead produces a waste liquor which can regenerate the leaching

solution. This process can provide an alternative to the formation of sulfur dioxide and subsequent production of by-product sulfuric acid by extracting sulfur when this is a more convenient by-product.

A similar line of reasoning can be made for flash smelting. In this process the sulfur dioxide gas will be richer, thus allowing a more profitable operation of a by-product sulfuric acid plant for those cases where there is a sufficient acid market. Oxygen enrichment is another method of increasing the sulfur dioxide content of the off gas and thus increasing the sulfuric acid recovery or allowing the production of liquid sulfur dioxide, another marketable chemical.

The decision to use one process instead of another is made by considering the by-products as well as the product. In this way, economic gains through reuse or resale of these wastes can be made greater and environmental degradation through waste disposal can be minimized.

Step 3. Site Assimilative Capacity: The purpose of this guideline is to analyze and interpret a proposed site's natural resource characteristics for its ability to sustain an industrial project's environmental impact. It is assumed probable industrial project stresses on the biophysical environment (scope of impact) will be delineated during Step 2 project process guideline assessment. Environmental parameters relating to water, land and air should be inventoried and interpreted to identify those implicit and explicit characteristics indicative of project impact/stress on the fragility of the local ecosystem. Direct and indirect effects should be assessed within this guideline framework to ensure least cost in natural resource degradation to the local site as well as direct or indirect effects over time to the regional environment.

Site assimilative capacity should not necessarily be constrained only to the environmental impact of an industrial project. Local and regional natural resource characteristics should be assessed for land use assimilative capacity. Proposed settlement patterns generated by an industrial project should be compatible with the land and its related resource characteristics; e.g., basic infrastructure such as water supply, sewage and solid waste disposal, road layout and design, land stability for housing construction and other land use settlement criteria should be considered as part of the site assimilative capacity guideline.

The choice of site does not only imply constraints, but also opportunities. Through the application of density controls for land use, the costs of abatement technology might be eliminated where the assimilative capacity is not exceeded and standards can be maintained.

A proposed coal mining operation site exemplifies site assimilation guideline application. A major environmental pollution problem is created by acid mine drainage occurring when pyrites--iron sulfides usually found in coal deposits--are exposed to air and water. The pyrites--oxidized to sulfuric acid and ferrous sulfate--leach through natural drainage waters and trickle into streams creating major pollution problems. The sulfuric acid not neutralized by receiving waters destroys vegetation, fish and other water biota rendering streams useless for recreation, water and food supply. Therefore, attention should be given to the hydrographic character of groundwater movements and gradients in the vicinity of operations to determine the natural capacity to neutralize drainage waters. Where site conditions might lead to water pollution, alternative abatement tactics should be considered. The alternatives for coal mining include: (1) closing the mine to oxygen after use by filling with an inert substance such as sand or by sealing, (2) neutralizing the waste liquor after it is formed by means of lime or limestone, (3) treating and recycling the chemicals in the liquor.

Step 4. Waste Management: The most important consideration in waste management is that the alternatives be planned to fit with the process or processes and the site. Emphasis should be placed on use or reuse of the materials whenever possible, and assimilation back to the natural ecosystem as a last resort. In this way treatment is not the complete pollution solution, rather it is a part of the solution in making the material(s) fit for reuse or for assimilation.

Step 5. Operation and Control: The objective of this guideline is to develop and maintain a project administrative framework capable of monitoring a facility within constraints indicated by previous guidelines--especially the performance of process and control devices. As a minimum, staff structuring might include expertise in environmental engineering applicable to the proposed industrial project. Environmental functions include monitoring systems applicable to materials flow from raw material input to final product output to ensure that tolerances are maintained according to design specifications. In-house research and development might be considered to ensure project efficiency and conservation of materials. Data compilation over time can be analyzed to monitor deviation from baseline (starting) conditions and the approaching threat of exceeding thresholds of ecological carrying capacity. An environmental engineering staff can serve in evaluating a change in process technology or industrial project expansion. Where feasible, simulation models can be developed and projected effects analyzed for project efficiency and environmental impact. Project quality control criteria could then include an active assessment of accumulative effects of waste streams.

Step 6. Social Aspects: This step previews social implications for the environment generated by industrial project investments. Social aspects, especially of those industrial projects employing a large labor force, influence in-migration of populations thus affecting land use patterns.

Locational requirements attendant to the in-migration of a labor force and its families' impact on land use patterns should be evaluated in the light of available food, water, shelter and accessible transportation systems, based on localized institutions, mores and customs. Medical and other public services should be available or accessible.

The social implications of product output consider effects on local land use patterns, e.g., cement manufacturing's effect on localized construction or a fertilizer plant's influence on agricultural techniques and the attendant changes in social, economic and land use structures. The guideline can consider such broad issues as the desirability of labor intensive technologies to aid in fulfilling employment and income distribution goals. Consideration might also be given to the impact of population movements on rural life.

Guideline assessments should generally preview the land and its related resources, identifying the ability of the area to sustain development pressures generated by habitation patterns characteristic of local cultural preferences. Attention to these potential problems can lead to desirable social cohesion and minimal social disruption. The effects on the push-pull of urban-rural migrations need attention, for the instabilities of urban life can be aggravated by adding industries to cities where the fixed capital of the infrastructure cannot effectively handle increased population loads and the tax base can tolerate little or no expansion.

Cost calculations of social aspects might include many different aspects: some quantitative, such as the cost of the provision of adequate worker housing; some qualitative, such as cultural change induced by relocating families or social tensions induced by crowded conditions. The assessment of social costs is not a simple engineering assessment and needs to be done in the light of broader qualitative criteria than are traditionally considered in project appraisal. This broadening of the definition of environmental assessment leads to linking project design with overall economic development goals and may or may not be done at the project level. However, specific project design in terms of location and physical layout can be affected by the more qualitative judgments, and attention would be usefully paid to dealing with the social issues somewhere in the appraisal effort.

Step 7. Health Aspects: This step calls attention to the need to monitor and consider maintaining the health and welfare of project employees and local and regional populations adjacent

to the project facility. In-house safety procedures can be designed through employee education and clear and concise management policy statements pertaining to operations. Job specifications can be communicated to ensure efficiency and safety operations. Product safety hazards, implicit and explicit, should be clearly defined for consumer protection, notably in export industries to countries with high environmental standards. Attention needs to be paid where chemicals, petro-chemicals, fertilizers and other products for consumer use with possible cumulative concentrations have effects on human health and welfare. Pollution vectors--water, land and air transport--should be closed or minimized where local and regional health is affected by the transport of disease.

Public health standards should be set and maintained through regional or local institutions based upon ecological, economic and human susceptibility criteria. Water quality, ambient air, sewage and other waste water, land use and other standards as they relate to human health, can be implemented with appropriate flexibility to prevent environmental conditions capable of sustaining the growth and cumulative concentrations of germs, viruses, particulate matter, toxic chemical emissions, haphazard land disposal of toxic wastes, etc. For instance, air quality criteria are affected where meterorological conditions are conducive to inversions, such as in river valleys which trap emissions with probable effects on human health and welfare; e.g., increased prevalence of chronic bronchitis and emphysema in adults, diminished pulmonary function, increased frequency of common colds and minor respiratory ailments.

An attempt to quantify health aspects which simply assesses the economics of worker-days lost through absenteeism, or the costs of medical clinics to provide cures would miss the most important cost of human discomfort. An assessment of this cost would have to be traded off against the illnesses associated with non-productive economies having poor levels of health due to poverty. The net cost calculated on this basis would then be more inclusive, even though it was not associated with dollar value.

Step 8. Final Resting Place: This step is considered in the overall evaluation in a manner similar to the natural resource linkage, in order to complete the natural cycles. Everything ends up someplace, there is no such thing as ultimate disposal. The step can be as complicated as a mercury flow chart locating every gram of the metal, or it can be as general as a paper discussion showing the amount to be recycled into pulp, the amount to be saved, and the amount to be dumped. The step must be included, however, for every disposal technique has a cost associated with it. In some cases, the cost may be high because it is a non-degradable substance, or because it has an intermediary or final product which is toxic. All these costs require evaluation.

A plant producing poly vinyl chloride can serve as an example. This is a non-biodegradable material which is resistant to compaction and large amounts could not be handled in sanitary land fills or compost heaps. Alternative means of disposal such as salvage or high temperature incineration would have to be considered. Not only do the solid, liquid and gaseous wastes from the project itself have to be considered, but the costs of disposal of the product after use should be included. In the case of poly vinyl chloride, it may necessitate a higher-priced method of disposal.

It is not possible to identify the range of dollar costs precisely because the cost of collection, the cost of the land for disposal and the capacity to recover valuables from generalized waste varies considerably according to the character of materials in an economy.

Step 9. Optimization: The analysis of costs of the various alternatives for protecting environmental values and for protecting natural resources will have to augment traditional costing procedures in order to accomplish overall optimum project design. The previous eight steps have called attention to information requirements which are reviewed in the last step. Choices of industrial processes or choices of techniques for mining and harvesting forest products will all be associated with different costs. There will be considerable variation from project to project in terms of amounts and kinds of costs, and the aim in this guideline is to establish concepts which guide the judgments to be rendered. Environmental cost analysis can be conceived as having two parts. The first deals with who bears the costs and the second deals with determining amounts of costs.

There is already a body of literature on who bears the costs and economists have made a convenient distinction between those internal costs borne by the firm, which may affect the financial rate of return, and those external costs absorbed by the society, which may affect the economic rate of return. Guidelines cannot determine who will bear the costs, for proper assignation of costs is dependent on circumstances which vary from society to society. However, the guidelines do need to consciously examine total costs to avoid overlooking the full range of requirements for project design and evaluation.

It would require a substantial theoretical treatment to examine the alternative modes of assessing costs, for environmental costing techniques are not as well developed as other economic guidelines. However, as a general rule, the information gathered in the first eight steps should suffice to bring to mind such factors as public health effects. For example, some of the costs of air pollution from sulfur dioxide levels which exceed the threshold of human tolerances can be noted in terms of man days lost from work as well as public health facilities to effect cures, as well as the qualitative judgment of the tolerability of respiratory illness.

For another example, the costs of river pollution, may be the cost of a water treatment plant downstream to render water potable, or the opportunity cost of using the ecological carrying capacity of the river for a more productive enterprise, or for public recreation, or for tourism or fishing. For another example, forest management techniques used in a pulp mill project might result in erosion and can severely limit the life of a downstream dam through siltation, causing earlier amortization than projected. Erosion can also deny a second use of the land such as agriculture or can deny possible multiple uses of the land which could help degray overhead costs. Forestry cutting procedures create opportunity costs in terms of later benefits to be derived such as satisfying a projected demand for construction materials for public housing.

In each case the costs can be identified from calling attention to the information from the guidelines. Whether these costs are borne by the project or by the society is a matter for discussion and negotiation in each case. It may often be the case that the social benefits from a project will outweigh the social costs so that the net judgment for the project is positive and the assignation of the costs is accepted by the society. Historically, this has often been true, but recent changes in public values and strategies of economic development require a reassessment of the position.

A framework for determining costs will evolve from experience. Before the environment can be handled by the tools of economists, it must at least have the characteristics of scarcity, priorities, and alternatives. The guidelines have been designed to satisfy these needs with information bearing on each. Scarcity arises from the fact that environmental assets such as clean water and air, have a limited capacity to absorb materials before they change state. The change of state may be through destruction of water bodies due to excessive nutrients which support plant life in water. The cost may be aesthetic, such as the loss of a lake, or it can be directly economic for such water chokes intake filters and cooling mechanisms of machinery. The change of state is due to the scarcity of carrying capacity for pollutants which represent materials outside of natural cyclical patterns. Such scarcity is the reason why the guidelines have called attention to monitoring and standard setting in order to know how much room for assimilation of materials is left before adverse changes of state must be borne. This scarcity of assimilative or carrying capacity also has led to emphasis on recycling and efficient use of natural resources in Steps 1, 2, 3 and 8.

Nature is constantly changing state, with or without the intervention of man, but industrial activity can hasten these changes and can send them in unfavorable directions with resulting counterproductive costs. That is why priorities need to be established. Whether or not changes of natural state are tolerable depends on priorities in economic development strategy.

Global survival may take first place and environmental damage which threatens man as a species would therefore be intolerable. However, the evidence that survival is at stake needs further development and anything less than that is a relative matter subject to ordering of priorities. Thus, whether or not developing countries want to repeat the public health costs borne by the developed countries is a matter of priorities and trade offs. The guidelines will indicate what the costs are, but how they are weighed is a relative matter. Economic development includes a mixed set of goals and the values of the environment impinge on many of them.

In the sense that other non-economic decisions are taken as parameters by growth economists, the environment is no different than employment goals, or income distribution goals, or political stability. The qualitative mix of economic development priorities will just include one more element. This element will have to seek its place in the priority schemes of planners, for allocating assets for the future is their task.

To help determine the place of the priorities for environmental and resource protection, alternative solutions have to be sought. One of the major alternatives which may be open to project designers is time. One can mortgage the environmental future by destroying now and hoping it possible to clean up later. This argument will have much currency in that it is the path which developed countries have taken. However, cost analysis will have to include some assessment of how much time is available before diseconomies set in and how much the cost of reversibility will be. In some cases reversibility will be so costly, or biologically impossible, that there will be no choice. The guidelines for site assimilative capacity in Step 3 include information on threshold values and the possibility of reversibility.

There are other alternatives besides time. Process selection as indicated in Step 2 is specifically designed to evaluate alternative methods of achieving the economic goals without incurring costs which must be paid, now or in the future. There are different techniques for foresting on slopes which will forestall erosion and avoid costs. Once again, however, whether or not the costs are deemed to be serious or are outweighed by the benefits, as indicated in pricing mechanisms is a matter of relative priorities.

Some Case Studies

For illustrative purposes extracts of five selected case histories are presented below. These project cases are drawn from the period during which the Bank Group has made special efforts to enlarge its project analysis; that is, early 1971 to the present.

Case Study No. 1: Iron Ore Project

The project provided for the exploitation of large quantities of high grade iron ore, and its rail transportation from the country's interior to a marine terminal to be constructed on an island located within the boundaries of a largely unspoiled estuary. At the terminal site in the bay, large (300,000 - 500,000 tons) combination oil/ore boats would load the ore for distant world markets.

The Bank's announced policy to pursue economic development with studied regard for environmental quality was put to a test by this large project which presented a number of apparent potential environmental problems. Expressions of concern were also received in letters addressed to the Bank from individuals who conceived of potential impairment of their respective interests. The bay's aesthetic beauty and recreational opportunities caused the population to swell from about 3000 permanent residents to some 15,000 during the summer months. It also supported an important shellfish and fin fish industry. The apparent threats therefore called for an immediate on-site study and the Bank Group accordingly dispatched a multi-disciplined team of consultants (marine biologist, fisheries and shellfish expert, and oceanographer/marine ecologist) to identify likely problems and recommend measures for their solutions.

The studies revealed inter alia a poor circulation pattern around the island that would prohibit efficient dispersal of any future waterborne waste emanating from the ore terminal. The extensive biological sampling program carried out throughout the bay established the major biotic communities as benchmarks against which any future changes may be related.

The tourism potential of the area was evaluated, as was the environmental impact at the mine site, along the rail transportation route, the rail trestle crossing the bay to the island, and the terminal site on the island proper.

The plans for the island terminal, as approved, involved construction of the railway access bridge, conveyor trestle and pier, ferry and tug dock, dredging, water and electrical systems and facilities to handle oil slops. The national law provided stiff penalities for dumping slops into coastal waters but protection for the bay in this regard was weak. The Borrower therefore agreed to prepare plans for dealing with slops at the terminal, for disposal of solid waste and sewage originating at the terminal and transferred from ships using the terminal, and to develop contingency plans and maintain standby equipment to minimize the effect of accidental spills at, or in the vicinity of, the terminal.

Standards for air and water pollution and details of the port regulations issued by the Borrower to govern ships using the terminal facility were determined on the merits and needs of the case at higher levels than existing local regulations would demand.

It was agreed that the Borrower would take all steps to preserve the ecological integrity of the part of the island not being used for the marine terminal and would preserve in its entirety a smaller island located between the terminal site and the mainland, and would terrace, landscape and otherwise provide for the visual amenities at the terminal site, prohibit the erection of advertising billboard signs on the island or adjacent mainland, and arrange for continuing studies of the impact of the project on the environment. Blending colors would be used for painting of facilities, and the trestle designed to serve as a catwalk for fishermen and tourists.

At the mine, conventional open-pit mining methods were already in use for ore extraction. Practices there demonstrated the Borrower's own interest in environmental protection. The new ore preparation plant would consist of primary crushing, screening, secondary crushing, final screening and washing, and hydraulic classification facilities. Drills for blasting will be equipped with dust collectors. Dust on haul roads will be minimized by sprinkling. The crushing plant will be equipped with dust collectors connected to hoods at the feeder and crusher. Water sprays will be used to control dust on open piles of ore stored after crushing, and tailings of a slurry of fine hematite sand and slime from the processing will be thickened by passing through a cyclone, and the reclaimed water will be returned to the process plant. The final slurry and natural runoff will be stored in a pond formed by an earthen dam in a valley behind the plant. Pond water also will be recycled to the plant after treatment with a synthetic polyelectrolyte flocculant to clarify the water.

Erosion in the mining and processing areas is to be minimized by various means including lined ditches at the top levels to carry off water. Reforestation will be applied to control erosion at the mining site and to minimize the visual impact of land stripping. Sanitary wastes from the facilities will be treated in an aerated sewage treatment plant.

Only limited solutions were found for the problems of safety, noise and dust on the rail line for transport of ore to the terminal. Heavily loaded ore trains will move frequently and the rail line will pass through several populated areas.

The joint effort by the Bank Group and Borrower looking to the conservation of the ambient region of the terminal for the future set an example in applied environmental policy and provided a practical demonstration of the relatively low cost, about

1.5 percent of total project cost, and slight delay involved in devising measures to avoid or minimize pollution and landscape defacement. The foreign exchange component financed by the Bank, $96 million, constituted 34 percent of the total project cost.

The values of prevention were in this case very large for the community and the nation because of aesthetic worth and because of avoidance of losses that would be critical for the smaller industries of tourism and the significant shell and fin fishery. Protection also was afforded for an estuarine nursery ground for important coastal fish stocks. The eventual fate of the estuary is uncertain for the long-term in view of other planned and potential industrial activites. Another industrial project on the bay, however, which has been financed in part by the International Finance Corporation (IFC) has received similar treatment to protect the local environment and offered an opportunity to reinforce the Bank Group's views of the need for long-term, integrated environmental planning.

Case Study No. 2: Mining and Infrastructure Project

The project, located in a country which became independent in the 1960s and is at the bare beginning of industrial development, comprises an open-pit mine for extraction of copper and nickel, a smelter, coal-fueled steam power plant, 40 miles of rail and road connections, and a new township. The township is to include buildings for public administration, health care and four schools, housing suitable to the cultural requirements of the 2000 employees, water supply, and sanitary waste disposal.

Several international agencies participated in this project in which the Bank financed $37.5 million out of a total capital cost of $185.5 million. The Borrower was the national government.

Under the terms of the loan agreement with the World Bank Group, the Government agreed to take all action, including enactment of legislation and regulations, to ensure that the operation of the mining project and infrastructure would be conducted with due regard to public health and the natural ecosystem. The government will cause the mining company to comply with the laws and regulations and will consult with the Bank Group before making any changes in them. The government also will act to control pollution in the construction stages and ongoing life of the project. To assist in fulfilling these requirements, the Bank Group provided an expert environmental consultant. Consultants also were engaged directly by the government and by the mining company.

The principal environmental hazards are atmospheric pollution caused by sulfur content in gaseous emissions from the power and smelter operations, and water pollution from the mining operation.

The distance between the smelter and power station and the future town is two miles, probably not sufficient for full protection from occasional exposure to exhaust gases and dust, although the prevailing winds were taken into consideration when determining the township location. The government recognized the need to examine the potential effect of gases and dust on the health of the human and animal population, fauna and vegetation of the area, and engaged a consultant through the British Ministry of Overseas Development, to investigate and report measures necessary to keep all aspects of pollution from the mining plant and power station to acceptable levels.

The principle protective measures against SO_2 atmospheric pollution focused on the height of the smelter and power station stacks which, it was determined, should be 525 and 250 feet respectively. The government is establishing a system for monitoring ground level SO_2 concentration and has the responsibility for taking necessary action if it exceeds acceptable limits. Enforcement will entail reduction or shutdown of mine operations until acceptable air quality is restored. Laboratory equipment has been acquired and a training program instituted.

The mining company will provide for treatment of liquid waste effluents from ore reduction so as to prevent discharge into nearby surface waters and injury to downstream users. Effluents will be conducted to a tailings dam where suspended materials will settle. Further treatment may be instituted as required. The company also is responsible for occupational health and safety measures including dust control at the mining faces, safety equipment and training, and periodic physical examination of miners.

Most of the solid wastes of the mining operation will be returned to the cavities left, in a rotating excavation and filling process. Wastes to be incinerated will have proper fly ash and particulate controls.

The project provides an example of international collaboration in aid to an incipient industrial development in a remote and inexperienced country. It involves the issue of environmental protection in all its broad aspects including basic legislation, regulatory and monitoring systems, care for preservation of the natural ecosystem, health and socio-cultural considerations from the long-term point of view, in addition to the immediate concerns regarding industrial pollution of air, soil and water.

The best of planning by the most farsighted experts, however, does not always keep ahead of the human factor. This project overlooked the overnight appearance of a squatter town, which sprang up with great suddenness in anticipation of project opportunities. Unplanned, unforeseen, patched together from mud, matting, cardboard, corrugated sheeting or almost any waste or salvage material, totally without water and sewage services, as

picturesque as they are squalid and unwholesome, such "towns" are inhabited by the people who come to seek work, accompanied by wives, children and camp followers. The one embarrassing this project's wholesome new town project was no exception to any of these characteristics.

The government acted quickly to promote order in this case by appointing headmen to supervise and guide the squatters. The government proposes establishing a site and service area near the coal mine and encouraging the migrants to move there. Such a service area was in fact originally recommended in the consultants' Township Report as a means of avoiding slum developments on the fringes of the new township, but planning and costing were not carried out. The cost of taking up the recommendation at this later stage was about US$50,000. The total additional project costs resulting from environmental/health considerations was estimated at approximately $1.6 million.

The case study illustrates what is found to be true generally, i.e. that even with the addition of overlooked and unforeseen items, the costs of building environmental protection into industrial development, including consultant service, changes from proposed to alternative choices of site, purchase and installation of special equipment, and training programs, are monetarily small in comparison with the overall investment. They are beyond that, much smaller still in comparison with the probable magnitude and scope of the unquantifiable values attained in terms of the physical and social health of nations and conservation of the health of the biosphere.

Case Study No. 3: Expansion of Steel Production

The project entailed the expansion of production facilities at a large plant located in a semi-arid, relatively isolated region adjacent to the Black Sea. At the end of the project in 1976 the manufacturing facilities will have doubled and will produce 900,000 tons of flat products, 300,000 tons of billets, 60,000 tons of ingots, and 180,000 tons of pig iron.

The loan requested from the World Bank Group was US$76 million, and the cost estimates for recommended pollution control equipment were $5 million, or 1.72 percent of total project cost.

The project includes a second blast furnace, a third oxygen vessel, a billet caster and a semi-continuous hot strip mill, an expanded cold reduction mill, and added auxiliary equipment. Each of the separate plants has specific environmental impact and pollution potential associated with it.

A first review showed that little or no provision had been made for control of the liquid and gaseous effluents which would be released into the environment in relatively large quantities. Of particular concern was the possible effect of air pollution on

public health and on livestock and vegetation in and around the project site. Further, the liquid wastes containing toxic ingredients were to be released directly into the off-shore waters of a sea shared with neighboring countries. This important body of water is now showing signs of heavy pollution and the United Nations Food and Agriculture Organization (FAO) has called attention to its seriously deteriorating condition.

Ecology in the country concerned is a new or unaccustomed subject to many, but both the government and the private interest were responsive to environmental recommendations from the World Bank. In close cooperation with them, an on-site ecological study was made by expert industrial pollution control consultants engaged by the Bank who recommended appropriate control technology. During discussions held with various Mnistries involved, the interest of the national govenment was stimulated to the extent that a scientific and research center of the country was directed to determine the air, water and noise pollution of the entire plant and establish the minimum requirements for control. The government is expected to follow the present international trend of progressively widening the scope of its environmental controls.

The specific recommendations for this project were based on the consideration that within the useful lifetime of the facilities to be constructed, it will be necessary to establish standards on the basis of available technology while the selection of treatment processes and the layout and installation of major production facilities should be compatible with additions which may be required in future to meet more stringent limitations on effluents.

Air pollution effects observed by the consultants were mainly aesthetic, consisting of visible smoke and dust emissions, sufficient, however, to require corrective action. This will include automatic equipment to contain gaseous emissions and stacks of adequate height. Smoke, gas and dust emission at the coke plant will be reduced through the use of design improvements such as self-sealing doors, quenching tower baffles, improved charging system, aspirators and smoke seal boxes.

The Company has agreed to present a specific plan acceptable to the Government and the Bank Group for dealing with air and water pollution, and to implement the specific plan to be followed will be based on the recommendations of the professional ecologists previously hired by the Bank.

Case Study No 4: Integrated Pulp and Paper Mill

The International Finance Corporation (IFC) has assisted the financing of an integrated pulp and paper mill in a sub-tropical location.

The environmental considerations have been the subject of concern and intensive studies on the part of the national government, company management, IFC, and the Bank Group's Office of Environmental Affairs. The mill effluents flow into a river which is the source of an important local commercial fishery and flows eventually into an important international body of water. About 30,000 people are dependent on the main river below the mill site.

On the basis of an ecological survey of the area done in 1971 by UNESCO, the national government established detailed standards for the mill's liquid effluent. The plant's waste treatment system was designed to meet those standards. Process water from the mill will be collected and discharged to a clarifier followed by aerated lagoons for BOD removal. Sewage will be treated in a separate oxydation pond. The final effluent will be discharged via a diffusion pipe into the river.

If the river flow in the dry season should not prove sufficient to ensure adequate dilution of the mill waste, possible oxygen depletion below levels required for aquatic life could cause problems. The UNESCO report, however, shows river flows even during the dry seasons to be sufficient to ensure adequate dilution of waste treatment plant effluents.

Odors emanating from pulp mills are obnoxious but maximum ground level concentrations were not expected to cause problems.

Despite the treatment to be given the effluent of this plant at an estimated cost of $1.8 million, or 3% of total capital project cost, the remaining effluvia, when combined with those from other sources existing and planned, can be expected to have unfavorable effects on the river biota and water quality.

The Bank Group has held meetings with the national government and the company to impress upon them the importance of this possibility and the government and the company have agreed to undertake monitoring of the environmental and human parameters likely to be affected, with a view to taking additional appropriate action should any problems arise. The Bank Group also has reminded the government and management of the importance of training. In this case special importance attaches to training personnel to manage the treatment and discharge facilities, including monitoring and the responsible authorities have also been reminded that training should include making this personnel aware of the great responsibility they have for protecting the river's biota and the many downstream users from the effects of pollution.

Case Study No. 5: Expansion of Metal Production

A 1973 plan for expanding existing copper mining operations entails an investment of US$644 million and will produce 186,000

tons of mineral annually. Part of the financing (about 2%), was sought from the International Finance Corporation (IFC). The project involves a new open-pit mine, new concentrator, and expansion of smelting and supplementary infrastructure facilities.

The location is a sparsely inhabited, arid plateau near the Pacific seacoast. The expansion would cause effluents and emissions created by mining and smelting operations now in existence at the same location to be doubled in volume: 30 million tons of tailings would be discharged and 600,000 tons of sulfur oxides would be released annually. Productive agriculture in neighboring coastal valleys, offshore fishery, and public health in a port city of 15,000 inhabitants would be endangered by air and water pollution from the project, in the absence of protective measures.

The disposal of concentrator tailings is by gravity directly into the ocean using a series of dry canyons where there is very little rainfall. Sewage from the mine and concentrator infrastructure is turned into the tailings. The disposal of tailings occurs in part in a valley where one of the few rivers on that coast having a flow of fresh water throughout the year has its course. The large amounts of SO_2 emissions, much of which also eventually end in the ocean, may have possible transnational effects.

The project is one of exceptional significance because of the environmental concern, especially in contrast with practices formerly traditional in the region, which has yielded minerals for world industry in quantity over a long period of time. Disregard of environmental effects was the practice in the past. The environmental factor has now been incorporated in planning on advice of the World Bank Group and demand from other sectors of the national economy. (The Borrower is a consortium of U.S. private corporations licensed by the national government. Proposals have been made fur further internationalization by arranging for investment in the equity by European and Japanese corporations which have a trade interest.)

An industrial/environmental pollution control expert employed by the Bank Group in his assessment also stressed the economic and social benefits that the proposed expansion of mining operations could be expected to contribute to the national economy as adequately balancing the possible adverse environmental/health effects. Based in part on the consultants ecological reconnaissance, the Bank Group's Office of Environmental Affairs and the International Finance Corporation (IFC) recommended that more extensive air quality and tailing disposal impact studies must be a prerequisite for World Bank Group participation.

No alternatives were found by the Borrower to disposing of tailings in the sea; and, fisheries apparently have not been

adversely affected thus far. An agreement was reached between the World Bank Group and the Borrower, however, which provides for IFC financing on the conditon that the Borrower will implement environmental controls as recommended after further extensive, in-depth studies by qualified consultants acceptable both to the IFC and the Borrower. The scope of the studies has been outlined in detail and additional assistance has been offered through the World Bank Group.

The Borrower will install and maintain a telemetric system of air quality monitors to record on a determined periodicity the SO_2 and SO_3 and other air components as indicated by the consultants. The data will be made available to the IFC and the national government. The air quality monitoring system will be used to alert plant officials when pollutant levels can be expected to have adverse effects on public health and other interests. Plant operations will be reduced or suspended until the quality of the air is restored to acceptable condition. If the cumulative record of data indicates that it is necessary, the Borrower in consultation with the IFC will take further steps required to control emissions.

Studies also will be made without delay of the distribution, dispersal and ultimate disposition of tailings entering the sea, taking into account surface and subsurface currents, tidal and wave action, chemical and physical interactions of the tailing particles with the water and bottom sediments and other factors. The exploration will include changes and potential benefits likely to result from alternative deep water disposal below the euphotic zone of significant trophic activity. Studies will be made of the effects of tailings on the marine biota, including the effects of untreated sewage carried with the tailings.

The Borrower presently is in compliance with national and local legislation regarding effluent standards and conditions for disposal of tailings and will continue to comply should they be made more stringent. The detailed and extensive agreements made with the Borrower regarding its operations and their environmental aspects is illustrative of the Bank Group's attitude and efforts in these matters. Its contribution to the total cost of project expansion is indeed very small, but among the consortium of private corporations involved the Bank Group alone has insisted on an environmental assessment. Whether or not, and to what extent, such pollution control measures should be taken is quite uncertain, but an agreement with the Borrower to undertake in-depth studies and later adapt to recommendations resulting therefrom seems entirely appropriate and represents a significant departure from past practices.

The case studies summaries as presented illustrate and indicate some of the accomplishments and difficulties encountered during the Bank Group's first years of experience and adaptation to the desired goal of continued economic development which is

environmentally sound as well. Exact data on environmental expenditures are not easily furnished for several reasons.

Environmental measures are often productive, and it is questionable whether a project's environmental dimension gainfully should be separated out. Project components are all intimately related, as is the project itself to other projects, the external environment and the society at large. The Bank Group operates under a broad definition of what is environmental, and seeks to incorporate a project's internal environment and its public health and socio-cultural aspects in its evaluations. This mode of operation calls for improvement of human ecologic conditions frequently not conceived of as environmental, while at the same time attempting to circumvent or mitigate errors made through development on the patterns of the past. The idea that well defined anti-pollution measures are to be added to a project as a cost is not seen as expecially productive or desirable. Frequently this is still the only solution available for industry, but often, and more so in the future, pollution is, and will be, overcome through redesign, recirculation, product changes, etc.; a style of planning and production in which steps taken specifically for reasons of environmental protection will be indistinguishable from, and will be a true part of the entire process. The Bank Group, furthermore, does not ordinarily separate out environmental expenditures as such on projects it finances; it frequently pays for part of studies undertaken and subsequently finances the foreign exchange component of a project, or parts thereof, alone or in cooperation with others. In other instances environmental expenditures relating to a project are financed from other sources entirely. At the time of project appraisal only estimates are made of expenditures to be incurred regarding resettlement, cost of land at new locations, training, occupational health measures, medical facilities, water supply and sewerage, landscaping, studies on how best to minimize industrial pollution, and subsequent cost of treatment facilities and final disposal. Additional money may in time be transferred for these and related environmental purposes or vice versa, depending on progress made toward project realization.

All projects are years in the making and none have yet been completed. In the case of the copper mining project [where] an estimated $500,000 will be spent on initial studies of potential impact on Pacific coastal waters and biota. The eventual expenditures which in the future may be incurred for pollution control are presently unknown altogether and may range from insignificant to a very substantial amount.

"The Role of Technological Development in Promoting Disease in Africa"[a]

by

Charles C. Hughes and John M. Hunter

For most countries of the world, this is an "age of development," of planned endeavors to intervene into the status quo ante with the purpose of initiating change, both economic and social. But developmental activities often produce unexpected and sometimes vitiating consequences. The very nature of change itself (being an intervention in the physical and human environment) is predispositional to disease, although not necessarily causative of it, because it disrupts established ecologic patterns at many levels of interrelationship. This idea can be extensively corroborated in contemporary Africa.

Field evidence relating to malnutrition and three selected infectious diseases (viz. sleeping sickness, bilharziasis and malaria) is reviewed. In each case, the evidence is replete with examples of development interventions that inadvertently increase disease hazards. In regard to the infectious diseases, examples of such evidence are: (1) increased incidence of trypanosomiasis (sleeping sickness) along new road networks in Liberia and Nigeria; the cycling of trypanosomes by migrant labor between Ghana and the Upper Volta Republic; and an outbreak of trypanosomiasis near the man-made Lake Kariba; (2) increased incidence of bilharziasis (schistosomiasis), especially the more serious intestinal form, Schistosoma mansoni, around irrigation schemes, with examples ranging from the Gezira cotton scheme in Sudan to sugar schemes in Nigeria and Tanzania, and tobacco farms in Rhodesia, with the dangers of further spread of the disease through presently planned agricultural schemes; and (3) an increasingly complex epidemiology of malaria in which, as a result of development activities and the emergence of insecticide-resistant vectors, sociocultural factors are playing a more involved role.

[a]The Careless Technology: Ecology and International Development. Edited by M. Taghi Farvar and John P. Milton, Natural History Press, Garden City, New York, 1972. This paper draws heavily from another discussion of this topic, including the psychosocial consequences of modernization. See References for Hughes and Hunter.

Ironically, nutritional deficiencies and diseases often accompany substantial regional agricultural development. The transition to a cash-crop economy (e.g., cocoa, rubber, cotton, groundnuts, coffee) in many cases had led to the neglect of food farming and the declining use of protein-rich sorghums and similar nutrients. Purchased foodstuffs such as protein-poor cassava, yam or plantain have become food staples, causing rural malnutrition.

Africa's burgeoning towns are both a vehicle for, and a product of, development activities. And, as has been the case everywhere else in human history, the towns are also very effective as disease-fostering environments. Despite the provision of certain amenities, such as clinics, urban health standards are often lower than rural standards. For one thing, gross overcrowding and lack of sanitation cause deterioration in health status, and infectious diseases, such as tuberculosis and infant gastroenteritis, are rampant in towns. With regard to nutrition, the overwhelming impact of urbanization has been negative. Nutritional standards among urban migrants are unsatisfactory for a variety of reasons explained in this paper. Children are particularly prone to nutritional problems. It is well known, for example, that protein deficiency in early childhood (kwashiorkor) can cause irreversible intellectual impairment. Furthermore, for each case of kwashiorkor in African towns, diagnosed or not, there are countless other cases of subclinical malnutrition in which health deterioration is insidious and persistent.

The conclusion seems obvious, but inescapable. Because development activities have not been coordinated within a comprehensive ecologic framework, there has been a drastic deterioration in the social and economic conditions of life.

Our purpose in this paper is to focus on some of the disease consequences of technological development activities in Africa. This discussion will underscore the need to emphasize an ecologic frame of reference in research and planning.

Development programs, being an intervention into the affairs of nature, will have both intended and unintended consequences; that is to say, they enter the scene as elements in the ecologic dialectic in which all life is enmeshed, and they must be examined as such. In his Man Adapting, Rene Dubos has in a sense expressed the basic philosophy of this paper:

"All technological innovations, whether concerned with industrial, agricultural, or medical practices, are bound to upset the balance of nature. In fact, to master nature is synonymous with disturbing the natural order. While it is desirable in principle to maintain the balance of nature, it is not easy to define the operational meaning of this idea. Nature is never in a static equilibrium because the interrelationships between its physical and biological components are endlessly changing. Furthermore, man placed himself apart from the rest of nature when

he began to farm the land and even more when he became urbanized. The survival, let alone growth, of his complex societies, implies that he will continue to exploit and therefore upset nature. The real problem, therefore, is not how to maintain the balance of nature, but rather how to change it in such a manner that the overall result is favorable for the human species." (1965, p. 416)

Dubos is, of course, echoing Hippocrates' ancient observation that change itself, creating the necessity for readaptation to a complex of conditions, is predispositional to disease although not necessarily causative of it.

It is changes that are chiefly responsible for diseases, especially the greatest changes, the violent alterations both in the seasons and other things. But seasons which come on gradually are the safest, as are gradual changes of regimen and temperature, and gradual changes from one period of life to another. (Dubos, 1959, p. 116)

In this connection, let us note some of the associated alterations in life conditions affecting man-environmental relationships which, while they may not in all cases be part of the explicit goal of any given development scheme, are nevertheless involved in the course of the implementation of the scheme. Aside from major purposes abstractly stated (e.g., "to raise agricultural productivity"), what other kinds of changes which have obvious relevance to the health status of the population often come about under the aegis of "development"?

(1) overall changes in man-habitat relationships (e.g., working in a new farmland or under other new geographical and geozoological conditions; relocation to different climatic and zoonotic areas)

(2) increased population movement, mixing, and concentration (e.g., building roads, railways, and other transportation networks; migration to towns and sites of economic opportunity such as mines, factories, hydroelectric or irrigation projects; relocation of communities, etc.)

(3) change of patterns of water flow and use (e.g., building irrigation schemes, dams and ponds; use of polluted water resources in undersanitized and overcrowded towns)

(4) change of vegetation cover (e.g., cutting down forest or bush, altering ground cover; denudation of landscape)

(5) changes in micro-environmental conditions (e.g., changes in housing, neighborhood, and settlement patterns; in house style and construction materials; in location with respect to modes of transportation, sources of water, kinsmen, etc.)

(6) changes in value systems and social sanction systems (e.g., conjunction of alternative ways of life in urban environments or socially heterogeneous populations, as in large-scale economic schemes; the erosion of traditional systems in conditions of economic deprivation, as in urban slums, etc.).

This listing of what might be called the "hidden costs" of development is clearly incomplete at this state and unquestionably could be expanded with additional comprehensive data on change projects. But let us review the extent to which a change in disease patterns has ensued from such changes in ecological situation as those suggested above. While the following selected illustrations make the point that frequently such consequent relationships do exist with some of the major pathological conditions in Africa, it should be clear that systematic epidemiological data are rare, and the data that do exist for regions or for the continent as a whole, are not comprehensive in their coverage. But they are compelling in their import--viz., that often the ecologically unenlightened introduction of a given scheme will result largely in a "robbing of Peter to pay Paul" as far as the overall improvement of health status is concerned.

THE ROLE OF DEVELOPMENT IN FOSTERING DISEASE

Trypanosomiasis (Sleeping Sickness). Sleeping sickness is a protozoan disease caused by the genus *Trypanosoma*, which can infect not only domesticated and wild animals, but also man.

The Kissi tribal region of northern Liberia, bordering upon Sierra Leone and Guinea, is a prime focus of sleeping sickness in Liberia. Surveys in the early 1940's showed that the infection rate had been pushed down by treatment from 26% to 2.5% (Veatch, 1946), but recent evidence shows that infection has increased, reaching 10% in many places. In some areas, 79% of the population are carrying *Trypanosome gambiense* in their blood, although advanced cases are rare (Vaucel et al., 1963).

There are two sets of reasons for this endemic focus. The first deals with the traditional way of life. For one thing, the Kissi raise swamp rice in a tsetse habitat. Secondly, their migratory habits make adequate treatment difficult and many cases relapse. In addition, they live in small settlements whose surroundings are kept insufficiently cleared of vegetation, so that tsetse can breed in the immediate area. Finally, they keep pigs, which may be a reservoir of *T. gambiense* (Veatch, 1946).

Another set of reasons for the endimicity is based on "modernizing" trends and socio-political developments. The Kissi tribe lives in adjoining sections of three countries: Liberia, Guinea and Sierra Leone, and much movement takes place across the international borders for purposes of trade and of visiting relatives. Political changes in Guinea following independence caused the control practices originated by the French to be dropped, and now Liberia is open to the ingress of new cases from that country

(Foster, 1963). Of late such movement has been greatly facilitated by improved road linkages. Reintroduction of trypanosomiasis into areas which were once clear of the disease has resulted. Such diffusion of the disease is illustrated, for example, in the case of the new road through Kissi country in northern Liberia, which was constructed in 1960. Because Glossina palpalis is found at every river crossing, a particular hazard arises wherever a road is intersected by a stream or river; vehicles often stop at such places for water and to refresh passengers, who thereby become highly susceptible to the bite of the tsetse fly. To compound the jeopardy, tsetse flies are attracted to moving vehicles and may therefore be carried by them for some miles, a fact instrumental in spreading the disease into former tsetse-free areas (Abedi and Miller, 1964; Bequaert, 1946).

Among the Ashanti in Ghana, there is a clear illustration of the role of migrant labor, another aspect of population movement, in the dissemination of the disease and the reinfecting of controlled areas. From the 1920's into the 1940's many laborers from the savanna areas of northern Ghana and from other northern countries such as the (now) Upper Volta Republic, Mali, and Niger moved into southern Ghana for work. As they migrated, they passed through the tsetse belt immediately north of the forest, where they picked up the infection. Upon reaching their destination, Ashanti country in central Ghana, they became the source for spreading the disease. It spread to such an extent that Ashanti foci began to have higher rates than the north. At the same time, eradication campaigns in the northern areas were effective in reducing somewhat the incidence of infection there. With the periodic return of (infected) migrant laborers from the south, however, the process of reinfection began. Such migratory movements continue today. One of the consequences is the recycling of trypanosomes in the northern savanna (Scott, 1957).

The case of the Moshie of the Upper Volta Republic provided some supporting statistics for this phenomenon (Scott, 1957). A sleeping sickness survey in Ashanti from 1952 to 1954 showed an incidence of 1.05% among adult male Moshie. The rate for the general Ashanti population was 0.18%, that is, one-sixth of the Moshie infection rate. A concomitant survey at the Yeji ferry on the north-south migration route in 1952 to 1954 clearly shows the degree of reinfection northward. The rate among Moshie males of ages 16 to 44, on their initial entry to Ashanti, was 0.14%; on leaving Ashanti, it was 1.44%. To a certain extent an increased risk of morbidity accompanied employment in Ashanti. While the difference in infection rates is not great in absolute terms, its demographic implication could be of much more significance, especially when coupled with the rest of the disease load under which most Africans labor. Davey (1948), for example, has estimated that in a population with a 6% trypanosomiasis infection rate, a stable population equilibrium is attained, while an infection rate as low as 3% allows only some natural increase. Other surveys, conducted along the road network connecting Ashanti with

the north, show clearly that the highest incidence of sleeping sickness occurs along the major highways because such lines of communication facilitate man-fly contact (Scott, 1957).

In Nigeria transmission has increased sharply in localized pockets along the main Jos-Yamba road, a road used by migrant laborers going to the tin workings in the plateau (Thomson, 1967). Another, almost textbook, illustration of a man-made transmission site also comes from northern Nigeria, the area of Kanawa. In 1961, as a precautionary measure for laborers working on the Bornu railway extension, Kanawa was surveyed for prevalence of sleeping sickness. It was found to be free of the disease. Later, however, there was a sharp outbreak of sleeping sickness. Subsequent investigation indicated the source to be man-made; a small forest reserve was deliberately planted along the banks of a stream at the point where it was crossed by the main road--a place where people gathered to wash, drink and relax. In this case the trypanosome strain was one of high transmissibility but low virulence (Thomson, 1967).

Roads are thus linear-type transmission sites. Although systematic epidemiological data are not numerous, modern roads built for economic development seem to constitute a major health hazard in endemic regions, their very purpose being to encourage movement and mixture of peoples and goods but having, as implicated effects, the facilitation of manvector contacts for several different kinds of insect-borne diseases. With the expanding road and physical communication networks in Africa, all of which facilitate population movement, the risks of rapid reinvasion of areas by tsetse (and consequent reinfection) are great. One obvious suggestion from the public health point of view would be the imposition of strict vigilance and control measures (Thomson, 1967; Scott, 1957).

Settlement relocation is often an etiological factor. In pre-colonial Africa, many traditional settlements were located in refuge areas, on mountaintops, on ridges, on high plateaus--inaccessible, easily defensible sites. These sites were elevated and therefore tended to be freer of fly-borne diseases than lowland sites. However, with the coming of the various European colonial regimes and the law and order they brought, settlements have tended to move down from the hills to better agricultural land on the plains. Agricultural developments of this sort have often led to a significant increase in sleeping sickness.

The Rukuba tribe of the Bauchi Plateau of northern Nigeria illustrates the point. This virile tribe came to the verge of extinction because of an epidemic of sleeping sickness. Glossina palpalis had inhabited the dense vegetation on the Rukuba escarpment long before the introduction of the trypanosomes themselves. After the Pax Britannica, homesteads were moved down onto the lowlands from the hilltop fortresses which had once repelled human invaders, thus bringing man and flies into ever increasing

contact. During 1931 and 1932, farmers returning from Piti brought trypanosomes first into Ikala and then into Kakkek, thus providing the one biological necessity which had been lacking. Man, fly and parasite were thus brought together and a transmission cycle began, resulting in a devastating and cataclysmic epidemic. Ruins of once-prosperous compounds and farms became a feature of the Rukuba landscape (Duggan, 1962).

Another illustration of sleeping sickness as a result of opening of new farmland occurred in Nigeria. Movement onto the plains west of the Jos escarpment resulted in one thousand cases of diagnosed sleeping sickness from 1960 to 1965 (Thomson, 1967).

In 1956, the people from Muyama in the Kasulu District of Tanzania, a barren and heavily eroded area on the hillside above the Milangilizi Valley, obtained permission to go down into the valley to cultivate new fields because of pressure on available agricultural land. The valley was fertile and well watered, but much of the riverine thicket contained large concentrations of G. morsitans. For a year nothing happened, and then, in 1958 and in 1959, after man, fly, and parasite contact had been established, an epidemic outbreak of sleeping sickness occurred (Apted et al., 1963).

From the Dodos country in northern Uganda, another illustration shows how government action can trigger off an epidemic of sleeping sickness with repercussions in settlement, land use, economy and ecological balance. The government evacuated numbers of the Napore and Nyangeya tribes in 1924-25 in order to stop tribal warfare. As a result, a barrier to tsetse was removed because wild animals began to enter the territory formerly occupied (and extensively hunted in) by the Napore and Nyangeya. With the game the tsetse arrived. The advancing game and tsetse began to put pressure on the neighboring Dodos peoples. Tsetse advanced eighty miles and infested 1500 square miles of Dodos territory in the 1920's. In the face of this tsetse hazard, cattle-keeping Dodos people were forced to migrate toward the south and west into a much more limited territory. This caused overpopulation, overgrazing, and soil deterioration, and seriously affected the health and demography of the Dodos people. However, in 1946, a tsetse clearance program was started and in three years two-thirds of the fly belt was cleared. The land which was reclaimed was in good condition after the long fallow (Deshler, 1960).

Another example of ecologically uninformed government action that resulted in an epidemic of sleeping sickness is from East Africa, in the endemic region around Lake Edward and Lake George, near the Semliki Valley in the (then) Belgian Congo. Native tradition holds that sleeping sickness had been present in the Semliki long before its occupation by the Belgians in 1896, and that it had decimated successive tribes who had tried to occupy this fertile plain. Soon after the European occupation, for greater ease of administration, the scattered agricultural population was moved into more compact settlements, which were placed on rivers

to provide permanent water. In this part of the valley, the whole length of the Semliki and all its tributaries holding permanent water are infested with Glossina palpalis, the vector of Trypanosome gambiense. Consequently, the great amount of movement called for by the concentration of the inhabitants, and the position of the settlements, brought about so much increased contact between the population and the tsetse that the existing endemic was rapidly turned into a fierce epidemic which literally wiped out many of these new villages. It was especially severe in the southern end of the Semliki Valley and around the shores of Lake Edward. Mortality was appalling. The epidemic reached its height between 1915 and 1923. In 1924 and 1925 the Belgian authorities took drastic action. The whole population of the valley was moved up onto the higher fly-free ground of the Mitumba and Ruwenzori Mountains and even deep into the Ituri forest along the new road being built from Beni to Irumu. In evacuating the Semliki Valley the Belgians eventually completely eliminated human trypanosomiasis (Morris, 1960).

Another example of population transfer forced by economic development occurred in Rhodesia, the Bumi River area, in 1958. The changes brought about by the Kariba dam produced an outbreak of sleeping sickness as well as a decline in nutritional standards (Apted et al., 1963) and overall health status (Scudder, 1966). A section of the Tonga tribe was displaced by the rising waters of Lake Kariba. They were moved to a dryer region in which their traditional crops would not ripen, but they were reluctant to use the new seed varieties given to them by the government. They therefore suffered from food shortage. When the group lived on the banks on the Zambesi River they had supplemented their diet with fish and rodents, which were not available in their new homeland. Severe malnutrition followed. A government grain store was established to help them, but because of its location, the store became a transmission site for sleeping sickness and a sharp outbreak occurred (Apted et al. 1963).

Bovine as well as human trypanosomiasis is a major disease obstacle to economic and social development in Africa. Huge areas on the African continent are infested by the tsetse fly, and the various trypanosomes which they carry are not only fatal and debilitating to man but also to domestic cattle. In the most highly infested fly belts, it is impossible to raise cattle. This produces a chronic shortage of animal protein; and protein deficiency, especially in early childhood, is one of the major health problems of Africa. As population increases, the problem will become more severe. Yet if the problem of tsetse infection could be solved in practical terms, the fly belts of Africa could be turned into productive cattle-ranching lands, thus in turn helping to solve the severe protein deficiency problem.

An experiment conducted in Nigeria illustrates the obstacles to development created by such bovine trypanosomiasis. In 1963, a herd of 28 Zebu cattle was trekked some 415 miles from a tsetse-free area in north Nigeria to Ilorin in the south. Al-

though the sample size in this experiment was small, the implications are significant. Such a trek is typical of the pattern for the whole of West Africa, whereby cattle raised in the tsetse-free areas of the far north are trekked or conveyed by truck through the fly belt to the southern zone where there is a shortage of animal protein. The journey through the fly belt took twenty-eight days, and measurements were taken daily of the increasing load of trypanosome infection. On arrival at their destination, 39% of the herd were infected. Typical trade cattle surveyed in other studies had an infection rate of 42% (Jordan, 1965).

At their terminus, the herd of 28 Zebu were held over for a seventeen-day observation period. Within this seventeen-day period, 19 of the cattle died and of the 9 survivors only 1 was in good condition. The others were dying of sleeping sickness -- illustrating the very high infectivity of sleeping sickness in the south and the obvious unfeasibility of raising cattle there (Godfrey et al., 1965).

In view of the vulnerability of the big Zebu cattle to trypanosomes and the great shortage of animal protein in the southern part of West Africa, it has been suggested that the N'dama dwarf cattle (which have some resistance to trypanosomes) should be developed for meat production in the fly belt. Veterinary opinion does not support this policy, however, because these cattle are slow-maturing, low-milk-yielding and low-meat-yielding. One further aspect of this situation is that the tolerance of the dwarf cattle to infection is broken down when the animals are subjected (as they often are) to adverse conditions such as malnutrition, overwork, mineral and vitamin deficiencies, and intercurrent infections such as piroplasmosis, anaplasmosis, helminthiasis and rinderpest, or exposure to heterologous strains and species of the trypanosomes. At present in the fly belt and in lightly infested fly areas the only way to raise cattle is to use a supporting regimen of chemotherapy and chemoprophylaxis (Stephen, 1966).

Bilharzia (Schistosomiasis). Schistosomiasis is the disease caused by the worm *Schistosoma haematobium* or *S. mansoni*. The worm uses human beings as a primary host and snails as a secondary one. One of the chief ways of improving agricultural production in many parts of Africa is manipulation and control of water resources by dam construction and irrigation schemes. However, the reliability of water resources is not all that is ensured. In addition to creating dependable water resources, transmission networks are often produced for the diffusion of snails, which are the intermediate host of the schistosome. Indeed, the World Health Organization commented: "The incidence of bilharzia has increased but it is of man's doing. As he constructs dams, irrigation ditches, etc., to alleviate the world's hunger, he sets up the ideal conditions... for the spread of the disease" (WHO, 1961, p. 431). Such schemes also tend to foster dense populations--both human and snail--and thereby increase

rates of transmission. Because many new projects serve as foci for migrations of labor forces, they result in population concentration, and often the introduction of the schistosome itself (by workers from endemic areas). And, in passing, it may be noted that of the two types of schistosomiasis--the urinary or vesical (due to Schistosoma haematobium), and the more severe form, intestinal bilharzia (due to Schistosoma mansoni), it is the latter which is mainly increased by the irrigation schemes (Alves, 1958). Thus irrigation, as an example of a technological improvement oriented to increasing agricultural yield, poses many health problems. Closer attention to bilharzia implications of expanding irrigation schemes is necessary in Africa (Waddy, 1966).

Insofar, then, as the opening up of Africa means, in part, the tapping of considerable hydroelectric potential for the development of irrigation systems, it should be recognized that with every mile of water the bilharzia snail will very often appear.

Its debilitating effects will strike man down and make him an unproductive worker. And as the World Health Organization noted with respect to the planning, and therefore preventive, phase, "The successful attack on the disease will be accomplished by a team: the engineer, the malacologist, the parasitologist, the sanitarian, the physician, and the chemist, widely divergent in training, speaking in the beginning different technical languages, but with a common purpose in mind" (WHO, 1953, quoted by Odei, 1961c). Such a plea for interdisciplinary coordination and planning is echoed by Lanoix (1958), who notes that irrigation systems have also been indicated by eipdemiologists and other health authorities as the causal agents of several other diseases of man, such as enteric bacterial infections, diarrheas, cercarial dermatitis, guinea worm, polio and possibly histoplasmosis; such irrigation systems also provide suitable breeding places for dangerous insect vectors of malaria, dengue, encephalitis and filariasis. Thomas (1965), in dealing with the ecology of a small man-made lake in Ghana, has studied the great variety and number of potentially dangerous pathogenic parasites, of both man and domestic animals, for which an aquatic environment is necessary. The numerous possibilities for the inadvertent spread of disease created by the spread of irrigation systems or the impounding of water can be seen in Appendix.

As far as general prevalence is concerned, it may be noted that bilharzia data on fourteen selected African countries collected by McMullen (1963) show that out of a population of 100 million persons, there were some 34 million infected. More than 50% of the population is infected in five of these countries: Egypt, 14 million out of 26 million; Ivory Coast, 1.75 million out of 3.1 million; Mozambique, 4.5 million out of 6.5 million; Rhodesia, 2.2 million out of 3.12 million; Tanzania, 5 million out of 9.5 million.

Other more specific rates and incidence patterns are those for French West Africa in 1952, which showed case mortality rates from vesical schistosomiasis of 0.3%, i.e., 3 per 1000, and that from intestial schistosomiasis of 1.46%, i.e., 14.6 per 1000 (Odei, 1961 c).

Egypt, with its vast irrigation network, is the most heavily infected country in the continent. A study in 1949 claimed that "since the erection of the [first] Aswan dam, bilharzia has spread out and health and mentality of the individual deteriorated." For example, in four selected areas in a three-year period bilharzia infection rates increased as follows: from 10% to 44%, from 7% to 50%, from 11% to 64%, from 2% to 75% (Lanoix, 1958).

Bilharzia is spreading gradually toward the west in Uganda. One study reports that S. mansoni is most prevalent in the Nile valley and along the shores of Lake Albert. In this disease, as in others, seasonal migration plays a role in the transmission (Nelson, 1958). In Kenya, the Lake Victoria area is one of the hyperendemic areas of Africa, with percentages for school children running up to 100%. Tanzania is likely to become a classic example of the dangers inherent in the economic opening up of Africa by irrigation and water conservation projects. It appears that infection is already fairly widespread throughout the country, but rates are not yet very high. However, irrigation schemes are certain to increase snail populations so that considerable epidemic bilharzia can be expected in the future (Alves, 1958).

In the Upper Volta Republic, about 50% of the population, more than 1.5 million people, are infected at some time during their life with S. haematobium. Yet here, as an example of a general point of this paper, an analysis in public health terms indicates that programs of bilharzia control are usually not of much practical value. One reason for this failure is that they are not combined with an integrated approach to general problems of environmental and urban sanitation. Ouagadougou, for example, has two public lavatories for a population of seventy thousand. Pollution by human waste along with refuse from houses and markets accumulate and offer harbor for flies and rats (McMullen and Francotte, 1962).

In the southwest Gambia coastal village of Kartung, the infection rates for the various age groups were as follows: 3 to 10 years, 59%; 11 to 12 years, 91%; 21 to 30 years, 52% (Odei, 1961a). The decline in rates was probably due both to mortality and development of immunity. It may be predicted that the Volta River irrigation scheme in Ghana will result in the spread of the snail hosts and convergence of infected peoples. In north Nigeria, in the Wulago region near Lake Chad, important irrigation works have been built, but in a location that reinforces an existing focus of bilharzia (Odei, 1961a).

The Gezira area of the Republic of the Sudan provides a particularly good example of the dangers of lack of ecological foresight. The welfare and prosperity of this area is significant to the country as a whole because the Gezira provides nearly one-third of the total revenue of the country. Before 1925, the people of the Gezira lived under primitive conditions, wholly dependent upon grain cultivation (mostly millet). Drinking water was scarce and drought was common. In 1918, work began on the dam at Sennar and it was completed after World War I. When the irrigation works were completed, cotton was planted and yielded abundantly. Prosperity came to the region.

Approximately three years after the establishment of irrigation, however, disease-transmitting snail vectors began to appear in the irrigation canals. The snail population increased from 1931 to 1953. The influx of migratory workers to the cotton fields, first from neighboring areas, then from western Sudan, and finally from West Africa, also increased. By 1954, half a million people worked regularly in the Gezira area. The total number of temporary migrants fluctuated between 150,000 and 200,000 per annum.

In 1942, attention was drawn to the ever increasing incidence of bilharzia, which, it is believed, was introduced into the area by the migrant workers from West Africa. In 1947, field investigatons in northern Gezira showed a mean incidence of 21% among adults and 45% among children. Another survey showed that infection rates among males were twice as high as infection rates among females. Much of the bilharzia in Gezira is the more virulent intestinal variety, S. mansoni (El-Nagar, 1958).

In Nigeria, an irrigated sugar-cane scheme was recently instituted at Bacita on the river Niger east of Jebba. It attracted large numbers of people to an already endemic area. At the beginning of the season, the recruited labor force had a S. haematobium rate of 6.5%. At the end of the season, the rate was 20%. A preliminary morbidity survey showed the prelavence of not only S. haematobium but also S. mansoni in the area. It seems clear, therfore, that the Bacita scheme will increase the rate of transmission of intestinal as well as urinary bilharzia in this area by exposing a large number of people who are drawing there by economic opportunity (Thomson, 1967).

Another example is found in Yo, northern Nigeria in the Lake Chad Basin, where the River Yobe separates Nigeria from the Niger Republic to the north. The irrigation system functions for only four months of the year, but is sufficient to serve as a transmitter of both S. haematobium and S. mansoni. Here S. mansoni infected 15% of the irrigation staff and 10% of the local population. Liver enlargement was found in 18% of the adult villagers examined, and spleen enlargement in 17%. The possibility that schistosomiasis can produce serious liver damage may also be considered in this area. Here, as at Bacita, the main effect of

irritation appears to have been the attraction of more people to natural transmission sites as well as the creation of new modes of transmission through the network of irrigation (Thomson, 1967).

Irrigation schemes are being rapidly developed in Tanzania, and there is fear of increased bilharzial infection. Until recently, the only large-scale scheme was at Arusha Chini where sugar has been grown for several decades. But, between 1955 and 1961, nine new schemes were started, and, in addition, another fifteen are now proposed. Since both forms of bilharzia, S. mansoni and S. haematobium, are endemic in many areas of Tanzania, it seems inevitable that the disease will spread and become severe as irrigation networks are developed and concentrations of human populations around them increase. And in many cases, migrant workers carry infection into the new irrigation scheme and establish a focus of transmission. For example, in one particular scheme, when the labor force was examined in an initial data setting survey, it was found that 1425 (86%) out of a total sample of 1652 came from areas where S. haematobium is endemic, and 320 (19%) came from areas where S. mansoni is endemic (Sturrock, 1965).

In the Mbarali irrigation scheme, Rufiji Basin, Tanzania, development began in 1950 and settlement started in 1961. Surveys of bilharzial infection were made in 1962, 1963, and 1965. In the four-year period from 1962 through 1965, the S. haematobium rate remained stable, ranging from 9.5% in 1962 to 8.7% in 1965. The S. mansoni infection rate, however, increased from 14.5% in 1962 to 28.9% in 1965. In the age group 5 to 9 years, the infection increased from 16.3% to 39.5%; age group 20 to 39 years, 17.3% to 26.4%; age group 40 years and over, 24.0% to 35.0%. The S. mansoni rates were also differentiated according to occupation Senior African Supervisors' infection increased from 2.5% to 12.8%, while Tenant Laborers' rose from 34.7% to 63.7%. Intestinal bilharzia is thus seriously increasing at both socioeconomic levels, and its prevalence is five times greater among tenant laborers, who work more in water on the irrigation scheme itself and whose villages are badly situated in relation to the irrigation scheme. The planned villages, in which the tenant laborers live, are all in the irrigated area and consist of mud huts which lack sanitation and depend for water on the secondary canal system of the irrigation scheme itself. This scheme provides numerous transmission sites. One of the obvious conclusions to be drawn is that all people moving into a new irrigation scheme should be examined for bilharzia, and infected persons treated (Sturrock, 1965).

In Tanzania, some five million people are infected. From northwest Tanzania, on the shores of Lake Victoria, figures from an unselected community sample indicate that S. mansoni infections are light but S. haematobium is rampant in the area, giving rise to hydronephrosis, ureteric lesions or non-functioning kidneys in more than 20% of the children and in over 10% of the adults (Forsyth and Bradley, 1966).

In 1954, the Department of Health in Rhodesia warned that large-scale irrigation projects might well wreck the health of the country and bring the most grandiose of schemes to an end. For example, one of the first irrigation schemes established in that country after World War II has been a complete failure and is now largely abandoned because the effects of malaria and bilharzia were not calculated (Lanoix, 1958).

In Rhodesia, a study of parasitic infection among 80 laborers on a tobacco farm showed that 45 had S. haematobium, 18 had S. mansoni, and 11 had hookworm. The investigator, however, did not feel that these parasite loads impaired the performance of these laborers to any great degree (Young, 1955). But this observation was impressionistic rather than based on systematic data.

In the Republic of South Africa, bilharzia is well known in Natal and is now also being reported in the Transvaal, particularly in the eastern low veld and in the north. It is likely that the extension of irrigation schemes in these areas will make the Transvaal a much more dangerous area than Natal. The S. haematobium incidence was only slightly higher among Africans on European farms in the north and east of Transvaal than in the African reservations (Anneche, 1955). However, the S. mansoni infection rate was 68.5% on the European farms, as compared to 33.4% on the reserves. The difference presumably resulted from the irrigation on the European farms.

Again in the Transvaal, on protected farms in the irrigated low veld the infection rates for Africans were 29.3% and 49% for S. mansoni and S. haematobium, respectively. On farms without control, the S. mansoni rate was 68.5% and the S. haematobium rate was 66.7%. On the African reserves the S. haematobium rate was comparable to that of the unprotected farms, but the S. mansoni rate was lower (Anneche, 1955).

It appears that bilharzia is spreading into Southwest Africa: S. haematobium and S. mansoni have been found in the east Caprivi Strip next to Zambia. The disease has also been found in the Okovango swamp at Maum, where previous surveys had been negative. The swamp provides an ideal snail habitat, and therefore the disease dangers are very considerable in this area. No bilharzia is found at present in Ovamboland, but a major water diversion scheme is planned whereby the Kunene River water in Angola will be conveyed through canals into Ovamboland for water supplies and possible irrigation in this densely populated area. When it is completed, bilharzia, which is present in the southern Angola rivers, will probably spread into Ovamboland (Geldenhuys et al., 1967).

Other kinds of occupational activity or development schemes which involve manipulation of water resources may also assist the spread of bilharzia. In the southern part of Cameroon, for example, it is noted that rice cultivation is eminently favorable for

the spread of infection, since dangerous transmission sites include slow-moving streams, ponds and marshes (Odei, 1961a). Liberia serves as another example. There, bilharzia is an occupational disease among women who spend a great deal of their time washing clothes along riverbanks. In the marshes of the coastal areas in Portuguese Guinea women grow the main crop, rice. They consequently develop a high rate of vesical bilharzia (Odei, 1961c). At another development project in a low-lying area of eastern Kenya, a rice scheme was developed which was a focus for bilharzia; in this case, however, attempts are being made to control the snail habitat. In rural areas where bilharzia infection is endemic, such scattered foci present a very difficult problem for public health planners because any water-connected development activity, such as a rice scheme, or the construction of fishponds, compounds the problem immeasurably (Fendall and Grounds, 1965b).

Numerous other deleterious effects of the disease can also be noted. On the basis of a study in Dakar, it is believed that schistosomiasis may give rise to cirrhosis (Charmot, 1954). Furthermore, it is possible that bilharzial infection can adversely affect nutrition. Disorders in the conversion of the amino acid tryptophan to nicotinic acid (the vitamin niacin) have been encountered in bilharzial cases. This would be significant in the upset of protein metabolism and in the increased likelihood of pellagra, another extensive public health problem in Africa (Mousa et al., 1967). Regarding another complication, King (1965) reports that Bantu mineworkers in South Africa who have schistosomiasis develop irreversible urinary lesions with genito-urinary complicatons.

In this discussion, we cannot further develop the associated physiological concomitants of the disease. That is more properly done by specialists in the field. We would, however, with Farooq (1964), point to the widespread problem of decreased labor output in areas of endemicity.

During 1962 and 1963, an attempt was made to assess the economic effect of chronic schistosomiasis among a labor force of young male African adults employed on an irrigated estate at Arusha Chini in northern Tanzania. Some 75% of recruits in 1963 had current or previous experience with schistosomiasis. Workers lived in camps provided with bore-hole water, washing places, and latrine facilities. But where irrigation water ran close to habitation, it was used for domestic purposes. Because latrine facilities were available in the camp but not in the fields, contamination of canals and reservoirs by infected persons was widespread. Transmission continued. Data on daily absenteeism indicated that schistosomiasis was second only to injury among principal causes of lost working time (Foster, 1967a).

Estimates were made of the annual cost in lower productivity ascribable to schistosomiasis. Without control, the cost of schistosomiasis is £ st. 2.6 per worker per annum. The cost is

made up of the following four items: direct treatment, additonal absenteeism, additional inpatient treatment, and additional outpatient treatment. With control, the annual cost of schistosomiasis per worker is £ st. 5 per worker per annum. Control costs are made up as follows: molluscicide, additional staff, transport and application, treatment of new labor and dependents. With control, and the resulting increase in worker productivity, the saving is £ st. 1 per worker per annum (Foster, 1967b).

In Africa, the distribution of the snail hosts of bilharzia is more widespread than the distribution of schistosomes. Therefore, the disease can easily spread over a much wider area than it covers at present. Since man is the primary carrier of the disease, its spread is greatly fostered by migration, by concentration around water holes, and by development of new ways of farming which implicate surface water resources (Odei, 1961c). A technique for measuring the spread of bilharzia that might be of help to epidemiologists in the development of the preventive measures is to ascertain the incidence of the disease by age groups. Normally, the measurable incidence, if not the actual incidence, is highest in young persons and somewhat lower in the adult population. In areas where it is believed that the disease has been recently introduced, measurable adult infection rates are significantly higher. Figures on incidence by age groups would help to portray the geographical spread of the disease.

Malaria. There are three types of malaria in Africa, caused by three different but closely related parasites: *Plasmodium falciparum*, *Plasmodium malariae*, and *Plasmodium vivax*. *Plasmodium falciparum* is the most common. The vector of the disease is the anopheline mosquito; two varieties are widespread and relevant to the dissemination of the parasite in Africa: *Anopheles gambiae* and *Anopheles funestus*.

When malaria does not kill, it debilitates. Victims develop a variety of symptoms: anemia, fever, high blood parasite level, and spleen enlargement. Populations in malarious regions are also characterized by high infant mortality and a greater susceptibility to many kinds of infection; in additon, pregnant women frequently suffer miscarriage as a result of the disease (Cannon, 1958). Thus, malaria contributes to the severity and exacerbation of a variety of morbid conditions in a population.

With malaria, as with bilharzia, the construction of irrigation schemes and expansion of agricultural programs has facilitated the spread of the disease; indeed, the spread of malaria in Africa was probably facilitated from the beginning by man's own constructive activities. Livingstone, for example, notes that the clearing of tropical forests for agricultural purposes and the establishment of thatched-roofed permanent villages provided ideal habitats for *Anopheles gambiae* (1958). Similar processes, and similar effects, continue today. Wilson (1957) made a plea for coordinated environmental planning in this respect. The fears he expressed were realized in the Taveta area of Kenya and

Tanzania when water from springs in the Kilimanjaro area was diverted for irrigation purposes and thereby provided ideal breeding sites for mosquitoes (Smith and Draper, 1959).

The fact that mosquitoes cannot transmit malaria directly to each other makes man's role in its diffusion a primary one; and widespread population movements in Africa, both those linked with traditional patterns such as pastoral nomadism and those linked with modern developments such as labor migration, are among the outstanding contributory features in this respect. As such, migrations both facilitate the spread of malaria and create serious difficulties in its eradication. Since most of these population movements are essentially uncontrolled and many are interterritorial and international, they often hamper effective eradication and control programs through the reinfection possible in uncontrolled areas. In fact, the eradication and control of malaria in Africa today increasingly has more to do with understanding and control of the human relations aspect of the problem than with the biological aspects. The techniques of the malariologists and entomologists are well established, as are methods of eradication (the main purpose of which is to interrupt the transmission cycle); but what remains is the articulation of these techniques within widely differing physical and sociocultural environments. Population instability and movement is only one consideration; the ways in which a population is distributed, its settlement patterns, house types, farming practices, communication patterns, and water-use patterns, are also important aspects of a malaria eradication campaign. It is in the area of the complex interrelationships among the parasite, the vector, and man that further data and studies are needed (Prothero, 1961; Fonaroff, 1963).

Malaria and attempts to control or eradicate the disease prove that the quest for health is continuous and that there is only temporary respite. Malarial programs are waging a continual fight to keep ahead of the proliferation of insecticide-resistant strains of the insect vectors which, through processes of natural selection, adaptive capabilities, and enormous reproductive capacity, are multiplying the disease threat. In a sense, the more control is attempted, the more the problem is exacerbated because of the need for new research to develop more effective and more specific insecticides. It might almost be said that unless the transmission cycle is broken at other points, insecticide spraying of the insect vector creates a new environment, an environment of "development," and is an attack on a problem which itself has been created by earlier spraying--a "disease of development."

This point has been documented in a number of studies. The study by Bruce-Chwatt (1956) with regard to DDT and dieldrin is a good example. After a four-year spraying campaign in the region of Thies, Senegal, the parasite rate among children under age fourteen was reduced from 22% to only 1%. However, the disease

rebounded to 16% within only a year. In the opinion of the researcher, this rebound occurred because of the adaptation of the mosquito vector to the new environmental conditions (Escudie and Abonnenc, 1958). In the Para area of Tanzania, there was another outbreak of malaria transmission based on similar factors. The spraying campaign ceased in 1959, and thirteen months after the final round of dieldrin spraying, parasite rates had sharply increased, from a low figure of about 5% only six months after the cessation of the spraying campaign, to an average rate of 30% for children from 2 to 9 years. The factor causing the rebound was the development of a new strain of Anopheles gambiae. Because the transmission cycle was not completely broken by the spray campaign, human susceptibility to the disease actually increased rather than diminished (Pringle, 1967).

Resistance of mosquito vectors to insecticides has three forms: (1) simple behavioristic, (2) excito-repellency, (3) physiological. Behavioristic resistance occurs when an insect population changes its habits to avoid contact with the insecticide. For example, mosquitoes may try to rest on clothing or furniture or leave the house immediately after taking a blood meal, instead of resting on the walls of a room. Excito-repellency is a form of hypersensitivity to an insecticide. When a mosquito comes into contact with the poison, it may take off again before it has received a lethal dose. Physiological resistance arises when strains of mosquitoes emerge which are genetically tolerant to doses of toxicants which would be lethal for the majority of the mosquito population of the same species. It is this latter kind of resistance which poses such a severe problem and which has developed as a result of man's own activities in spraying campaigns. In 1967, the WHO Expert Committee on malaria reported that twenty-four vector species of Anopheles show resistance to dieldrin, DDT, or both. In sixteen countries, eleven of these twenty-four vector species showed double resistance, which is much more difficult to counter than single resistance.

It is therefore clear that no single method will rid the world of malaria. Combination programs incorporating techniques such as spraying, draining marshland, clearing of the bush, and mass chemotherapy and chemoprophylaxis have the best chance of success although even with these measures it should be recognized that there may be a serious problem of drug resistance to the chemicals. Although such programs might be expensive to mount and complicated to administer, there is no question of the overall gain in terms of worker well-being and productivity. In the Transvaal and Natal, for example, malaria control programs decreased worker absenteeism by at least 30%; and in Rhodesia an antimalaria campaign reduced absenteeism during the harvest season in the Mazoe Valley from 25% to almost nothing (Winslow, 1951, pp. 24, 25; quoted in Taylor and Hall, 1967).

It is not appropriate here to enter into complicated matters of the economics of labor supply; but insofar as much of the worker absenteeism in developing countries is of an erratic and

aperiodic nature (thereby making permanent replacement of trained workers from the unemployed pool difficult to accomplish), one further observation is relevant to the general issue. Calculations by Mushkin are reported to the effect that in a hypothetical developing country, with 80% of its population affected by malaria, for example (which would decrease productivity of agricultural workers by 30% during a three-month period), the output loss in the agricultural sector would be 6%. If agriculture accounted for one-third of the total output, the gross national product would be diminished by 1% for that period alone; and over a twelve-month period the loss would be 4% (Taylor and Hall, 1967). Of course, the specifics of such calculations might well vary; but what is quite clear is that sick workers simply do not work as well, nor as regularly, as those who have their health. Even an effective antimalarial campaign brings other problems. First, the complete eradication of malaria from holoendemic areas will increase susceptibility so that any attacks that do occur after the campaign will tend to be more crippling to adults. Thus, in the long run, partial control may prove to be a social detriment. Secondly, the demographic effects of an antimalarial campaign will include a rise in the rates of population increase. In fact, the rate of increase may exceed that of food resources. Other problems, such as malnutrition, may arise because antimalarial campaigns lead to a sharp increase in birth rates and sharp decrease in death rates (Learmonth, 1954; Cannon, 1958). In the short run, too, it is foreseeable that a sharp reduction of infant mortality rates (as, for example, from a successful antimalarial program) will lead to protein-calorie malnutrition because more surviving infants are competing for limited supplies of breast milk and other protein supplies. Thus, even an effective antimalaria campaign may at best substitute complex new problems for old ones.

Rural Malnutrition. Many traditional African diets provide an excellent and well-rounded nutritional regime, especially where there is no population pressure and no cash-cropping. For example, the Karamojong of Uganda possess many cattle, which are the mainstay of their economic and social life. Sorghum, milk and blood are the main foods and meat is eaten in times of famine. In this situatin, protein-calorie malnutrition is rare (Jelliffe et al., 1964). The Mabaans occupy the bush country in the southeastern part of Sudan near the Ethiopian border, and they, too, have an excellent nutritional status; there are no nutritional deficiencies. Their major foods, all rich in protein, are guinea fowl, rodents, game, millet, sorghum, nuts, and dried fish (Rosen et al., 1962). In short, many indigenous diets are good diets which include a high proportion of protein-rich foods. Considerably more research, however, is needed in this area (Jelliffe, 1955).

On the other hand, it should also be noted that in numerous cases culturally-based food taboos prevent consumption of animal protein which is available for either an entire group or for special classes of persons in the group. These food taboos play

a part in denying children some of the vital nutritional elements required. In the Ankole area of Uganda, for example, many weaned children are deprived of goat milk because the goats are not used for this prupose; of eggs, because they are believed to be unsuitable for human consumption; and of meat and fish, or even an adequate quantity of cow's milk, because of the expense. The value of vegetable protein, as in beans, peas, and ground nuts, is likewise not appreciated (Cook, 1966).

The introduction of cash crops in the colonial period often led to the neglect of traditional diets and proper food production. In many African countries, a high proportion of the men engaged in farming are still concerned primarily with cash-crop producton, and the vigorous efforts to increase cash-crop yields have often been at the expense of subsistence farming. This is observable, for example, in the cocoa and coffee-growing districts of West Africa, where the best lands are used for cash-crop purposes. In many areas such a concentration of cash-crop production has reduced the quantity of locally produced food. Meanwhile, income derived from cash crops is subject to wide fluctuations and is not in every case wisely spent or wisely spread out. Lump sums derived from bulk sales tend to be quickly spent on items such as educaton fees or clothes and status symbols, leaving little for food purchases (Hendrickse, 1966).

In this connection, a study of the effects of cocoa production in West Africa are pertinent:

Economically, the most important finding for the country which came out of our survey concerns the cocoa villages. Cocoa is one of the best cash crops in the world, giving the highest cash yield for the smallest energy output. One might therefore expect the cocoa villagers to be well off, well fed, happy and gay. We found exactly the reverse. The people were dull, apathetic and unhappy. Their villages were run down, dirty and dilapidated and their children naked, pot-bellied and sickly. The reason for this is that it is not enough to introduce a highly paying cash crop to an illiterate peasantry and expect them to profit by it. What happens is that it tends to kill their traditional life, merely putting money in their pockets for a short period in the year, during which time they enjoy themselves. When the money gets scarce, months before the next harvest, they find themselves short of everything. In a pure cocoa village they have given up most of their land for cocoa and are no longer able to till the ground for food.... Hence, with their money running out they can only buy the cheapest of food, e.g. cassava and yam .... At Igun [West Nigerian cocoa village] the villagers are apathetic, complaining if asked questions, and appear devitalized and sick. (Collis et al., 1962b, pp. 223-24)

Cash-crop production of mainly coffee and cotton in the Kilimanjaro District of Tanzania, mostly by the Chagga people, leads to some neglect of local diets. The main crops are bananas, pulses, maize and yams. The diet is very high in starch and, not

surprisingly, kwashiorkor is the main form of protein-calorie malnutrition (PCM) found in this area. It is observable in 2% of the children (Marealle and Kazungu, 1964). The real incidence of PCM will probably be much higher than the 2% figure for kwashiorkor, since subclinical PCM and post-PCM cases should be taken into consideration for such an assessment.

There are other examples of deleterious effects on diet and nutritional health following government programs. The Hadza (or Watindiga) are a small hunting and gathering tribe living in the tsetse-infested savanna adjacent to Lake Eyasi in northern Tanzania. It is believed that they may be related to the Bushmen of South Africa. Their diet consists of grain and gathered fruits, seeds and berries. Intercourse is forbidden during the prolonged lactations. At five months children are given bone marrow, seeds and pre-chewed meat. Overall, their nutritional status is excellent, and dental caries are almost absent. But tsetse clearance programs are changing the ecologic and nutritional status of this group. Because of tsetse clearance, surrounding tribes are encroaching upon Hadza territory, and diet changes are inevitable. Corn meal, which can bring PCM and pellagra, is starting to make inroads on the diet (Jelliffe, Bennett et al., 1962).

The Lugbara, a large tribe living on both sides of the Congo-Uganda border, traditionally had a high-protein diet. Feeding and weaning of infants was satisfactory. The tribe had a high intake of beans, milk, peas, ground nuts, and sesame seeds; and their main food crops were millets and sorghum. Such a diet kept PCM incidence low. Following famines in the West Nile District, however, a law was introduced in 1950 requiring every householder to plant half an acre of cassava, a plant with very low protein content. The crop has now become a secondary staple, and if its cultivation further increases, as it may well do, the nutritional implications are obvious (Jelliffe, Bennett et al., 1962b). With mounting population pressure in rural areas, there is an inevetiable tendency to change from protein-rich staples, such as millet and sorghum, to carbohydrate staples, such as cassava, yams and plantain. Areas of high rural population density are usually characterized by a dependence upon starchy staples, which yield more calories but less protein to the acre. For example, cassava produces four to five times the calories per unit area as does millet:[2]

[2]Table from J.F. Brock and M. Autert, 1952.

Table 7-1

CALORIES PER HECTARE OF AFRICAN CROPS

Cassava	7090
Maize	2845
Rice	2151
Sorghum	1854
Millet	1530

However, from the nutritional point of view, protein supplies are vital. Comparative protein content of various African foods are shown in Table 7-2.[3]

In such areas with considerable dependence upon starchy staples lacking supplementation, PCM is usually found. For example, in the Kayonza District of Kigezi, Uganda, a densely populated area in which the major food staple is plantain, a high

Table 7-2

GRAMS OF PROTEIN PER 100 CALORIES

Dried fish	15.3
Soya (whole dry seed)	11.3
Beef	9.6
Beans or Peas	6.4
Ground nuts	4.7
Millet (*Pennisetum*)	3.4
Sorghum vulgare	2.9
Maize (whole meal)	2.6
Yams	2.3
Plantain	1.0
Cassava (fresh)	0.83
Cassava (flour)	0.44

incidence of PCM is found among the Bachiga children. This has occurred because of pressure on the land (Jelliffe *et al.*, 1961).

When regional surveys of foodstuffs are taken into consideration with population density, they give a good indication of patterns of nutritional risks. In the Buganda region of Uganda, for example, there is a heavy dependence upon plantains (46%), at the expense of cereals (11.3%), pulses (9.7%), and animal products (4.2%). These figures express the percentage of total calories derived from the sources indicated. In Buganda therefore, protein intake is low, especially when compared to the northern region of Uganda, where total calories derived from cereals, pulses, and animal products were 39.3%, 24.1%, and 5.2%

[3] *Ibid*.

respectively. While the protein intake in the northern region is much better, cassava has recently spread into northern Uganda and at present accounts for 24.2% of total calories (Burgess, 1962).

The development of hybrids is often hailed as the agriculturists' answer to the problem of population increase. And although hybrids do produce spectacular increases in yields, it is sometimes the case that protein content in hybrids is lower than in unimproved varieties. For example, Japanese hybrid rice has a 5% protein content (as compared to 10% for other rice), and U.S. hybrid maize has a 6% to 8% protein content (as compared to Nigerian or Brazilian maize with 10%). Allowances should be made for these differences in rural development planning; in particular, the amino acid composition of those food crops selected for promotion in rural areas should be carefully considered.

Much of the acute rural poverty on the South African reserves, where there is heavy soil erosion and serious malnutrition, is a consequence of the phenomenon of urbanization, for the rural hinterlands of towns serve as labor reservoirs. Government restrictions on movement mean that wives and children are left on the reserves, in many instances to fend for themselves, while the men work in the towns. Food production consequently, has fallen rapidly behind food needs on the Bantu reserves (Fox, 1954).

A study of an African reserve in northeast Transvaal (Sekhukuniland) clearly shows some of the severe social and nutritional problems. Soil is poor and rainfall is highly seasonal and sparse--averaging only 23 inches per year. Women and children form the bulk of the population because the able-bodied men have migrated to the cities. Child wastage because of malnutrition is an important problem. This study, among numerous others, illustrates the nutritional stress of the transition from tribal life to wage-economy in South Africa (Waldmann, 1960).

In one health survey of a rural Zulu community in southwest Natal, in the Polela District, it was shown that about three-fourths of the males between 25 and 40 years are absent from the community most of the time. Although from 1945 to 1955, health, education and welfare services aimed at improving the nutritional status of infants and at developing preventive measures pushed down the infant annual mortality rate from 202 to 86, the present high mortality levels caused by poverty and malnutrition cannot be reduced without economic assistance (Bennett, 1960).

THE ROLE OF URBANIZATION

The relationship between "development" and urbanization is obviously not a simple one. But that there is a relationship of evolving complexity in today's context of accelerating urbanization all over the continent is quite clear (Steel, 1961). Many of the tangible instances of "development" schemes (schools,

amenities, multifarious goods, occasional wage-jobs, health clinics, etc.) are concentrated in towns and cities, and whether accurately or not, the city or town is taken as the exemplar of the process of betterment. It thus serves as the magnet drawing population from a hinterland, and creates that mix of peoples and ideas which, in the absence of ameliorating influences, is commonly predispositional to diverse pathology (Brockington, 1958, Chap. 10). The growth of urban areas in many parts of Africa today may therefore be taken as at least a corollary, if not a simple result, of developmental ideologies and programs. But it is a corollary which includes many ecologically based conditions conducive to widespread pathology. Such pathology is both physically rooted (as in crowded and unsanitary living conditions) and psychosocially rooted (as in widespread conditions of anxiety and stress deriving from economic deprivation, unemployment, physical threats, insecurity and social alienation).

Recalling the pathogenic conditions accompanying the industrial development of the Western world, a fairly recent summation (1959) by the World Health Organization of African urban conditions is pertinent, and essentially unchanged in its gross details today:

The situation created by the rapid urbanization of Africa was examined by the WHO Regional Committee for Africa at its ninth session in Nairobi in September 1959. The influx of immigrants into the towns leads to overcrowding, which in turn produces water shortages, overloading of existing sewage disposal systems, the creation of fresh sanitary problems in towns without such systems, and the risk of spread of infectious diseases. The rural immigrant ... is the least adequately protected of all town dwellers from the standpoint of environmental sanitation because of his poverty and his ignorance of the ways of the town. He is poorly housed and badly fed; he is without access to a wholesome water supply; his personal hygiene is of the lowest standard. Sanitary measures seem to be designed less to protect his health than to protect the town community from any infection he might carry. His attempts to earn a living by hawking food and drink, for example, are frowned upon. Householders are prevented by anticrowding measures from giving him cheap shelter. His very presence in the town is discouraged, not only by the health authorities but also by the police. He accordingly settles outside the town, entering it daily to look for employment; and the overcrowded, unsanitary hovels in which he and his fellow-immigrants live form the peri-urban slums, the "shanty towns," of modern Africa. From the sanitary aspect Engels' description of the Manchester slums in 1844 is applicable to these shanty towns. Sanitation is non-existent, and open drains run down what passes for streets. The shanties are built of mud and wattle, old packing-cases, or kerosene tins, with tattered blankets as doors. Children crawl among the uncollected rubbish or in the drains. Water has to be fetched from a pump, well or tap, and may be contaminated. The atmosphere is unlikely to be polluted, as it was so often in Industrial Revolution towns, and the warmer climate

leads to life being spent out of doors to an extent not possible in more northern latitudes; but the climate also encourages vast numbers of flies and mosquitos and, in places, the snails which transmit bilharziasis. Occasional floods convert the ground into a quagmire. Malaria, the diarrhoeal diseases, tuberculosis, bilharziasis, and the helminthiases all abound. Malnutrition is common, with its train of deficiency diseases and kwashiorkor. The destruction of tribal traditions and the general social disorganization lead to alcoholism, prostitution, and veneral disease; and mental disorders are frequent. Morbidity and mortality are both high. (WHO, 1960, p. 176)

Urbanization is perhaps the most salient social and economic feature in the life of Africa today. While populations of African countries are doubling in a period of from twenty-five to forty years, African urban populations are doubling in less than fifteen years. The towns in Senegal have increased by more than 100% in a decade. Enugu, in Nigeria, was an empty site in 1914 and now has a population of more than eighty thousand; Ibadan, also in Nigeria, has trebled its population in twenty years. And much of this population concentration is packed into the peri-urban fringes, slums and shantytowns. A recent housing survey in Jinja, Uganda, for example, showed that one-third of the workers live in mud-and-thatch- or metal-roofed huts on the fringe of town, and such peri-urban slums are a constant feature of the large cities and towns (Fendall, 1963). Migrants to these slums often lack a good understanding of how to operate in a monetary economy, and face the stresses of unemployment and social heterogeneity often without the support of traditional relationships (Fendall, 1963; Little, 1966).

Such social heterogeneity--particulary in the "new" towns and cities of Nairobi, Johannesburg, Abidjan, Dakar, Freetown, Accra, Lagos, and Kumasi--is manifested not only in economic and wealth differentials, but also in considerable tribal and linguistic diversity (H. Kuper, 1965). In Accra, for example, more than sixty ethnic groups are represented. Many people are strangers to each other; they huddle together in areas where there are kinsmen who speak their languages; they feel a sense of estrangement from much of their environment. An additional socially disruptive feature is that many towns (especially in industrial or mining areas) have an excess of males, particularly single males, or married men without their families.

The stresses which affect life are therefore not simply those relating to the traditional concerns of public health; they also derive from the psychosocial dimension of a human environment. For man lives not only in terms of physical parameters; he is also enmeshed in a framework of social relationships which constitute varying patterns of threat and support. He functions within a symbolically transmitted framework of values and orientations which define the nature of legitimate goals, means, and aspirations. One salient feature of the widespread phenomenon of

urbanization in Africa today is the disruption of these frameworks of social relationsips and value systems. This social aspect of the urban context is described by us in aother work. (Hughes and Hunter, 1968). Here we shall review some of the primarily organic pathogenic conditons, focusing on communicable diseases and malnutrition.

Nonpsychological Disorders and Pathogenic Conditions: Tuberculosis and Other Communicable Diseases. The association between health status and overcrowded, unsanitary conditons is well known in public health literature. Africa's towns are no exception to this maxim; they serve as the breeding ground and reservoir for many diseases of mass contact: whooping cough, smallpox, polio, malaria, typhoid, gastroenteritis. Many examples of overcrowing can be cited. There is the case of Kericho, a small town in Kenya, where two-fifths of all families live in single rooms (Fendall, 1959).

Tuberculosis is commonly associated with other diseases such as malnutrition, anemia, helminth diseases, and malaria. Not unexpectedly, then, tuberculosis in Africa is primarily an urgan slum disease. In Kenya it is of fairly recent origin. Reports of the disease from the coast early in this century describe it as "galloping consumption," of acute onset and rapid fatality. Immediately after World War II the disease assumed primarily an urban locale, and in the last twenty years the most prevalent type of tuberculosis has changed from tuberculosis septicemia to chronic pulmonary tuberculosis. A 1948 survey estimated a rate of proved and suspected cases at 11.1 per 1000 for the country as a whole.

A WHO survey of 1958 and 1959 in Kenya confirmed that the disease was more prevalent in central and coastal regions than elsewhere. Except for the Lake Victoria region, these regions have higher humidity and greater population densities than anywhere else in the country (Fendall and Grounds, 1965a). Indeed, the disease is most closely tied to the density of population rather than to any other single feature of the urban milieu. A study in Kenya corroborates the finding of the highest rural rates in areas of highest population concentration: the Myeri district, an area in which the population has almost doubled in the last twenty years, is associated with a concomitant precipitous increase in tuberculosis (Turner, 1962). Another study similarly reports the highest prevalence in the Zambian countryside in those areas of highest population density (Grave and Ililonga, 1962).

A TB study of forty-four thousand African children in Rhodesia showed the highest rates in urban areas (Shennan, 1960). Another study of children in the Kano area of Northern Nigeria showed an infection rate in the congested central area almost twice as high as the infection rates in the better-quality housing of the suburbs and villages (McArdle, 1961). And a gen-

eral WHO summary of TB surveys in African countries shows that the highest rates are found among men rather than women, and in urban rather than rural areas. These data support the inference of a close relationship between the migration of labor to congested urban areas and the prevalance of the disease (Roelsgaard et al., 1964).

Through migration, especially labor migration, TB, orginating in urban slum areas, is being transmitted to the rural areas in Africa. These areas then become additional foci (e.g., Fendall and Grounds, 1965a). Migrants, for example, come to town for work and contract TB there, and then often return to their rural homeland because they are too sick to work. One study traces the diffusion of the disease from Abidjan to rural areas in the Ivory Coast (Delormas, 1960). Another example of TB spread by such migrant labor occurs in Gao. Many farmers of Gao apparently contracted the disease while they were working or searching for work in Ghana. One practical implicatin would be the impositon of control and inspection of migrants returning from Ghana to Gao (Plessis et al., 1959).

Urban Malnutrition. Protein-calorie malnutrition is emerging as a significant force in the rapidly growing towns of Africa as well as in rural areas. Urban diets, in fact, are often deficient in vitamins, minerals, and proteins. These deficiencies occur, in part, when important nutritional elements are lost in the processing of grains and cereals (Jelliffe, 1962; Mead, 1955). Traditional methods of preparing these plants for consumption in the countryside do not result in comparable vitiation of nutritional elements. One study of polyneuropathy (a condition strongly related to pellagra) in Dar es Salaam, Tanzania, indicates that the condition is probably of nutritional origin and could be based on the use of highly refined (and therefore niacin- and thiamine-deficient) maize flour (Ebrahin and Haddock, 1964). Kwashiorkor and marasmus were found in some 2% of the children in a sample in Dar es Salaam. These diseases occurred because of high starch diets and, in some cases, early weaning followed by poorly administered artificial feeding (Marealle et al., 1964).

The Acholi peoples inhabit the north central part of Uganda. In a study comparing rural Acholi with urban Acholi the latter were found to have a higher rate of PCM, presumably because of the substitution of maize flour and other foods for traditional vegetable proteins, including millet, sesame seed and ground nuts (Jelliffe, Bennett et al., 1963). In Durban, where 1565 cases of kwashiorkor in children admitted to clinics were studied, the peak age of prevalence was 1 to 3 years. Fifty-three per cent of the children died, and in some instances their condition was complicated by pneumonia and gastroenteritis. Excessive use of starch products was judged to be the main reason for the poor diets of these urban Africans (Scragg and Rubidge, 1960).

Several factors are implicated in urban malnutrition. One of the chief culprits is money and the high cost of protein-rich foods. The urban environment, to a much greater extent than the rural, revolves, of course, around a money economy. This factor is the core of many aspects of the malnutrition often found as a concomitant of the shift from rural to urban areas (Mead, 1955). A study done in West Africa, for example, indicates that malnutrition is more common in urban and peri-urban areas than in rural areas. It states that the value of money income in the towns is diminished by (1) obligatory expenditures such as rents, transportation expenses, and clothing; (2) by higher food prices; and (3) by having limited and even no access to home-produced foodstuffs (Hendrickse, 1966). But there are other features in a monetary economy which are detrimental to nutritional standards. One study, for example (Fendall, 1963), shows that twice as much is spent on food in the first ten days immediately after payday than in the last ten days of the month. Similarly, three times as much is spent on alcohol in the first ten days than in the last ten days.

When men work in towns and live without their families, they frequently feed themselves much less adequately than when they live in the rural areas. They lack women's expertise in food preparation and purchase. They often eat in canteens which provide monotonous and poor-quality diets. Living in towns also frequently leads to extramarital liaisons which involve a man in a new set of familial obligations under which either his village family or his city family will suffer financially (Hendrickse, 1966).

Because of less effective child care in the towns, urbanization frequently results in infant malnutrition. In the towns considerable pressure is placed on young mothers to go to work. In their mother's absence, babies from two to three months old are often cared for by children from seven to ten years old. The diet for such babies is often poorly prepared canned foods. This poor diet can produce gastroenteritis and eventual malnutrition (Fendall, 1963). Kahn (1962) also reports kwashiorkor in children of working mothers.

Not only are there fewer relatives to help care for the children in towns and cities, but there is also less sunlight and therefore more rickets. In addition, there tends to be earlier weaning in the town than the country, with consequent intake of less protein. Subsistence depends mainly on expensive and poorly carried out artificial diets (Jelliffe, 1962).

Ignorant and uninformed adoption of European-type baby bottle-feeding also contributes to infant malnutrition in the towns. The practice of feeding powdered milk to babies is rapidly growing in urban areas, but this practice is being used by women with no knowledge of hygiene, no ability to read the instructions on the can, and no money with which to buy sufficient

powdered milk. Thus, diluted powdered milk from dirty bottles and dirty teats is substituted for breast milk. This leads to malnutrition and dietary disorders such as marasmus, diarrhea, or vomiting (Cook, 1966). Welbourn (1958) also comments on the uninformed use of bottle-feeding and its deleterious effects. In Uganda, bottle-fed children were two pounds lighter in average weight than breast-fed children.

It is worth looking at some specific studies of relationships between overall physical and mental development and early protein dificiency. For eleven years, Stoch and Smythe studied twenty Cape colored infants who were grossly undernourished during infancy. The undernourished group lived under unhealthful slum conditions in one-room shanties built on sand without any sanitary facilities. Those who lived in houses were crowded into unventilated dark back rooms. Thirteen were illegitimate and, in another three cases, the fathers had deserted. Mothers appeared too apathetic to care for their children. Social workers and district nurses repeatedly requested the mothers to take their children to municipal soup kitchens or to clinics for meals but there was little cooperation. Compared to matched controls, the head circumference, height, weight, intellectual and psychological assessment and encephalograms of these children show that undernutrition during the period of active brain growth has resulted in a significant reduction in brain size and impairment of intellectual development (Stoch and Smythe, 1963, 1967).

In brief the findings are as follows (1967):

Table 7-3

	Control Group	Under-nourished Group	Magnitude of Difference
Average head circumference	52.04 cm	49.58 cm	2.46 cm smaller
Average height	133.68 cm	125.73 cm	7.95 cm shorter
Average weight	29.45 kg	24.38 kg	5.07 kg lighter

In addition, electroencephalogram data indicate that twelve of the undernourished children had poorly formed low-voltage alpha waves with poor response to eye opening, whereas seventeen of the controls had well-formed high-voltage alpha waves, especially posteriorly, with an excellent response to eye opening. In terms of the New South African Intelligence Scale (not standardized for Cape colored children), the mean for the control group was 76.70, and that for the undernourished group, 61.15--some 15.5 points lower.

Another study points to the same result--i.e., long-term crippling effects from nutritional deficiencies in early infancy, the period of maximum brain growth. From 1953 to 1964, data were

collected on 1094 autopsies performed at the Mulago Hospital at Kampala, Uganda, on children from the age of birth to fifteen years old. The children were divided into two groups: those who had suffered from malnourishment and those who had not. The malnourished children had been afflicted with kwashiorkor or marasmus. In each autopsy the child's brain was weighed. The findings for the age group 4 to 5 years indicated that the non-malnourished brain weight was 1127 grams, and the malnourished brain weight, 985 grams. The malnourished brain was 13% lighter than the non-malnourished brain (Brown, 1965).

At birth the human brain is approximately 40% of its adult weight; it increases to 70% after one year and to 80% by the age of two years. The brain increases in weight in incremental stages, but because of the metabolic stability of many of its constituents, once these constituents are laid down they may be inaccessible to the general metabolic pools of the body in times of shortage. Therefore, even good nutrition in later life cannot repair the irreversible damage done to the brain in infancy, damage which may well result in poor learning capacity in adult life (Brown, 1965; Scrimshaw, 1968). Such an assertion is supported not only by clinical experience with human beings, but also by experimental data on animals such as the pig and the rat (Barnes, 1967). A recent article covering studies of this kind notes that they

> ... indicate that poverty and the poor nutrition that almost invariably accompanies it may bring into the world children who are less able to learn and to earn than their genetic potential would otherwise allow.
>
> The studies give the expression "food for thought" a new dimension. They have shown that children who receive inadequate nourishment both before and shortly after birth suffer a diminished capacity for intellectual achievement.
>
> In fact, studies of infants and laboratory animals have indicated that children inadequately nourished while still in the womb may start life with a subnormal number of brain cells--a deficit which can never be made up. (Brody, 1968)

Thus, the concept of a close, reciprocal interrelation between aspects of organic growth and psychological capacity, influenced by both a social and an ecologic context, is a critical area for further research. Indeed, the spiraling effect, once set in motion, is difficult to break. Cravioto, after commenting on the pervasive and permanent psychobiological effects of protein malnutrition in Central America, another "underdeveloped" area, says on the "PCM spiral":

A low level of adaptive capacity, ignorance, social custom, infection, or environmental paucity of foodstuffs appears to result in malnutrition, which may produce a large pool of individuals who come to function in sub-optimal ways. Such persons are

themselves more ready to be victims of ignorance and less effective than would be the case in their social adaptations. (1966, p. 320)

A concept like the PCM spiral would seem to be particularly useful in understanding many aspects of the social history of West and Equatorial Africa. Vansina (1966) discusses the rise and fall of traditional political-military empires in the Congo in terms of the spread of cassava, a very-low-protein staple. Dependence on cassava is predispositional to the development of kwashiorkor and other deficiency diseases. Such a "cassava belt" stretches along the coast of West Africa where kwashiorkor was first clinically described. And the tragic events of today in eastern Nigeria and Biafra are only too compelling in their underscoring of the close relationship between a protein-adequate diet and effective bodily and psychological functioning. On the latter note--that of the interpenetration of "social" or "political" events and nutritional health--one may recall the pessimistic appraisal by the African pediatrician Hendrickse, who said:

> The high incidence of nutritional disorders in Africa today reflects the seriousness of the social and economic problems of the people of Africa. Current trends in African affairs offer little hope of improvement. On the contrary, the direction of social change and the long-term effects of economic policies currently in operation will inevitably result in deterioration of the present position. Meanwhile, the unstable political situation in the continent threatens constantly to disrupt the existing economic structure and to precipitate disaster. (Hendrickse, 1966, p. 346)

Beyond the obvious clinical cases of protein deficiency in African children in the towns, there are numerous cases of <u>subclinical</u> protein-calorie malnutrition, sometimes known as <u>mild-moderate</u> malnutrition. It is difficult to diagnose. Children suffering from mild-moderate malnutrition are not suffering from kwashiorkor nor are they visibly emaciated yet they are completely outside of the normal range of body weight for age, and they have an increased susceptibility to disease. How common this nutritional growth failure is can be judged by field surveys of preschool children and records of young-child clinics that often show that between 15% and 30% of children weigh below 75% of that which is normal for their age, and therefore fall into this mild-moderate malnutrition group (Cook, 1966).

Thus, it would appear that the major benefit of urbanization for child nutrition is the provision of clinics and other health facilities in which mothers can eventually be educated and severe cases of malnutrition can be treated. But thus far the overwhelming impact of the urban environment on child and adult nutrition has been negative.

In conclusion, we firmly assert that programs of economic or agricultural development, population relocation, industrial con-

struction, or any program which either deliberately or inadvertently changes pre-existing relationships between man and any aspect of his environment must be viewed from the outset in an ecologic framework. We must realize the serious hidden costs of a new "ecologic contract" between man and his surroundings. Perhaps it would be useful for public health specialists to start talking about a new category of diseases analogous to the "iatrogenic" diseases known in medicine. Such diseases could be called the "diseases of development" and would consist of those pathological conditions which are based on the usually unanticipated consequences of the implementation of developmental schemes.

Appendix

SOME PARASITES OF MAN AND DOMESTIC ANIMALS IN AFRICA FOR WHICH AN AQUATIC ENVIRONMENT IS OBLIGATORY
(Thomas, 1965)

PARASITES OF MAN

PARASITES	INTERMEDIATE HOST	METHOD OF INFECTION	MOST COMMON DISEASES TRANSMITTED
Viruses:			
About 32 mosquito-borne viruses are associated with human infections	Mosquito	Mosquito bite	Yellow fever, dengue fever
Protozoa:			
Trypanosoma gambiense Dutton	*Glossina palpalis* and *G. tachinoides* (found near water)	Tsetse bite	Trypanosomiasis (Gambian sleeping sickness)
Plasmodium spp.	Mosquitoes	Mosquito bite	*P. vivax*: benign tertian malaria *P. malariae*: quartan malaria *P. ovale*: mild tertian malaria *P. falciparum*: malignant subtertian malaria
Nematoda:			
Wuchereira bancrofti (Cobbold)	Mosquitoes	Insect biting man	Bancroftian filariasis (elephantiasis)
Setaria equina (Abildgaard)	Simulium, mosquitoes	Insect biting man	
Dipetalonema perstans (Manson)	Mosquitoes, *Culicoides*, *Simulium*, tabanids, *Pulex*, ticks	Insect biting man	
Dipetalonema streptocerca (Macfie and Carson)	*Culicoides*	Insect biting man	
Mansonella ozzardi (Manson)	*Culicoides*, *Simulium*	Insect biting man	
Dirofilaria repens (Railliet and Henry)	Mosquitoes	Insect biting man	
Loa loa (Guyot)	*Chrysops*	Insect biting man	Loiasis (calabar swelling)
Onchocerca volvulus (Leuckart)	*Simulium*	Insect biting man	Onchocerciasis (river blindness)
Dracunculus medinensis (L.)	Copepods	Drinking water containing infested copepods	Dracunculiasis (Guinean worm)
Trematoda:			
Fasciola gigantica Cobbold	Aquatic snail	Infective stage on water plants	Fascioliasis (river fluke)

Appendix (continued)

PARASITES OF MAN

PARASITES	INTERMEDIATE HOST	METHOD OF INFECTION	MOST COMMON DISEASES TRANSMITTED
Trematoda: (continued)			
Fasciolopsis fuelleborni Rodenwaldt	Aquatic snail	Infective stage on water plants	
Heterophyes heterophyes (Siebold)	Aquatic snail, fish	Infective stage in fish	Intestinal fluke
**Stictidora tridactyla* Martin and Kintz	Aquatic snail, fish	Infective stage in fish	Intestinal fluke
**Echinostoma revolutum* (Froelich)	Aquatic snail	Infective stage in snail or second intermediate host	Intestinal fluke
Echinoparyphium recurvatum (Linstow)	Aquatic snails, frogs	Infective stage in snails or frogs	
Paragonimus westermani (Kerbert)	Aquatic snail, crustacean	Infective stage in crustacean	Paragonimiasis (lung fluke)
Schistosoma mansoni Sambon	Aquatic snail	Infective larvae enter through skin of man	Intestinal schistosomiasis
Schistosoma haematobium (Bilharz)	Aquatic snail	Infective larvae enter through skin of man	Genitourinary schistosomiasis
Watsonius watsonsi (Coryngam)	Aquatic snail	Infective stages on water plants	Intestinal fluke
Cestoda:			
Diphyllobothrium sp. larva	Copepod, man	Infective stage in copepod	Broad fish tapeworm
**Spirometra pretonensis* (Baer)	Copepod, reptiles, amphibia, mammals (including man)	Infective stage in intermediate host	

PARASITES OF DOMESTIC ANIMALS

PARASITES	INTERMEDIATE HOST	METHOD OF INFECTION
Protozoa:		
Trypanosoma brucei	*Glossina palpalis* and other *Glossina* sp. Mechanically by tabanids or mosquitoes	Biting of cattle, sheep, goats, camels, pigs, dogs, etc., by flies
Trypanosoma vivax	*Glossina palpalis*, etc. Also mechanically by tabanids	Biting of cattle, sheep, goats, camels, pigs, dogs, etc., by flies
Trematoda:		
Fasciola gigantica Cobbold	Snail	Eating infested vegetation
Paramphistomum cervi	Snail	Eating infested vegetation
Paramphistomum microbothrium Frischoeder	Snail	Eating infested vegetation
Cotylophoron cotylophorum (Frischoeder	Snail	Eating infested vegetation

*Recorded in Africa but in mammalian hosts other than man. However, man is a potential host.

Appendix (continued)

PARASITES OF DOMESTIC ANIMALS

PARASITES	INTERMEDIATE HOST	METHOD OF INFECTION
Trematoda: (continued)		
Gastrodiscus aegyptiacus Cobbold	Snail	Eating infested vegetation
Schistosoma bovis (Sonsino)	Snail	Infective stages penetrate skin
Schistosoma matthiei Veglia and la Roux	Snail	Infective stages penetrate skin
Schistosoma leiperi (la Roux)	Snail	Infective stages penetrate skin
Schistosoma margrebowiei (la Roux)	Snail	Infective stages penetrate skin
Schistosoma curassoni Brumpt	Snail	Infective stages penetrate skin
Nematoda:		
Setaria equina (Abildgaard)	*Simulium*, mosquitoes	Fly biting horse
Setaria digitata (Linstow)	Mosquitoes	Fly biting sheep, horse
Setaria labiato papillosa (Alesc)	Mosquito	Fly biting cattle, sheep
Dipetalonema ruandae Fain and Herin		Fly biting cattle
Brugia patei (Buckley *et al.*)	Mosquitoes	Fly biting dog
Dirofilaria immitis (Leidy)	Mosquitoes, ticks	Fly biting dog, cat, etc.
Dirofilaria repens (Railliet and Henry)	Mosquito	Fly biting dog
Onchocerca armillata (Railliet and Henry)	?	Fly biting cattle
Onchocerca fasciata Railliet and Henry	?	Fly biting camel
Onchocerca gibsoni (Cleland and Johnston)	*Culicoides*	Fly biting cattle
Onchocerca gutturosa (Neumann)	*Simulium*	Fly biting cattle
Elaeophora poeli (Vryburg)	?	Fly biting ox
Dracunculus medinensis (L.)	Copepods	Cattle, dog, etc., drinking water containing infested copepods

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HEALTH ASPECTS OF ENVIRONMENTAL POLLUTION CONTROL:

PLANNING AND IMPLEMENTATION OF NATIONAL PROGRAMMES[a]

Report of a WHO Expert Committee[b]

The WHO Expert Committee on the Planning and Administration of National Programmes for the Control of Adverse Effects of Pollutants met in Geneva from 16 to 22 October 1973. Dr. P. Dorolle, Deputy Director-General, opened the meeting on behalf of the Director-General. He called attention to the differences among Member countries with respect to the scope and priorities of environmental pollution problems. In many countries, both developing and developed, pollution of the microbiological type still retained its importance; superimposed were the pollution problems resulting from urban and industrial development and the use of chemicals in agriculture, in industry, and in households in the form of chemical consumer products.

The Committee's tasks were to lay down general principles for the prevention and abatement of pollution, to delineate the functions of health authorities in this field, and to provide practical guidelines for the planning and implementation of national programmes for the control of adverse effects of pollutants on man's health and his wellbeing.

1. INTRODUCTION

Many countries state that the protection of human health and wellbeing is the primary purpose of environmental pollution control. In reality, however, there is usually a wide gap between the philosophy of health protection and policy decisions on environmental pollution control; this is particularly reflected in those policy decisions concerned with environmental problems in which the risk of adverse health effects is uncertain.

[a]World Health Organization Technical Report Series, No. 554; World Health Organization, Geneva, 1974

[b]This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the World Health Organization.

A review of the historical development of environmental pollution control programmes in industrial countries in the past decades shows that medical and public health experts had at first to face the complex question of scientific evidence on cause-and-effect and dose-response relationships between a pollutant, or pollutants, and observed adverse effects. Unless these experts could provide satisfactory and convincing evidence of the adverse effects of pollutants, their opinions were neglected or even rejected.

More recently, as a result of strong social pressures, medical and public health experts have often been confronted with the task of providing scientific evidence of safety in a given environmental pollution dispute. Contrary to the situation in earlier days, it is now frequently assumed that there is a hazard, even when no completely satisfactory proof can be provided.

The difficulty at present lies not in the acceptance of the general philosophy of human health protection but in the convincing presentation of the findings on safety and risk to human health arising from defined pollutants. In earlier days the situation described in the second paragraph of this section was more prevalent; now, however, in the period of keen social concern about environmental pollution, the situation described in the third paragraph has become more prevalent. Both attitudes are extreme ones. When the existence or absence of adverse effects cannot be definitely established, it is for the responsible public health authorities to decide whether a preventive or a conservative attitude should be adopted.

At present the insidious adverse effects, such as carcinogenic, teratogenic, and mutagenic effects, that may result from long-term exposure to a pollutant or pollutants are of greater social concern than the acute or subacute adverse effects. There is far greater uncertainty about the chronic adverse effects; nevertheless there is strong pressure for a preventive approach through prediction and evaluation of such adverse effects of environmental pollutants.

2. GENERAL CONSIDERATIONS ON A HEALTH-ORIENTED ENVIRONMENTAL POLLUTION CONTROL PROGRAMME

2.1 Scope of the problem

The environment is considered as polluted when it is altered in composition or condition, directly or indirectly as a result of the activities of man, so that it becomes less suitable for some or all of the uses for which it would be suitable in its natural state. This definition implies qualitative and quantitative changes in the physical, chemical, and biological properties of different components of the environment (air, water, soil, and food, and the occupational, residential, and recreational environment) that result from intentional or unintentional discharges

of waste materials or deliberate use of chemicals or dissipation of energy in the form of heat, noise, vibrations, or radiation. Pollution thus occurs when environmental changes create or are likely to create nuisances or hazards to public health, safety, or welfare, or when they are harmful to domestic, industrial, agricultural, recreational, or other legitimate uses of environmental components, or to livestock, wild animals, fish, aquatic life, and other biological species.

The uncontrolled discharge of domestic and municipal sewage, which always contains a variety of microorganisms, some of which may be pathogenic, affects water, soil, and food quality. It will remain the major problem of environmental pollution in most developing countries for many years to come, whereas in the more affluent countries it has been largely overcome. The problem of protecting watercourses from pollution by pathogenic microorganisms is of paramount importance for developing countries, because of their acute shortage of good-quality drinking water. However, protection against this type of pollution should not be forgotten in developed countries, which have areas where biological pollution is extremely important; recent experience shows that at certain times some communicable diseases related to the biological pollution of water and food can cause outbreaks of epidemic proportions. Existing methods of sewage purification (including biological treatment) do not completely elimiate microbiological pollutants and these may in some circumstances give rise to outbreaks of intestinal diseases.

Highly industrialized countries, however, face mainly problems of environmental pollution caused by chemical and physical agents. Moreover, in the developing countries, there are limited areas where rapid and uncontrolled urbanization and industrial development tend to create pollution problems of a more complex kind.

As nations move towards higher stages of industrial development, environmental problems are not necessarily always encountered in the same order or to the same degree. Because the situation is continuously shifting, environmental pollution control programmes must be flexible, adaptive, and innovative.

All aspects of pollution of the environment are directly or indirectly related to health and wellbeing. For some types of pollution, epidemiological evidence gathered over many years has established a definite cause-and-effect relationship. For others the effects are more subtle, and intensive study is still required to find out whether they are significantly related to man's health.

Public health and occupational medicine have played a leading role in the development of health-oriented environmental pollution control programmes. Public health has provided the epidemiological approach, laboratory facilities for pollution studies,

and approaches to water and food control derived from environmental sanitation practices. Occupational medicine, including toxicological and pharmacological research, has provided some of the basic knowledge of cause-and-effect and dose-response relationships between pollutants and adverse effects. Basic sciences (chemistry, physics, and biology) and engineering sciences have provided knowledge and understanding of environmental pollution phenomena. Engineering technology, in conjunction with physics and chemistry, has provided basic understanding of source control and the techniques for its application. Various sectors of administration, such as those concerned with public health, industry and trade, agriculture and water resources, and transportation and traffic, have gradually been involved in the formulation and development of health-oriented environmental pollution control policy and programmes.

In the formulation of environmental pollution control programmes, four basic questions have to be answered: (a) What and how much should be done? (b) How should it be done? (c) Who should do it? (d) When should it be done?

(a) What and how much should be done? The answers depend on the existing situation and on the forecast of future developments. The role of technical agencies is to present clear and accurate information on the alternative courses of action available and to assess the benefits and risk that may result from different alternatives. Such efforts will enable decision-makers to establish a policy and choose a course of action. The increasing number of new chemical contaminants and new opportunities for physical insults to human health put additional stress on the necessity for preventive programmes based on the study of potential or new health hazards of the human environment.

(b) How should it be done? This question is concerned with technology and management. Possible components of a control programme include the identification and quantification of pollution sources, baseline surveys, building of monitoring systems, establishment of acceptable limits for the quality of environmental media, making a choice of control technology, development of a legal and administrative framework, and the provision of manpower.

(c) Who should do it? An internal policy decision will be needed to decide who should implement the programme and which government agency should be involved. Since health considerations are of paramount importance, it seems reasonable that health agencies should participate actively in the promotion, planning, and evaluation of anti-pollution programmes and projects and be responsible for the setting of health standards for environmental quality and for environmental health monitoring and surveillance. On the other hand, the effects of pollution are far-reaching in nature and in time. Programmes aimed at improving the environment should therefore be developed cooperatively

by the agencies concerned and should include representation from industry and the general public.

(d) When should it be done? The answer to this question depends on the intensity of the problem and the benefits to be derived from pollution control, given the possible "trade-off" that it may permit resources to be diverted to high-priority programmes of social interest.

Defining national programmes poses a number of problems. These are related specifically to:

(1) the substantive content of the programmes, including the understanding of the relationships between pollution and health (this is the major problem); and

(2) the attitudes of the people and institutions involved, including the political, economic, and social circumstances as well as the level of development reached.

A distinction must also be made between preventive, curative, and restorative processes. In addition to measures for controlling pollution, there is a need for public education programmes stressing prevention. Both health protection and pollution control are essentially areas of clear, well-defined responsibility that can be assigned to the relevant authorities. There exist less clear peripheral problems where the degree of activity is conditioned by the competition for limited resources.

Two questions compound the issues of the peripheral problems: on the one hand, it is extremely difficult to obtain a consensus as to what should be done first and at what cost; and on the other hand, the traditional competition between various organizations may cause conflicts of interest that are not easily solved.

Although health is central to all measures for environmental management, health services proper are often largely divorced from the major efforts to control the quality of the environment. Health authorities must be aware of the levels of pollutants in the environment, as this knowledge is essential for preventing and controlling the hazards to man. Concentrations of various pollutants in air, soil, water, and food must be known, in order to estimate overall intakes, and the possible relationship between chronic disease and low-level exposure over many years must be borne in mind. Such considerations are now assuming greater importance because of new methodologies that allow identification of potentially toxic substances at very low levels. However, levels of pollutants in environmental media are not necessarily

correlated with exposure levels for man. Critical[1] pathways for the exposure of individuals and populations need to be examined. Exposure to pollutants occurs through air, water, food, and direct contact with the human body. These exposures may take place in occupational, community, residential, or recreational settings. The quantity and quality of total exposure through multiple routes in various settings are the major issues and should be carefully investigated. Characteristics of individuals or specific segments of the population, such as heavy fish-eating, are important considerations in assessing pollution exposure. Also, critical populations need to be carefully identified.

Determination of body burden (i.e., organ or tissue burden) is one way to assess the exposure of an individual to a pollutant. Estimations of the content of mercury in hair, lead in the blood, cadmium content in the urine, and organochlorine compounds in fatty tissue are examples of body burden determinations. Observation of the specific and nonspecific symptom or symptoms can provide background information for the identification, differentiation, and evaluation of health hazards caused by a pollutant. In making such an evaluation, consideration should be given to the reversibility or irreversibility of the disease symptoms and the fact that complications, recovery, residual disability, and death are different phases of the disease process. In addition to these somatic effects, the possibility of genetic effects should be considered. Also, transplacental transmission leading to direct fetal exposure should be differentiated from mutagenic effects.

Consideration must also be given to the transfer of pollutants from the source to environment and then to the target[2] where effects are produced. Each step of the transfer may have scientific, technological, administrative, legal, economic, social, or political implications.

Preventive and control measures can be applied at various points along the pathway from the pollution source to man. Generally, control at the source is most efficient, but action can

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[1] "Critical" is used in this report to describe pollutants, pathways of exposure, and groups of the population that deserve primary consideration (cf. Principles of environmental monitoring relating to the handling of radioactive materials, Oxford, Pergamon, 1966: International Commission on Radiological Protection, Publication 7). This use does not in itself entail any idea of danger.

[2] The target (or receptor) is the organism, population, or resource to be protected from specific risks. This definition, which includes organs or tissues, was proposed to the United Nations Conference on the Human Environment in Stockholm, 1972. See also: The WHO environmental health criteria programme (unpublished document EP/73.1), p. 36.

be directed to the discharge of pollutants into the environment (e.g., treatment of waste before discharge); to the various environmental media (e.g., improving the assimilating capacity of water bodies); to the prevention or reduction of exposure (e.g., quality control of food products, personal protective devices in industry, water treatment before distribution into the supply system); the prevention of adverse effects on exposed individuals (e.g., immunization); or the treatment of affected population groups. The effectiveness and the relative cost of the different measures vary according to the type of pollutant, the principal pathways of exposure, and the types of effects.[1]

2.2 Present trends and approaches

2.2.1 Principal approaches

There are two principal approaches to environmental pollution control: (a) environmental quality management, and (b) best practicable means.

(a) The environmental quality management approach relates control requirements to the desired quality of environmental media. Knowledge is required, therefore, not only of the desired environmental quality but also of the sources of pollution. Given such basic information, a mathematical model can sometimes be developed that can be used to forecast future pollution levels, for example, as a result of increasing urbanization, industrialization, and economic growth in general. The stringency of an abatement programme depends on the difference between the existing or estimated future environmental quality and the desired quality in terms of national standards or goals. When the necessary reductions in pollutant emissions are estimated, emission standards can be adopted. Effective application of the environmental quality management approach requires adequate surveillance networks and the full use of the data gathered.

Environmental quality management is a logical approach. It encourages the development of coordinated programmes, combining various activities, such as city planning, industrial development, water resource development, and transport policies, in order to achieve and maintain the desired environmental quality. It has, however, a number of drawbacks. Present knowledge of the effects of many pollutants is incomplete, so that scientifically based environmental quality criteria and standards are difficult to formulate. Emission inventories and pollution transport data are particularly incomplete and approximate, and the prediction of environmental quality based on such limited information is subject to a large margin of error. There is therefore a need for continuous reappraisal of the adequacy of the predictions made in the planning stages as additional information becomes

[1]See also: World Health Organization (1972) Health hazards of the human environment, Geneva, Part IV.

available on the performance of control programmes, and programme readjustments must be made when necessary.

(b) The best practicable means approach stresses that the emission of a pollutant should be kept to a minimum without reference to environmental quality standards. For this approach to be effective, there must be an authority to decide in each case on the best practicable means of controlling the particular emission. The determination of what constitutes the best available control technology is not a simple process; the expenditure that is considered acceptable depends on the effects of pollution on the environment and human health, and on the political climate and public opinion. Indirectly, some consideration is given to environmental quality also in this approach. Because it is more expensive to introduce controls on existing installations than on new plants, a practical consequence of the adoption of the best practicable means approach is that the requirements for new ad for existing sources of pollution are often different. Emission standards are used to define the best practicable means for single sources.

These two approaches are not mutually exclusive, but complementary; and in practice they are usually combined.

2.2.2 Environmental impact

There have been several studies aimed at the total environmental assessment of major projects--with a view to predicting the environmental consequences of the construction and operation of major works. The methods by which the studies have been undertaken are variable and reflect specific orientations to the project category (hydroelectric installations, nuclear power plants, industrial complexes, transportation facilities, airport developments).

Environmental impact has been defined as the sum of the short-term and long-term effects of any proposed action (or absence of action) on man himself and on the physical, biological, and socioeconomic environments, including the effects of policies, legislative proposals, programmes, projects and operational practices. Attention needs to be paid to significant adverse effects on the quality of man's environment, including both those that affect him directly and those that affect him indirectly through adverse effects on the environment.

2.2.3 Forecasting potential environmental health hazards

After-the-fact recognition of adverse health effects on man and his environment has prompted administrators and scientists to

examine potential hazards from exposure to new products resulting from technological advances.[1] It can be predicted that certain technological possibilities will be realized; for example, alternative sources of power will be developed to meet the current fuel crisis. Other developments, however, may be of a totally unexpected nature.

In considering technological forecasting one must first agree on the appropriate time-scale. The turn of the century may be a useful reference point for forecasting densities and determining the necessary supplies of food, air, water, and adequate living space, and the requirements for waste disposal sites. However, it is even more important to look at the technological developments that are likely to take place in the near future and can be examined with a greater degree of assurance that the extrapolations are accurate.

Well-established technologies may be changed because the demand has increased, because the raw materials needed are no longer available, or because the cost of processing has ceased to be profitable. Thus, known toxic products may be produced in increasing amounts or become more difficult to remove. It is also possible for administrative measures to produce potential health hazards without the adoption of new technologies, for example, by blocking old ways of waste disposal. In these situations proper forecasting is possible without too much uncertainty.

It is clear that in making such evaluations heavy reliance is placed on known facts about old technologies and less weight on evaluations of new and untested procedures. Where drastic changes in technology are made, it is essential to look for unusual exposure of certain population groups to new chemicals and by-products, in addition to exposure of the general population.

A thorough evaluation is needed of the whole complicated field of the interactions of old and new pollutants and their effects on the ecosystem and on the health and wellbeing of man. This is no easy task because many ill-effects are the results of long-term exposure to some agents, so that evaluations are not easily made and experimental data are not readily confirmed by epidemiological investigations in man. The difficulty in assessing potential health hazards from new technological developments is further compounded by the fact that those who develop industrial processes are lacking in awareness of the potential damage to health that might occur.

[1] See also: Environmental health criteria: Report of a WHO Scientific Group (unpublished document EP/73.2), chapter 5; The WHO environmental health criteria programme (unpublished document EP/73.1), chapter 6.

Methods of technological forecasting have yet to be developed, and little experience is available to indicate how the resulting information should or will be used by responsible agencies. However, if such agencies over-react to possible low-risk threats, new and potentially useful technologies may remain undeveloped. The development of such technology forecasting should be approached conservatively and cautiously. It must also be looked at in the international context. National governments in neighboring countries may propose very different solutions to pollution problems. But since pollutants do not recognize national borders international agreement on methods for the evaluation of technological trends and their potential health hazards is essential.

2.2.4 Management techniques and information processing

It is important for the administrator and others connected with environmental quality control to become acquainted with modern management techniques so that they can communicate effectively with the experts.

The problems of environmental pollution control have become complex as a result of technological advances, and over the past few years considerable interest has been focused on the use of modern management techniques. Among many techniques that have been applied to environmental quality management problems are techniques based on systems theory, systems analysis (including linear and non-linear programming), dynamic programming, integer programming, and stochastic programming; queuing theory; network techniques, such as programme evaluation and review techniques (PERT) and the critical path method (CPM); and simulation techniques.

Systems analysis is a strategy for solving problems that relies heavily on mathematical modeling to assess the technical and economic merits of alternative systems, designs, policies, and operating procedures for performing various functions and meeting various needs with limited resources. It seeks to rationalize the application of common sense, assisted by mathematics and computer techniques, to the solution of problems of allocating limited resources to competing activities in an optimal way.

Although they have limitations, systems analysis techniques have some advantages over traditional methods. First, they provide for a more effective union of technological and economic considerations in the formulation and solution of management problems. Secondly, they provide the means of analyzing alternatives and incorporating considerations relating to risk and uncertainty, factors that should not be ignored although they cannot be evaluated precisely for many situations.

Many mathematical management models and optimization techniques would be of academic interest only were it not for the concurrent development of high-speed digital computers. The use of mathematical models to explain in detail interactions of a large number of systems components, and the effects of these interactions on total systems cost, performance, or other characteristics obviously requires the processing and organization of large amounts of information. This can be done efficiently only with high-speed computers.

Limitations in the application of these modern management methods to environmental pollution problems are of two types: data limitations and conceptual limitations. Data limitations arise when insufficient information is available to permit the determination of critical parameters, costs, functions, or other variables that may be needed to generate solutions to the mathematical model. Conceptual limitations arise when the structure of the system and the interrelationships between its components are not sufficiently well understood for the real system to be represented accurately by means of a mathematical model, or when the system under investigation is too complex to be represented by a model.

Perhaps the most serious constraint on the application of systems analysis to environmental pollution problems relates to the lack of reliable and informative data. It is not difficult to conceive of environmental pollution problems that are amenable in principle to fruitful analysis by these techniques. It is much less certain, however, whether sufficient and reliable input data exist for a satisfactory solution to be obtained.

When limitations such as those discussed above are encountered, the usual management approach is to employ simplifying assumptions in order to overcome the difficulties. In interpreting--and especially in applying--the results of such a simplified analysis, it is therefore of the utmost importance to determine and evaluate the validity of the assumptions used.

In conclusion, these modern management techniques are very useful tools provided they are applied with caution and by experienced experts. It should, however, be remembered that they cannot replace experience and professional judgement.

There are many specific models of information processing, but they cannot be useful unless there is a will and a common resolve to reduce the distance that has traditionally separated professionals, technicians, and administrators working in the field of environmental health.

3. POLICY FORMULATION

Policies for the control of the adverse effects of pollutants on man's health must clearly be made consonant with the

other social objectives and, as another expert committee has clearly stated,[1] they must fit into the political and administrative framework within which they will be implemented.

3.1 Objectives

The objective of a health-oriented environmental pollution control programme is to promote better quality of life by reducing pollution to the lowest level possible.[2] An additional objective is the assessment of possible adverse effects of new or potential pollutants and the prevention of environmental health hazards through the control of input of pollutants into the environment.

Monitoring of pollution and surveillance of the health of the population are undertaken to assess and evaluate the background levels and distribution of pollutants in environmental media and in man. Continuous monitoring and surveillance can provide important background information and indicate changes in pollutant levels in the environment and in the target organism. Special investigations should be carried out to provide the information necessary for the early detection of specified adverse effects. Such studies should preferably be focused on critical population groups exposed to specified pollutants under well-defined environmental conditions.

Case identification, differential diagnosis, and the subsequent treatment and rehabilitation of fictims are the objectives of action taken in the case of accidental or other episodes of acute pollution. Special environmental health-care systems, compensation programmes, and the reclamation of the polluted environment are essential parts of these remedial approaches.

3.2 Priorities

An important problem in making policy decisions on the formulation and development of environmental pollution control programmes is the identification of priorities. As is pointed out in the later section on resources (section 5.6), various programmes compete for the same limited resources and there must be a correct appraisal of the need for the pollution prevention and control in relation to other national programmes. Once resources are allocated to a programme, they must be distributed in some priority order to the competing components of the programme. This priority order may differ from one country to another, depending on local circumstances. For example, microbial pollutants are still much more important for many countries than chemical contaminants, a fact clearly reflected in the high priority given to basic sanitation in the WHO environmental health programme.

[1] Wld Hlth Org. techn. Rep. Ser., 1970, No. 439.

[2] Cf. Off. Rec. Wld Hlth Org., 1971, No. 193, p. 114.

Priorities also differ somewhat within different aspects of the programme. For example, the pollutant priority for present regulatory action programmes will be somewhat different from that for the development of control technology or for research on pollutant health effects. Since all these priorities are based on the prevention of pollution effects, there are some general principles that it is useful to keep in mind when establishing them. Some of these principles deal with the characterization of the pollutant itself, and the population exposed; they have been summarized as follows:[1]

Severity and frequency of observed or suspected adverse effects on human health. Of importance are irreversible or chronic effects, such as genetic, neurotoxic, carcinogenic, and embryotoxic effects including teratogenicity. Continuous of repeated exposures generally merit a higher priority than isolated or accidental exposures.

Ubiquity or abundance of the agent in man's environment. Of concern are inadvertently produced agents, the levels of which may be expected to increase rapidly, and agents that add to a natural hazard.

Persistence in the environment. Pollutants that resist environmental degradation and accumulate, in man, in the environment, or in food chains, deserve attention.

Environmental transformations or metabolic alterations. Since these alterations may lead to the production of chemicals that have greater toxic potential, it may be more important to ascertain the distribution of the derivatives than of the original agent.

Population exposed. Attention should be paid to exposures involving a large portion of the general population, or occupational groups, and to selective exposures of highly vulnerable groups represented by pregnant women, the newborn, children, the infirm or the aged.

Consideration should also be given to the possibility that a pollutant may be important in another public health problem, e.g., that it may contribute to the pathogenesis of heart disease or some other major condition. Such possibilities certainly give the pollutant a higher priority for research and, if the suspicions are confirmed, they also give it a higher priority for regulatory or control action.

[1] Environmental health criteria: Report of a WHO Scientific Group (unpublished document EP/73.2).

There are, of course, difficulties in determining priorities. Priority setting may be facilitated by analogy with a known problem or frustrated by the paucity of knowledge or by conflicting conclusions from existing research. Other factors, such as interactions of pollutants, availability of control measures or techniques of prevention, social awareness of the problem, social acceptance of the control measures, and availability of material resources, including trained manpower, can influence priorities. Previous WHO reports have dealt with these considerations in more detail.[1]

3.3 Cost/benefit analysis

Clearly, decisions concerning the degree and nature of pollution control and abatement require a comprehensive estimation of the costs and benefits involved. However, there is no completely satisfactory and objective means of arriving at such decisions. Three main reasons for this are pointed out in a report of the Royal Commission on Environmental Pollution.[2]

(a) There are great practical and theoretical difficulties in measuring all the costs and benefits or reducing pollution.

(b) Even if all these difficulties could be overcome and all the data on costs and price collected, acceptance of the data as "true" measures of the relevant social costs would involve ethical rather than scientific judgements and they would be influenced in conflicting ways by different aspects of our present legal, political and social framework.

(c) ...an important consequence of measures to reduce pollution will be that some people will lose while others will gain. It is true that distributional effects of this nature are likely to follow from almost any economic measures but the special nature of pollution costs, that is their "externality", is such that the distributional impact of measures to control pollution is likely to be larger than usual and hence to have important political and social implications.

The report goes on to point out that "...the difficulties of obtaining precise scientific measures of the relationship between the costs and the benefits must not provide a pretext for failure

[1] The WHO environmental health criteria programme (unpublished document EP/73.1); Environmental health criteria: Report of a WHO Scientific Group (unpublished document EP/73.2).

[2] Royal Commission on Environmental Pollution (1971) First Report, London, Her Majesty's Stationery Office.

to analyze individual pollution problems as carefully and quantitatively as possible..., the difficulties as formidable as they are, should not prevent us from reaching decisions about the scale of abatement of pollution which is socially desirable...".

The issue raised in (c) above is that the costs of meeting the adverse effects of pollution are seldom paid completely by those who cause it. At this point, governments have to intervene in the process and allocate responsibility. In simple terms this can be done by two methods often used in combination: (1) incentives not to cause pollution; and (2) deterrents to prevent pollution from causing harm to others.

The economic approach to pollution control refers to positive or negative impositions (subsidies or taxes) to achieve an equitable allocation of costs. Requiring somebody to pay for damage caused to others forces him to assume increased "private" costs to offset the "social" costs that are the result of his actions. It may also be less expensive for the authorities to subsidize pollution control measures rather than risk the unwillingness or inability of industry to sustain the cost of such measures, as this may result in unemployment and loss of other benefits for the region. Generally it is better to keep the two problems separate and to think in terms of offering both an incentive to production and a deterrent to pollution.

The costs of pollution control will vary widely for different activities at different levels, but the general approach, which is now standard, is represented in Fig. 1. Moving to the right along the horizontal axis signifies a reduction of pollution resulting from increased control, whether imposed or carried out voluntarily. The curve $C-C_1$ represents incremental costs of control, and the curve $B-B_1$ represents the benefits secured by the decrease in damage as a result of control.

FIG. 1. COMPARING THE BENEFITS AND COSTS OF POLLUTION CONTROL OR ABATEMENT

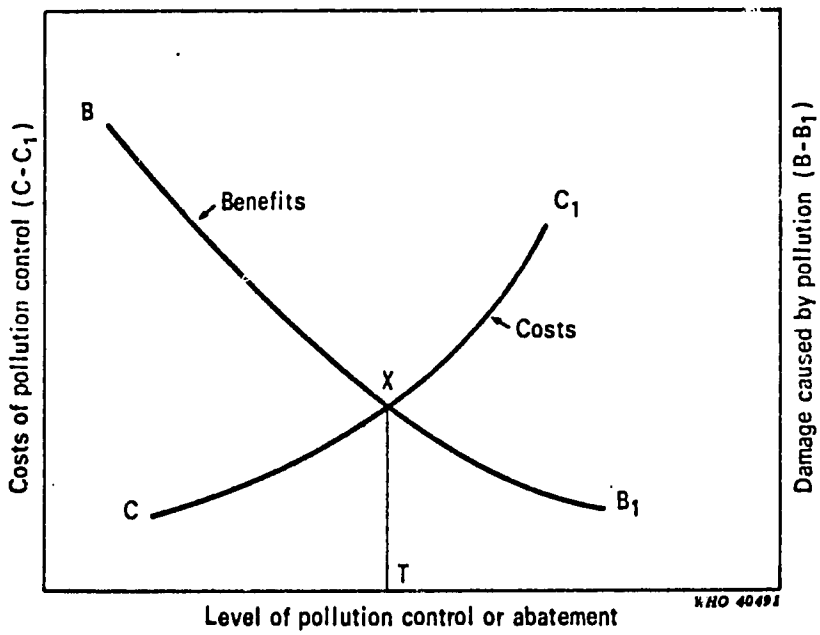
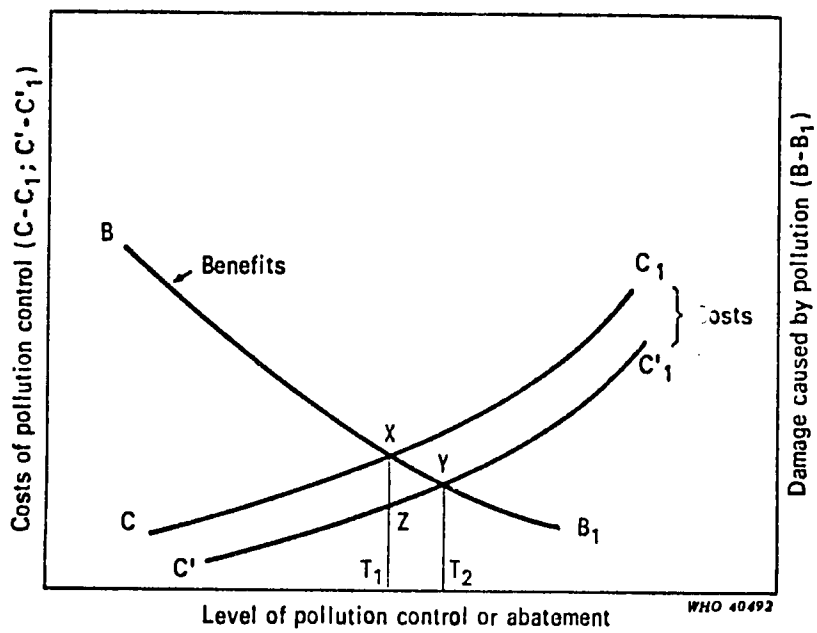


FIG. 2. COMPARING THE BENEFITS AND COSTS OF POLLUTION CONTROL OR ABATEMENT—THE EFFECT OF TECHNOLOGICAL INNOVATION



For society the optimal amount of control is at the point T since, past that point, the costs of control exceed the benefits obtained.

This objective can be secured in two ways, either by the introduction of a regulatory licence conditional upon control or by imposing a fee, which would be progressively reduced from B to X as better control was achieved. Obviously, once the level of pollution control reaches T, it would be cheaper to pay the fee than to improve control further.

The double advantage of this method is that the same result is obtained from the same basic information. Safety factors can be incorporated either by raising the curve $B-B_1$ or by raising the level of treatment required.

If the cost of control is reduced through technological innovation, the curve $C-C_1$ is lowered to $C'-C'_1$, as shown in Fig. 2 and there is therefore an incentive to increase the level of control to T_2. The net social cost of using licensing, rather than incentives, is represented by the triangle XYZ.

If some pollution is to be permitted, incentives are an efficient way of allocating "pollution rights". The fees derived can be used for compensation payments, overall environmental improvements, ecological research, and other investments that are difficult to finance by other means.

4. TECHNICAL PROGRAMME COMPONENTS

4.1 Criteria, risk and benefit considerations, and standards

4.1.1 Criteria

Criteria are essential to provide a rational and scientific foundation for the standards on which administrative decisions and actions will be based.[1] Although the terminology in current use is not uniform, a criterion is generally understood to be a body of knowledge used as a basis for judgement. As applied to pollution and its effects, criteria can be defined as information on exposure-response relationships. In practice, it is usually difficult to obtain quantitative information on exposure and response in man, particularly for chronic effects caused by long-term low-level exposure. Qualitative information can be obtained more readily. Dose-response relations can be obtained from animal experiments with a reasonable accuracy, especially in tests at fairly high levels of exposure, but it is not an easy task to obtain exposure-response information with satisfactory accuracy at low levels of exposure.

[1]See also: The WHO environmental health criteria programme (unpublished document EP/73.1); Environmental health criteria: Report of a WHO Scientific Group (unpublished document EP/73.2).

In retrospective studies in man, information on exposure is usually seriously limited, and the time periods and levels of exposure pose difficult problems. It should be stressed that, for epidemiological studies to be meaningful, there should be both full monitoring of the environmental media to assess exposure and measurement of effects in the population. Environmental health epidemiology requires a complex and extensive interdisciplinary approach with close collaboration among specialists in both the environmental and the health sciences.

The effects on human health of exposure to environmental pollution may be either short-lived and reversible or permanent. Acute and chronic effects may occur after a short-term or single exposure to a hazardous substance at high concentration, or may result from low-level long-term exposures, whether continuous or repeated intermittently. Classical toxicological studies on animals are generally designed to detect only the acute effects of short-term exposures. Epidemiological studies of natural living populations, on the other hand, tend to focus on chronic effects of long-term exposures. The chronic effects of short-term exposures and the acute effects of long-term exposures are often neglected. Thus, for example, a single high dose of asbestos (short-term exposure) may cause lung cancer after a lapse of many years (chronic effect), while an acute heart attack in a non-smoking urban resident may have resulted from the continuous stress of city noise, pollution, and crowding (long-term exposure). These associations are difficult to establish scientifically because cause and effect are often far apart in time. Ultimately, the ability to associate acute and chronic health effects with short-term and long-term pollutant exposures is determined by the current state of etiological knowledge.

When information about exposure-response relationships is being used in the preparation of criteria documents,[1] the conditions of sampling, analysis, measurement, and data-processing must be examined in relation to the exposure conditions of the host (target). Critical evaluation of exposure conditions is

[1] Criteria are critical summaries of the existing knowledge ready for application--expressed, if possible, in quantitative terms--on identifiable immediate and long-term effects on man's health and welfare which may be expected from the presence (singly or in combination) of chemical and biological pollutants in air, water, land and food, or from physical factors such as noise, vibration, ionizing and non-ionizing radiation, temperature, radiant heat and humidity, low and high barometric pressure and crowding (Off. Rec. Wld Hlth Org., 1971 No. 193, p. 98). The Twenty-sixth World Health Assembly in 1973 recommended that governments should, inter alia, participate in the WHO long-term programme in environmental health, particularly in the formulation of environmental health criteria, by contributing reviews on national research related to the health effects of environmental pollution and other environmental agents (Resolution WHA 26.58, Off. Rec. Wld Hlth Org., 1973, No. 209, p. 32).

the key problem in the assessment of pollution effects in terms of exposure-response relationships. The information on health responses is essentially a probelm of identifying sensitive indicators of biological response that can be applied to individuals regardless of whether their exposure is occupational or otherwise. Medical and public health personnel are then faced with the problem of deciding whether the objective indicator so measured represents an adverse health effect.

Criteria documents should be strictly scientific in nature, which means that they should be prepared by groups of scientific experts under their own names and responsibility. Administrators must furnish needed administrative and financial-support but should not interfere in their preparation. The documents should contain accurate information about what is known and where more information is needed. Uncertainties should be made explicit. It is also highly desirable for them to include risk information, expressed in terms of the probability of adverse effects. Such risk data will be of great help to policy-makers when they take decisions on standards on the basis of the criteria documents. While no one disputes that the main concern of pollution control is to protect human health, disagreements do arise when the required level of health protection is being decided for a specific pollutant and a specific effect.

4.1.2 Risk and benefit considerations

To permit wise steps to be taken towards legislative control of hazardous substances in man's environment, it is essential to make a very careful evaluation of risks and benefits, but this may be extremely difficult.

The expertise needed for the evaluation of risk is different from that needed for benefit evaluation. On the risk side, concern is focused on adverse health effects on man, damage to the environment, and misuse of natural resources. On the benefit side, the emphasis is on value to the consumer and on the country, i.e., improvement in the health of the population and the availability of cheaper and better products, particularly those that modern man considers indispensable. Economic considerations, such as the improvement of productivity, the development of resources, or a better balance of trade, are also important.

In both types of evaluation, consideration must be given to the consequences that could arise from a regulatory action. It is possible that the remedy may prove to have worse consequences than the evil it was intended to cure. For example, the proposal that the addition of tetraethyl lead to petrol (gasoline) should be discontinued raises questions about the impact on health from the increase in aromatic compounds in the fuel and the possible introduction of larger quantities of other antiknock agents.

Other problems that may arise are of a different kind. For instance, cloud seeding, once established as effective, raises

the issue of its permissibility, since precipitation in one place may decrease rainfall in another. Moreover, the production of rainfall to serve the needs of one group, e.g., orchard owners, may be detrimental to the interests of another activity in the same area, such as the tourist trade.

Although the evaluation of benefits presents few problems--the monetary value of some aesthetic advantages is not easy to assess--the evaluation of risk has always been difficult. The problem lies in the uncertainty of extrapolations from experimental studies on laboratory animals, using high exposure levels, to conditions encountered by man. Protecting a very large and varied population from harm is a very different matter from knowing what may happen to a small group of animals living under optimal conditions, especially in view of the importance of genetic and nutritional and other environmental factors in modifying human susceptibility to toxic chemicals in the environment.

The existence of such modifying factors, which complicate toxicological assessments, has been well documented for man. Examples are cigarette smoking, where cocarcinogenic factors seem to play a very important role, and industrial exposure to mineral oils, where the observed incidence of skin cancer could not be correlated with the content of carcinogenic polycyclic hydrocarbons. Animal experiments have shown that other components of the oils, such as dodecane and related compounds, although not themselves carcinogenic, could enhance tumour incidence and reduce the latent period significantly.

Dietary factors have also been found to exert considerable influence on the incidence of tumours in man and experimental animals. Some of the reasons are now understood, such as the inhibition of metabolic processes by vitamin deficiencies leading to a change in the cancer risk, but others, such as the cocarcinogenic effect of a high fat diet, have not been explained

Inability to extrapolate with any degree of confidence has led to stringent and inflexible legal action in some countries forbidding the use of carcinogens (as detected in laboratory studies) as food additives, a step that could not be taken in other situations where carcinogenic chemicals are present in man's environment.

In order to make an acceptable evaluation of carcinogenic risk, it is essential to clarify the question of the existence of a threshold below which no adverse effect occurs, or, if it does, occur, it is reversible. That such a threshold exists is not doubted. There is evidence for it in the efficient repair of genetic damage in microorganisms and in human cells in culture. In contrast, cells of human subjects with deficient DNA repair mechanisms are far more susceptible to carcinogenesis by ultraviolet light or certain chemicals. This observation has been made on men suffering from the genetically determined disease

xeroderma pigmentosum, who show a greatly increased incidence of small skin cancers in areas habitually exposed to light.

Thus organisms possessing adequate DNA repair mechanisms have a much higher carcinogenic threshold than do deficient ones. However, it should be stressed that a number of chemicals have been found that will inhibit DNA repair mechanisms and therefore merit careful study.

The metabolic pathways that may activate or deactivate certain chemicals that are precursors of toxic substances are very numerous. The degree to which one or the other enzyme system predominates may depend on hormonal, genetic, or enzyme inductive factors. A threshold for carcinogenesis exists here, too, but its determination is difficult.

Synergism between chemicals in their effects on biological systems has been described for many situations. A well-known example is pesticide synergism, which has found practical application in the use of pyrethrins together with piperonyl butoxide. With regard to carcinogenesis, it has been shown that in the absence of promoter (or cocarcinogen) small amounts of carcinogen applied to the skin remain without demonstrable carcinogenic activity to the end of the life of the animal.

If the dose-response curve of a chemical is such that no adverse effect will occur within the average life expectancy of the species, the threshold value for that chemical will generally not be reached provided the individual is kept free from exposure to cocarcinogenic agents or other synergists and his immunological competency remains intact.

This concept differs from the principle originally adopted by the International Commission for Radiological Protection in 1958, that every and all exposure, however slight, could entail a risk, the significance of which increased with the dose. It must nevertheless be pointed out that recent findings in basic radiobiology may make us reconsider this concept of the absence of a biological action threshold for ionizing radiation, especially the discovery of the important phenomenon of genetic repair.

The so-called "one-hit" theory of radiation exposure cannot be translated into a "one-molecule" theory for toxic chemicals, for this would imply that one molecule could exert a permanent effect on DNA and that a cumulation of similar minute effects received over a lifetime could finally produce overt symptoms of cancer. Experiments, however, have failed to show such a cumulative effect; on the contrary, initiated cells (cells that have been transformed into dormant cancer cells) do not necessarily persist because if a strong promoter is applied later no cells are activated. These findings suggest that a threshold exists for carcinogens and mutagens as for other toxicants.

These examples suggest that, in principle, a risk/benefit evaluation is possible even for carcinogens and mutagens, although this does not imply that there are a certain number of cancers or genetic defects that are, by necessity, acceptable.

4.1.3 Standards and guides

Whereas determining criteria and producing criteria documents is essentially a scientific task, setting standards is a matter of policy decision and administration. As there are various kinds of standards, the first question must be what kinds are going to be set. It should be clearly stated whether the standards are to be for desirable conditions, for minimum requirements, for maximum permissible or allowable conditions, or for specific conditions or specific actions.

Desirable conditions may serve as performance goals for control programmes in already polluted areas. However, such standards should not be considered as granting an authorization to pollute non-polluted areas. The principle of keeping environmental pollution as low as possible is crucial to environmental policy development. On the other hand, desirable condition standards cannot always be used as direct enforcement tools. Minimum requirement conditions serve as obligatory instructions for a control programme, but it is similarly doubtful whether they can be used as direct enforcement tools for source control. While minimum requirements for the maintenance of environmental quality and for source performance can be set as a general policy decision, standards for maximum permissible conditions should then be applied as direct enforcement tools. If pollution exceeds the maximum permissible conditions, authority for pollution control should be exercised immediately. Injunction, abatement, suspension, and cancellation are typical administrative actions in cases of violation. Unless there is guaranteed administrative authority and power for taking appropriate enforcement actions, it is pointless to set maximum permissible or allowable standards. Some specific provisions may be stipulated for the enforcement of maximum permissible standards--for example, the maximum permissible concentrations may apply only to new sources or new areas, and some time delay may be allowed for compliance in the case of old sources and already polluted areas--but such provisions should be the exception rather than the rule.

Guides for specified administrative actions are useful tools for environmental management operations. For example, in air management programmes guides will specify various degrees of control action for different alert or warning conditions. In some cases, automobile traffic control will be exercised to a specified degree, or operations control will be implemented to reduce fuel use or a technological process to a specified level. Other cases may call for the initiation of a special surveillance programme. To take another example, if the cadmium content of unpolished rice is found to exceed 0.4 mg per kg, the guide may

specify that a detailed pollution and health study is to be started in specified areas; if it exceeds 1 mg per kg, then soil reclamation may have to be implemented.

In most cases, environmental quality standards have little significance if the number of emission sources is small, because source control can be exercised by means of emission or effluent standards. However, if the sources are multiple and numerous, environmental quality standards have important implications for setting emission standards. Individual emission standards should be set so that environmental quality standards will be satisfied even if there is possible compounding of pollution contributions from each individual source.

When standards are being set for environmental quality, with the object of enhancing the general wellbeing and quality of life of the population, amenity and aesthetic values will be the determining factors. In the present climate of keen awareness of the quality of the human environment, practitioners of medicine, occupational health, and public health need to have a proper orientation in these matters.

The role of scientists is thus to provide the best information possible in the form of criteria documents; the role of administrators is to choose appropriate standards based on probable consequences, as detailed in the criteria documents, and propose alternative measures for implementing them as quickly as possible. It is wise to make the criteria documents, possible standards, and alternative control measures and their consequences known to the public and ascertain its value judgements and preferences. This will help in selecting from the proposed alternatives those that are socially acceptable. Understanding the social climate and public preferences is essential for decision-makers and politicians.

Through such procedures, definite standards can be adopted on the basis of criteria documents and the necessary policy and administrative guidelines for implementation of the control programme can be established.

4.2 Monitoring and surveillance

Monitoring programmes are concerned with sources of pollutants, pollutant levels in environmental media, and the effects of pollutants.[1] Thus, the essential components of a monitoring and surveillance programme are: continuous and systematic checking of these sources, levels, and effects; compilation, analysis, and evaluation of relevant data in terms of the available criteria and standards; the application of measures indicated by

[1]See also: World Health Organization (1972) Health hazards of the human environment, Geneva, p. 269.

these findings; and a feedback mechanism to facilitate the updating of scientific and technological knowledge.

Monitoring and surveillance programmes may be initiated for several reasons: (1) for environmental quality management purposes in the case of pollutants for which criteria and standards have been established; (2) to deal with specific pollution problems over a wider geographical area; (3) to facilitate retrospective assessment once a new pollutant has been identified or a more sensitive technique developed; (4) to determine pollution trends; and (5) to devise models of human exposure.

Adequately compiled source inventories are an indispensable part of monitoring and surveillance in current environmental pollution control programmes. Monitoring of pollutant sources has often been regarded as outside the scope of health-oriented pollution abatement programmes, and monitoring and surveillance have traditionally been directed at environmental pollution levels and their effects. However, with the growing importance of chemical pollutants having potentially grave effects on health, their monitoring and surveillance at the source has become an important element in health-oriented regulatory programmes. Furthermore, as the result of progress in instrumentation technology, it is now routine practice to monitor and survey emission sources simultaneously with the monitoring and surveillance of environmental quality.

One important problem is to decide what pollutants are relevant to source monitoring from the standpoint of health. For example, in the case of Minamata disease it was learned that methylmercury could not be found in the plant effluent because its concentration was below the sensitivity of the analytical method used. However, methylmercury was found in the bottom sediment in the water zone just below the plant effluent outlet.

Environmental pollution data and source emission data should be considered simultaneously by the control authority. In addition to source inventories, systematic monitoring in an environmental pollution control programme should therefore include monitoring of the natural environmental media (air, water, and soil), food and drinking water, and appropriate human samples such as hair, blood, urine, fat, and organs. In addition, there should be special monitoring programmes concerned with the occupational environment[1] and with pollution accidents.

Monitoring and surveillance programmes require many resources in terms of professional experts, equipment and facilities, time, and costs, so that it becomes a pressing task to determine priorities as regards pollutants and effects to be monitored. As already disucssed, priorities should be carefully examined at the

[1]See also: Wild Hlth Org. techn. Rep. Ser., 1973, No. 535.

preparatory stage of planning and designing such programmes. The second important step is the specification of sampling requirements, measurement methods and instruments, and data processing and evaluation procedures. The design, implementation, and management of a sampling system all require the collaboration of experts from a wide range of professional disciplines. In addition to expertise in sampling design and practice such as can be offered by those with experience in traditional public health or environmental sanitation surveys, special expertise from other sectors of science is needed. For example, soil sampling, crop sampling, and fish sampling require special design and precautions. Analytical (measurement) precision and qualtiy control requirements are also inportant for obtaining accurate, valid data and may call for special skills. Determination of critical exposure groups may require the help of ecologists and anthropologists familiar with local cultural and other factors. Modern engineering technologies of simulation and prediction can often be helpful in spot-sampling in given areas. Briefly, expertise is needed from a broad spectrum of basic and environmental science sectors, such as chemistry, physics, biology, meterololy, geophysics, geochemistry, agronomy, hydrology, oceanography, and agricultural and aquatic sciences.

In the selection of methods and procedures for analysis and measurement, the specific requirements and objectives of monitoring and surveillance should be kept in mind, e.g., whether one is carrying out research monitoring, a routine administrative programme, or a special problem investigation that may involve legal issues. Standard methods or reference methods should be specified and inter-laboratory calibration procedures should be decided on as necessary. The provision of an arbitration laboratory is desirable when highly controversial problems are being dealt with. The technical feasibility of methods and procedures should be carefully examined, as well as ease of operation and maintenance. Computerized data processing and recording methods should be designed by communications and information experts.

4.3 Prevention and abatement technology

Technological methods used for preventing or reducing environmental pollution[1] fall under the following broad categories:

(a) Waste management--the collection, storage, transport, treatment, disposal, and recycling of wastes.

(b) Development and use of alternative raw materials and fuel in industrial processes, heating, and power generation.

(c) Application of low-waste technology.

[1]See also: World Health Organization (1972) Health hazards of the human environment, Geneva, chapter 33.

(d) Development of alternative energy sources (e.g., the use of nuclear or hydroelectric sources instead of fossil fuels).

(e) Use of less hazardous chemicals, such as biodegradable detergents or non-persistent insecticides.

(f) Improvement of the regenerative capacity of the environment.

Methods aimed at reducing pollution loads at source (b, c, d, and e) are of paramount importance in reducing the problems under (a) and (f) to manageable proportions.

There are only a few areas where the technology for the treatment of water for public consumption remains inadequate. One example is the removal of nitrates and sulfates from water, for which no adequate technological solution is yet available. By and large, failure to provide water supplies of adequate quality arises from insufficiency of resources. The main task is to develop reliable and cheaper processes and materials that can be applied in treating polluted water for use as drinking water.

Most of the processes used today for treating municipal wastewaters before they are discharged have been practised for many years; improvements have been made in their performance, but the basic technology has remained essentially the same. New techniques are required for removing toxic substances (particularly from industrial wastes), plant nutrients, viruses, and other contaminants.

The main obstacle to the use of existing methods of solid wastes disposal is an economic one. As much as 80% of the cost for the disposal of certain solid wastes is for collection and transport. Better on-site procedures are needed to prevent scattering of refuse, to reduce its volume, to remove toxic substances, to prevent contamination of water and air, and to recover useful materials for reuse.[2]

Considerable progress has been made in reducing the particulate matter produced by the combustion of fossil fuel in power stations and dwellings, by installing control equipment or by replacing coal with oil or natural gas. Smokeless fuel has been used very efficiently in some urban areas but in many countries the pollution caused by domestic heating and cooking is still serious. Much remains to be done to improve the control of emissions of gaseous pollutants. Numerous processes for the removal of sulfur dioxide from stack gases are being studied but are costly, and the desulfurization of fuels is still in the development stage. Despite the increasing effectiveness of the

[2]See also: Wld Hlth Org. techn. Rep. Ser., 1967, No. 367: 1972, No. 484.

pollution control methods used or envisaged for the existing type of motor vehicle, it is probably that alternative transport systems will have to be devised.[1]

In the field of pesticides much work is being done in developing new chemical and biological methods of pest control.

These examples show that the technology for environmental pollution control is essentially available. However, some of the existing methods are costly, and more economical techniques are being sought. Still other deficiencies are the time-lag between discovery and application, and the delay in the transfer and adaption of technology from the developed to the developing countries. In many cases there is a need to develop a technology specifically suited to the conditions in developing countries.

Governments should investigate their own specific needs and instigate appropriate research. There should, however, be adequate dissemination of information to avoid duplication of otherwise costly work.

5. ORGANIZATIONAL PROGRAMME COMPONENTS

5.1 Legislation

Every country has a constitutional structure that defines, by means of laws and regulations, the rights and duties of citizens and those of the authorities in order to preserve the health of the nation.

The nature of a country's legal system and the detailed content of its laws--in particular the scope of the powers delegated to the executive authority, and more specifically to the administrative body responsible for ensuring that the laws are faithfully implemented--will determine both the extent to which the laws produce the desired result and the effectiveness with which the courts can interpret the laws and can punish infringements of the laws.

Appropriate legislation provides a basis for effective pollution control. There is now a tendency to combine various enactments into laws covering environmental pollution as a whole.[2] In certain cases the application of national legislation can be extremely effective at local level. The need for legislation of general applicability is very evident in countries with

[1]See also: Wld Hlth Org. techn. Rep. Ser., 1969, No. 410.

[2]See also: World Health Organization (1972) Health hazards of the human environment, Geneva, p. 343.

a federal structure. Whereas legislation should aim at uniformity and some legislation must be applied nationwide, there are aspects where local control is advisable, e.g., the declaration of clean air zones.

Power to issue regulations is often given under an act of the legislature, and the regulations include detailed requirements and provide flexibility in that they can be made, amended, or revoked more easily than acts of the legislature and their provisions readily adapted to current needs.

When drawing up new legislation, government departments should consult with interested bodies such as national and local voluntary associations, local authorities, and professional and trade associations.

In some legal systems the use of strict standards is appropriate even though their scientific basis may be uncertain and the levels required more or less arbitrary. Other legal systems, such as those giving greater powers of discretion to the courts, permit of a more pragmatic approach, although even with these systems some strict standards are necessary, e.g., in regard to contaminants in food, water pollution, or toxic substances in the factory atmosphere. In other cases, satisfactory control over pollution may be achieved by methods not requiring strict standards. For instance, the clean air legislation in the United Kingdom has produced a marked reduction in air pollution as a result of powers of control conferred on local authorities with respect to the creation of smoke control areas and to the limitation of smoke emissions from factories. Another example is the use of the best practicable means of controlling factory emissions by the Alkali Inspectorate in the United Kingdom. The use of such methods, although not requiring the setting of formal standards, requires a wide knowledge of the health effects of pollutants.

Standards should be realistic. Regulations may need to allow for time during which they are to be implemented. Legislation should give powers of entry and inspection and realistic penalties as a means of enforcement of standards. A guiding concept in drawing up legislation should be that to pollute constitutes a punishable misdemeanour. The legislation should empower the health authorities to intervene effectively in all situations that may give rise to concern over the health of individuals. The authorities should also be empowered to compel polluters to install equipment that will limit or even prevent pollution.

5.2 Implementation plans

As defined by a WHO Expert Committee,[1] "planning is a process by which available data, needs, and resources are appraised

[1] Wld Health Org. techn. Rep. Ser., 1970, No. 439, p. 11.

and analysed, and used in preparation for change." Careful, coordinated planning of environmental pollution control programmes is essential for a number of reasons besides those that bear directly on man's seemingly insatiable use of resources and the limited space available for the disposal of his waste products:

(a) the rise in the number and concentration of people;

(b) the increasing production of new chemicals and potential contaminants; and

(c) the lack of institutional safeguards against marginal pollutants and, more specifically, against unforeseen crises and episodes.

Environmental pollution control programmes as a whole should therefore be planned on the broadest scale and should aim at the complete wholesomeness of the community and its defence against unforeseen and unsuspected perils. Such programmes require appropriate monitoring and surveillance and the unwillingness to invest in research and development.

The need to integrate the planning of environmental health and consequently of health-oriented pollution control programmes into overall social and economic planning was discussed in 1964 by a WHO expert committee on environmental health aspects of metropolitan planning and development. The present Committee's attention was drawn particularly to the conclusion of a section in the 1964 report:[1]

In order to be effectively integrated into overall planning, environmental planning must be based on clearly identified objectives. Familiarity with the planning process is therefore needed in addition to a basic understanding of environmental health. Health standards have been useful in developing planning guidelines, but because of the subtle effects on the community of long-term exposure to low levels of inanimate environmental contaminants, epidemiological evaluation is rapidly changing in character. Often no direct cause-and-effect relationship between contamination and health can be established, and environmental health workers must extrapolate their experience and exercise judgement in assessing the situation.

Community environmental planning must reach beyond the concept of simple disease prevention towards the long-range goal of comfort, efficiency, and the promotion of general well-being. Sometimes these objectives are partially included within the meaning of "aesthetics", but it is surprising how clearly the general public sees them as "health-related".

[1] Wld Hlth Org. techn. Rep. Ser., 1965, No. 297, p. 14.

Even before a comprehensive pollution control programme is planned and initiated, some effects of pollution can be offset by such ad hoc measures as improving working conditions, considering special nutritional needs, and designating safety areas around industrial plants.

The first step in drawing up any programme for pollution control is to assess the degree of pollution, i.e., to compile a "pollution inventory". Any possible association of pollution with other factors should also be investigated. For example, according to as yet unpublished findings in the USSR, antibody formation to influenza vaccine is inhibited in urban areas with a high level of pollution. In a mass vaccination campaign concentrated on urban areas where the incidence of influenza was 3-4 times the national average, epidemiological studies showed a lack of antibody formation, although in an unpolluted control area response to the vaccine was normal. This suggests an association between pollution levels and antibody formation.

In order to develop implementation plans it is essential to know the general framework within which a programme will be carried out, as well as the resources necessary for doing so. An implementation plan is never a static blueprint for action but a dynamic instrument subject to constant review and updating in the light of changing situations and circumstances. It may stipulate every step of the action to be taken, or it may allow for the exercise of a considerable amount of discretion at the local level. The administrative practice involved is a matter of choice; while there is much to be said in favour of a systematic and well ordered system, beyond a certain point local interpretations and "on-the-spot" decisions can provide a more efficeint and economical system.

Consequently, an implementation plan has to incorproate provisions for the continuous reappraisal of its usefulness. The inclusion of an evaluation mechanism in the design stage permits the monitoring and regulation or adjustment of the programme from the start on the basis of an adequate feedback system. Such an approach will improve the realism and specificity of the plan and, while more expensive initially, will avoid the difficulties and expense of after-the-fact evaluation studies that may, in addition, indicate a need for major and expensive changes in the programme already implemented.[1]

It is important that any health agency that is to be responsible for pollution control should have a major share in the drafting of the implementation plan, so that it will have confidence in the plan. The agency should have an important say in the preparation of the plan, whether or not it is to be responsible for all or any of the operational aspects of control.

[1] Wld Hlth Org. techn. Rep. Ser., 2973, No. 528.

The implementation plan should:[2]

(a) be simple and straightforward;

(b) be capable of achieving its objectives;

(c) be flexible and adaptable;

(d) be realistic in terms of economics, available resources, social acceptability, legal application, and the time allotted for carrying it out;

(e) be subject to regulation, evaluation, and change;

(f) clearly define the distribution of responsibilities, especially among the government agencies concerned and for the private sector;

(g) acknowledge the need for public support by including, where possible, adequate provision for the information, education, and participation of the public;

(h) recognize the need for research;

(i) involve relevant agencies to the maximum extent compatible with their responsibilities for pollution control programmes;

(j) take into account differences among communities;

(k) use standards that are practical, have been tested, and also include qualitative aspects;

(l) take account of the establishment of new development programmes and services;

(m) provide for evaluation on the basis of results and benefits rather than of resources expended; and

(n) include the monitoring of effects of other and ancillary programmes, particularly those affecting local conditions and activities.

To avoid operational conflicts with other programmes and established interests, some governments have set up special mechanisms to secure support of programmes by constantly studying strategies, minority views, enforcement through reward policies, and other devices.

[2]See also: Wld Hlth Org. techn. Rep. Ser., 1970 No. 439; 1973, No. 528.

5.3 Institutional and administrative arrangements

Although the administrative and organizational arrangement for pollution control differ from country to country, health authorities bear a number of key responsibilities. The provision of basic sanitation services remains an extremely important area of pollution control in which authorities responsible for public health should continue to provide leadership. Public health authorities should also be equipped and willing to take the responsibility for many other components of pollution control programmes, including the following:

- identification of pollutants;

- assessment of health effects of environmental pollutants;

- promotion of research on health effects of environmental pollution;

- establishment and enforcement of environmental quality standards necessary to protect public health, including standards for the quality of water used for drinking, other domestic purposes, and recreation; ambient air quality standards; maximum permissible limits for occupational exposure to toxic chemicals; standards for the exposure of man to various forms of radiation, noise, and other physical hazards; and maximum daily intakes and tolerances for toxic substances in food;

- evaluation of environmental health projects;

- participation in licensing procedures;

- inspection of factories and other workplaces;

- control of the use of toxic substances in agriculture and in households;

- provision of guidelines for the disposal of toxic solid wastes;

- monitoring of environmental influences on health;

- monitoring of air pollution in urban and industrial areas and of the quality of community water supplies, sources of drinking water, and of recreational waters;

- development and use of public health criteria for the siting of potential pollution sources, such as power plants or industries, and the establishment of protective zones;

- training of health workers in pollution control; and

- provision of guidance in all aspects of pollution control that may have public health implications.

As regards the design, construction, and operation of pollution control facilities, the role of health authorities may differ from country to country. The trend in some developed countries is for specialized agencies to design and construct water and waste treatment facilities and for health authorities to supervise their operation from the health standpoint, which includes issuing licenses and playing an advisory role. Active participation of health authorities is always necessary in all phases of the planning and implementation of environmental pollution control programmes.

A vigorous health department at the national level is thus essential for adequate pollution control. This department should include a strong environmental health unit and in view of the ever-increasing sophistication of modern technology and equipment it is essential that there should be public health engineers on the staff. In some countries the unit is headed by a public health engineer.

It may also be desirable to set up services responsible for making specific regulations and for fixing the technical conditions under which industrial or other polluting activities may be pursued.

The optimum geographical unit for the supply of environmental health services will vary according to the service being provided. It may be a country or a region, as is the case for units combating pollution of some rivers or the air, or it may be a unit at the lowest local level.

Some of the responsibility for pollution control should rest with local authorities. Certain services, such as the collection and treatment of wastes, the maintenance and cleansing of public roads and property, the policing of traffic, and the collection and treatment of wastewater, are generally regarded as local problems. Local authorities may also have an important role to play in the monitoring of air, inland waters, drinking-water, and food. A number of authorities may combine to carry out these functions, sometimes with the participation of regional or provincial authorities. Another task of the local authorities is the supervision and application of regulations, and the surveillance of activities that might lead to pollution. They should be invested with the power to intervene in all cases where violations occur, whether as the result of simple negligence or deliberate acts. It is necessary in some situations to give local authorities additional powers to control toxic wastes, and further legislation may be needed on this subject. Local authorities may therefore in future need to employ more highly trained pollution officers.

Regional authorities may also be concerned with pollution control. Under new legislation in the United Kingdom, for example, the water industry is being reorganized and large regional water authorities will have responsibility for overseeing

the discharge of domestic and industrial effluents to rivers, the purity of rivers and estuaries, the provision of drinking-water, and the disposal of sewage; local authorities, however, will retain the power to sample drinking-water and ascertain its safety and suitability for public use.

The extent to which responsibilities are delegated to local or regional authorities will depend on:

(a) whether the country has a federal for a unitary system of government;

(b) whether the local authority system is well enough developed to cope with problems of pollution control;

(c) how jurisdiction is shared by various levels of government - central, regional, and local;

(d) to what extent use is made of nongovernmental organizations and special interest groups;

(e) whether the government has accepted the principle of outside review boards of eminent professionals to carry out independent evaluation.

Another important point to be considered with regard to institutional and administrative arrangements is that one cannot be one's own judge. Therefore, polluters, and particularly industrial polluters, cannot be given final responsibility for organizing the fight against pollution. This does not mean that these industries should not be consulted. On the contrary, they can often contribute usefully to solving pollution problems. In a number of countries over recent years, some industrial polluters have cooperated readily with the responsible authorities. Some have made valuable suggestions regarding modifications of production, equipment, or processes to reduce pollution, and some have even eliminated their particular problem completely. However, it is frequently necessary to allow some time, often years, for the more expensive improvements to be made.

A number of institutional and administrative arrangements are concerned with coordination. Because of its importance in environmental pollution control, a separate section is devoted to this problem.

5.4 Coordination[1]

There are three major prerequisites for coordination:

(1) The government must be interested in planning.

[1]See also: Wld Hlth Org. techn. Rep. Ser., 1973, No. 528.

(2) There must be enabling legislation.

(3) There must be a ministry or another body competent to undertake the coordinating role, including its technical, financial, and administrative aspects.

Administrative capability is essential to all planning and coordination. In developing countries with limited resources, the administrative systems of government are often inadequate and need to be strengthened for planning and coordinating functions. Even in developed countries, lack of financial resources and of trained personnel sometimes constitutes a serious handicap in setting up efficient coordination systems. Various coordination mechanisms have been suggested on the basis of actual experience, but three main methods have been tried:

(1) Leadership and responsibility are entrusted or assumed by an existing authority.

(2) A federation of agencies is formed without fully defined lines of authority or responsibility.

(3) A new agency is superimposed on existing agencies but frequently without being given strong legal authority.

Which of the three possibilities is most appropriate would have to be decided on the basis of existing conditions and the severity of the environmental problems.

It may be thought desirable to place responsibility for most of the categories of activities related to pollution control with one ministry so that the functions of the several ministries and departments concerned with environmental pollution can be better coordinated. The ministry selected may be the ministry of health, the ministry concerned with planning, or a new ministry for the environment. In the latter case it is essential that all health policy matters remain the responsibility of the ministry of health.

One drawback to amalgamation is that technical pollution control activities require qualified, experienced, and specialized staffs at various levels, and these experts usually work most efficiently within their own technical departments. There is another danger that cannot be ignored and must be borne in mind when the organizational framework is being decided upon: where there is a strong central agency, environmental problems risk being dealt with from a specialized point of view, insufficient account being taken of the many social objectives involved in pollution control.

Irrespective of the degree of amalgamation or division of responsibility among different departments, a coordinating committee or ministry of the environment is essential. The coordinating body must be a strong one. Unfortunately, some health ministries do not meet this requirement. Since the ministry of

health has the final responsibility for the health and wellbeing of the nation, it must be in a position to advise on the desirability and adequacy of any proposed action from that point of view - a fact that could be used as an argument for strengthening national health departments in many countries.

The need for all ministries to be aware of environmental pollution must be stressed, together with the value of interdepartmental committees on pollution. Such committees are particularly valuable where there is no coordinating ministry. The USSR, for example, has made satisfactory use of a high-status coordinating council; the Deputy Prime Minister is chairman and the Deputy Minister of Health and Chief Sanitary Physician is vice-chairman.

In some countries a "single environmental agency" approach has been adopted to overcome duplication of effort and inconsistency of policy implementation, and to ensure focus on the total problem. The agency makes policy recommendations for approval and implementation by departments. In defining the duties and powers of such an agency and its relation to government departments, consideration should be given to such matters as consulting power, scientific and technical advice, allocation and licensing, revenues, spending, execution of works, information, policing power, and right of appeal. Several of these duties, e.g. execution of works, belong to the "line" departments of governments, while others, e.g., power to coordinate, should belong to the environmental agency.

Coordination must be viewed as the result of a series of interconnected activities that depend largely on collaboration and cooperation in the handling of information. In addition to the supply of adequate and timely information within the governmental system, the coordination function must include communication with a variety of nongovernmental bodies. Moreover, in order to avoid an impossibly large and inevitably open-ended public demand for health assistance, it is imperative to have the individual citizen assume some responsibility for his health and that of his family. Close coordination must therefore be maintained with nongovernmental agencies and organizations involved in public information and education and relief operations.

5.5 Evaluation

Several WHO expert groups have called attention to the importance of evaluation as a process for analysing results in relation to goals, for measuring benefits against costs (or outputs against inputs), and for determining the relevance of programmes to health needs. A recent WHO scientific group on the evaluation of environmental health programmes has reviewed in detail the technical and administrative factors involved in assessing the quantitative and qualitative results of environmental health programmes; discussed the advantages and shortcomings of past and present methods of evaluation, and the possibility of using recently developed evaluation techniques; and

indicated problem areas that may require operational research or further study.[1]

The objectives of evaluation must be viewed within the social context in which decisions are made, since the resources available are always finite. Some of these objectives are:

(a) clarification of social purposes and values;

(b) clarification of objectives of programmes and organizations;

(c) improved choices among alternative policies, programmes, and programme processes, within the field and as between environmental pollution control and other social action programmes;

(d) validating or discovering cause-and-effect relationships that can lead to more soundly conceived and effective programmes;

(e) defining means of discriminating effects produced by other causes;

(f) better knowledge of interrelationships among health-oriented environmental pollution control programmes, other programmes of health promotion and care, and other programmes of production and socio-economic development; and

(g) improved mobilization, development, and utilization of resources.

From a practical point of view, one way to evaluate a control programme is to measure the concentration of a pollutant remaining in the environment. Another is to monitor disease incidence or some other concurrent effect of pollution upon the community. The first method has the advantage of being more readily applied. However, since the immediate objective of environmental pollution control is the reduction of morbidity and mortality associated with the exposure to pollutants, its success is more impressive if expressed in terms of such reduction, as well as that of reduction of general ill-health. It is necessary to think beyond disease control and prevention and consider such matters as comfort and the simple enjoyment of the amenities of life.

Evaluation provides information that is useful in planning and other decision-making - not only data but also conclusions, preferences, and value judgements. Even so, in some countries planning and evaluation are carried in separate units.

[1]See also: Wld Hlth techn. Rep. Ser., 1973, No. 528.

Public participation and involvement in programme evaluation is becoming increasingly accepted, and in a large number of countries, more efficient health programmes appear to have resulted from this practice. At the same time, governments and the public are examining public services critically and asking about programme selection and continuation and about the extent to which programmes are meeting needs and dealing with relevant problems; evaluation can facilitate the better use of resources, in both developed and developing countries.

5.6 Resources

The resources necessary to implement health-oriented national pollution control programmes must be viewed in the broad context of their contribution to the population's health and social and economic development. Accordingly, adequate resources must be available directly to health agencies, as well as peripheral assistance to other agencies, in the form of a health component in their own programmes, whenever this is appropriate.

5.6.1 Financing

Finance can come from the public authorities or the private sector. In either case the providers of finance need to be convinced of the need for it. Financing is complicated by other factors: the increasing cost of goods and services, especially those based on advanced technology; the disproportionately high cost of meeting somewhat higher environmental quality standards; and reluctance of the part of private individuals and organizations to pay for services that they consider should be provided for by public funds.

It is frequently difficult to show short-term results from pollution control, as from public health measures generally. It is also difficult to compete with the often dramatic results seen, for example, in clinical medicine and surgery. Hence the need to provide for public information and education - education regarding pollution control generally and regarding the fact that the health budget is limited and that the preventive services, including pollution control, must have their fair share. The public should appreciate that one way they can assist is by refraining from making unnecessary and unreasonable demands on the curative services, thereby reducing their cost. In countries where medical and hospital services are totally or partly paid for by government funds, there is an ever-present risk of unnecessary demand for medical attention.

Where the private sector does not provide any finance towards pollution control, government should make such provision compulsory. Possible methods include licensing of sources of pollution with provision for (a) charging for licenses and (b) fines for non-compliance with the conditions of the license.

Fines should be realistic and punitive and, where necessary, should include extra penalties for each day the offence continues. There are examples of pollution being reduced in countries that have adopted the policy that the polluter pays. Legal provision for closing an industry or plant that fails to comply with licensing provisions is an effective way of ensuring compliance. Licensing should take into account the problems, especially the financial problems, that might be experienced by established industries. Such industries should be given time - possibly several years - to comply but new industries should meet the required standards from the outset.

As finance is closely related to the sociopolitical structure of a country, it is important to have an adequate information system making good use of all available channels for information. Informed people are more likely to approve of and to contribute to pollution control. For example:

(a) In some countries a proportion of the profits of industry is set aside for the welfare of workers; part of this money could be spent on pollution control.

(b) Some countries have special fund-raising campaigns, such as the issue of environmental postage stamps sold at a premium, and the profits are used for environmental control.

(c) The principle that the polluter pays works well in an informed community - industry is more likely to pay when public opinion favours pollution control; this is an indirect way of inducing the polluters to bear some of the financial cost of the control and surveillance that are essential if the environmental health management services are to take effective action.

The choice of method of financing is clearly influenced by the political, economic, and social climate of the community concerned but whether it be from public funds, taxes, levies, or user charges, the purpose to which the funds are to be put should be made clear. If the programme comprises far-reaching procedures such as relocating populations, raising the cost of production beyond competitive levels, or other such drastic social or economic measures, it may be useful to incorporate a system of subsidies to alleviate immediate costs; but it is then necessary to specify not only who will be subsidized and for how long, but who will provide the subsidies:

(a) the nation - in the national interest;

(b) the region - in view of the socioeconomic development that would ensue;

(c) the community wishing to retain the activity; or

(d) the shareholders or employees of the industry, or the consumers of the goods it produces.

Funds are also necessary for research. Legislative bodies that lay down principles for controlling the various causes of pollution should at the same time ensure that funds are allocated for research both into the cause-and-effect relationships between pollutants and any diseases that may be detected in the population, including animal toxicological studies, or in fauna and flora, and into the means of reducing or containing pollution, either by treating wastes themselves or by developing industrial techniques free from harmful effects.

These legislative bodies should also provide for the finance needed specifically for surveillance and control activities at various levels, and for the cost of support programmes such as training, health education, and public information.

For many countries, however, there are ways and means of securing outside assistance in the form of grants and subsidies for the collection, treatment, and disposal of wastewater, as well as technical assistance.

5.6.2 Manpower

The lack at all levels of personnel trained in pollution control is often one of the main obstacles to developing and implementing pollution control programmes, in both highly industrialized and developing countries.

Pollution control is not the prerogative of any one profession, and a multidisciplinary team approach is necessary involving medicine, engineering, the biological sciences, chemistry, the physical and mathematical sciences (including statistics), operational research and systems analysis, and the social and behavioural sciences.

There is difficulty in recruiting staff, especially university graduates, into public health generally and environmental health specifically. This is true particularly of medical officers and sanitary engineers dealing with environmental problems and is a consequence of the low status accorded to public health in some countries and the low salaries often paid to public health workers.

At the national level it is essential to have high-grade professional officers with both technical and administrative training and with a knowledge of the various aspects of pollution control. There should also be an adequate staff of technical officers and of administrative personnel at all levels, ranging from the managerial staff to the operational staff. Their number will depend on the size of the country, the scope of the problems, and the stage of the nation's social, economic, and industrial development.

It is sometimes possible for government departments to commission independent groups such as local firms of consulting

engineers to undertake specialized work and so relieve the authorities of the need to employ costly staff for whom there is insufficient work. The encouragement of such local firms can also benefit the physical and economic development of a country. Similarly, much construction work, and particularly specialized work, can be entrusted to contractors rather than to directly employed labour. For major works it is often necessary to call in foreign consultants, sometimes with international financial help. In such cases it is wise to arrange for local counterparts to acquire experience by working with the consultants.

Efforts to attract students to environmental pollution control disciplines and to organize appropriate training schemes should receive high priority. Courses can be general or specialized (air pollution, water pollution, marine pollution, etc.) and are best carried out at graduate or postgraduate level in research institutes and universities.

Pollution control should be included in the undergraduate training of chemical, civil, and sanitary engineers, and in public health or environmental health courses for medical students. It is important that administrators and teachers in the teaching institutions appreciate the importance of public health and pollution control. The education and training of various categories of personnel have been discussed by various expert groups.[1]

The World Health Assembly has passed a number of resolution dealing with manpower development, in particular Resolution WHA 26.59,[2] which recommends that Member States

(1) introduce or strengthen teaching of the health sciences within training programmes for the various categories of environmental manpower;

(2) give priority to the use of such manpower within the institutions responsible for planning and carrying out coordinated programmes to promote health and to improve the human environment, as well as at all operational levels.

Other areas where education in pollution prevention and control should be carried out are:

(a) as part of primary and secondary school curricula;

(b) in training programmes instituted by industrial and municipal management;

(c) in educational articles and programmes disseminated by the mass media; and

[1]See Wld. Hlth Org. techn. Rep. Ser., 1967, No. 376; 1968, No. 385; 1971, No. 481.

[2]Off. Rec. Wld Hlth Org., 1973, No. 209, p.33.

(d) in government-sponsored extension programmes in the field of environmental management.

5.6.3 Instrumentation and materials

Instrumentation

Reference has already been made to the question of routine measurement of pollution and to the potentially spiralling cost of using the latest instruments, processes, and materials for this purpose. In particular, the use of sophisticated instruments should be avoided; they are usually expensive and their maintenance often requires skill that is not possessed by the user and cannot be acquired locally. In fact, the use of highly qualified personnel to operate such instruments may yield disproportionately small returns in terms of health gains in countries where such manpower is short.

A commonsense approach is required. Automatic equipment should be purchased only after close scrutiny of the actual need. Manual tests and instruments have worked well in many circumstances and their use should be encouraged. The same is not always true of automatic equipment. For example, several types of automatic device may be used to measure different parameters of river pollution. In most cases the probe must be protected by filters or strainers. A problem frequently encountered is the obstruction or choking of the strainer apertures by various sediments in the river, so that the equipment becomes inoperative, despite the complexity of the measurement devices it contains. The only solution is to remove the blockage by hand.

The use of local materials and local construction of instruments is desirable wherever possible. WHO and other international agencies should encourage this effort. Even developed countries often manufacture and use inexpensive equipment when there are limited funds for the programme. In a number of countries inexpensive instruments have been used successfully for years in the fields of radiation monitoring and of air pollution control. It is recognized, however, that sophisticated equipment may be necessary for research purposes.

WHO has an important role to play in developing this commonsense approach, especially in developing countries, where it is not always known that many developed countries are managing well by using manual equipment in a wide range of pollution control programmes, often in preference to automatic equipment, which can be delicate and difficult to maintain. Pollution control programmes can be initiated with slender financial resources and yet still be effective.

Some degree of standardization of equipment, materials, and methods is essential and should be achieved with the cooperation of all interested bodies, in particular the designers and manufacturers. It is important that information be fed back from the

user so that the equipment can be modified and improved in the light of experience. Specifications should not be so rigid as to preclude acceptable variations by local designers as tradesmen. Comparability of the results of measurement and so of equipment and methods is essential at the country level, and inter-laboratory calibration should be encouraged both at national and international levels.

As pointed out by a WHO expert committee,[1] it should be a principle of national environmental health programmes to make optimal use of locally available materials. In this way foreign exchange can be saved, the overall cost of works can frequently be reduced, and local employment can be stimulated.

Designs should take into account the materials available, care being taken not to adhere too rigidly to type designs, specifications, and codes of practice that may have been prepared for use in other countries and under different circumstances. Simple, locally designed control equipment can be just as effective as imported goods, and much cheaper.

6. PROGRAMME CONSTRAINTS

Environmental pollution control programmes, as any other programmes concerned with the delivery of services to the public, are subject to a large number of constraints. These constraints must be identified and evaluated at the planning stage and taken into account in the formulation of the programme. If any are overlooked, the success of the programme may be seriously impeded. Many of the programme constraints have already been mentioned in the previous section and some will be discussed later in more detail.

Some constraints result from geographical or climatic conditions, and may be cultural or traditional, including customs and behaviour patterns. Specific and local constraints must therefore be carefully studied in each particular case.

A serious limitation on the effectiveness of pollution control programmes is the present rate of urbanization and industrialization and the concurrent growth of population. Pollution problems grow more rapidly than do the resources available to control them, and programmes planned today may already be inadequate before they can be implemented.

Other main categories of constraints are:

Inadequate scientific knowledge. The lack of complete information on the pollutant's behaviour in the environment and uncer-

[1] Wld Hlth Org. techn. Rep. Ser., 1970, No. 439. Local materials

tainty about the relationship between exposure and its effect on man's health and the contribution of this pollution to the development of disease or to the exacerbation of existing conditions in man are examples of such constraints. As previously discussed, lack of knowledge is a serious obstacle to the establishment of environmental quality standards and to the setting of programme priorities.

Inadequate technology. Inadequacies in technology, related to the measurement of pollutant levels and particularly to effective control, are major areas of constraint. This problem is aggravated by the high cost of applying technology so as to obtain the desired control.

Inadequate resources. The lack of resources, both financial and manpower, as a constraint in programme formulation and implementation has already been discussed.

Inadequate legislation. A lack of enabling or specific legislation is a major constraint in programme implementation. In some cases, the problem is made more difficult by the absence of concepts and doctrine on which to build a legal system.

Unsuitable administrative and organizational framework. The existence of traditional administrative patterns, the departmentalization of various governmental agencies, and the lack of adequate coordinating mechanisms are examples of such constraints that have been mentioned.

Social factors. Lack of social awareness and of understanding of the problem by the public may be an important reason for the low priority accorded to environmental health in general and environmental pollution control in particular. The relatively small financial resources allocated for pollution control is to some extent a reflection of the comparatively low value the community attaches to environmental quality or the lack of awareness of the importance of environmental quality.

Social and cultural habits may also hinder the development and effectiveness of control programmes. To avoid such situations, control programmes should be compatible with the social and cultural values of the population and should be brought to the attention of the population, starting with the schoolchild at an early age.

An exaggerated and unrealistic evaluation of pollution problems, based on emotional reactions rather than on facts, may be an equally severe constraint in the development of appropriate national pollution control programmes.

Political constraints. Pollution control programmes may be politically desirable or inopportune, because of the restrictions they may place on economic development. Hence the need to integrate pollution control programmes with other elements of economic development programmes. Decisions on economic development

schemes should be made with reference to environmental consequences, especially those affecting the health of man and the ecology. Also, there is sometimes a tendency to support health programmes in which quick results can be seen rather than to invest in long-term pollution control programmes with less demonstrable beneficial effects.

7. SUPPORT PROGRAMMES

7.1 Health education and information

The committee emphasized the need for education on environmental pollution at all levels of the community, in particular of national and local politicians, university and other teachers, the staff of government departments, and all schoolchildren.

Close cooperation should be maintained with voluntary health agencies, which can give valuable assistance in this field. Stress was laid on the importance of seeking the support and cooperation of the press and other news media when planning health education of the public on pollution matters. Such action can help reduce the likelihood of sensationalism, which can provoke an exaggerated and emotional response from the public. The local health department has an important role to play in reassuring the public in such situations. A national health administration should contain a unit adequately staffed with health educators, one of its functions being to work with those responsible for pollution control on the health education aspects of their programmes. It was generally agreed that all information disseminated on pollution control should be factual and unbiased.

Health education programmes should both inform and influence the public and the national, civic, and other leaders, convincing them of the importance or prevention.

WHO has a role to play by providing governments with advice and with consultants. These consultants can assist with training programmes and the preparation of suggestions for public and community information programmes regarding the importance of environmental health and the need for strong, well-staffed public health departments.

Governments, as custodians of the resources of the environment, must be well informed so as to be able to respond to the needs of the public, which, in turn, has the right to be informed. Insufficient information and misinformation are detrimental to environmental health programmes. The central health agency should therefore evaluate its educational programmes and materials.

A service should be developed to encourage public participation in pollution control programmes by acting jointly with

public interest groups, assisting in the dissemination of educational material on pollution problems, and receiving and considering the public's comments and suggestions. Such an arrangement would facilitate (1) the dissemination and interpretation to the public of factual information; (2) the development of extension programmes aimed at creating a better understanding by the public of basic pollution problems and programmes; and (3) the availability of environmental material suitable for use in the schools.

When a public information policy is being developed, it should be borne in mind that as much as possible of the programme should be carried out at the community level, that local initiative should be encouraged, and that local people are likely to know more than the central authorities about local conditions. Informtion programmes appear to be most successful when they are directly attached to the operational agencies they serve.

7.2 Research

The formulation of sound environmental pollution control policies depends on the availability of adequate information on which to base decisions. Research must seek to obtain the data needed to elucidate and solve existing environmental pollution problems and to prevent future hazards. Higher expenditure may be necessary in the absence of accurate scientific data. For example, if the health effects of a particular environmental pollutant are not precisely known, it may be necessary to apply more stringent environmental measures to assure the protection of public health than would be necessary if full information were available; and the implementation of more rigid standards is, of course, more costly.

Research and development are heavy consumers of funds, manpower, and effort and few countries can afford to support an adequate research programme covering all environmental pollution problems. Exchange of research information between countries and collaborative international research are therefore essential. The transfer and adaptation of control technology to local needs and circumstances need particular attention.

Various research needs in the field of environmental pollution have been summarized in a number of WHO publications.[1] Research is needed on the following topics in particular:

(a) the health effects of long-term low-level exposure to environmental pollutants, including carcinogenesis, teratogenesis, and mutagenesis;

[1] Wld Hlth Org. techn. Rep. Ser., 1968, N. 406; The WHO environmental health criteria programme (unpublished document EP/73.1); Environmental Health criteria: Report of a WHO Scientific Group (unpublished document EP/73.2).

(b) the synergistic effects of pollutants;

(c) the potential effects of pollutants (particularly chemical) on immunological defence mechanisms, including the possible consequence of greater susceptibility to bacterial and viral infections;

(d) the metabolism of pollutants, including absorption, accumulation, and bio-transformation; identification of target tissues; detoxification and enhancement of toxicity through metabolic processes;

(e) epidemiological studies of vulnerable groups in the population;

(f) the transport, dispersion, and environmental reactions of pollutants;

(g) the effects of pollutants on ecosystems;

(h) control technology for gaseous air pollutants; advanced waste water and raw water treatment and procedures for closed-circuit systems and reuse of wastewater; low-cost methods for environmental pollution control.

An important aspect of research promotion and coordination is the harmonization of techniques for experimental, epidemiological, and environmental studies in order to facilitate the comparability of results obtained in different laboratories and in different countries.

Many disciplines must work together to build the broad technical and social information base for more effective criteria documents. The health, social, cultural, and economic aspects of environmental pollution and regulatory controls must be considered as essential parts of this effort. These activities should include studies on new or potentially important environmental agents.

Groups of internationally recognized specialists, in collaboration with national and other research institutions, should examine any conflicting results and gaps in knowledge, identify further research needs, and set priorities. This will also be one of the tasks for the specialists concerned with the identification of new hazards from technological development. The recommendations of these groups of experts and their reports on research needs and priorities should be made available to all governments and national and other research institutions.

8. INTERNATIONAL COLLABORATION

Pollution of the environment often has consequences that cut across national frontiers.

8.1 International pollution problems

Air pollution is windborne and can cover great distances particularly if the pollutant is taken up by cloud masses and carried with them until they fall as rain.

Water pollution also is of international concern because some rivers and streams cross more than one country and can bring or acquire pollution along the way. Problems arise when the receiving country needs to use this water for certain purposes. In some cases the pollution source may be situated not far beyond the frontier of the country receiving the water and may therefore have even more impact on that country than on the original one. A similar situation can occur with parts of the sea or shared estuaries, when pollution from one country reaches the shores of another.[1]

In addition to pollution problems arising from routine operations, there are also accident risks and possibilities of acute pollution resulting from the lack of dispersion conditions. Whatever the specific problem may be, there will be a need for arrangements, treaties, and collaborative decisions and agreements between the countries directly involved. Many examples of such arrangements already exist, sometimes in rather complex form, and have proved to be efficient for handling international water pollution problems.

The results obtained in a national water pollution control programme on an international river should serve as a pattern for solving problems in pollution control on a regional basis, and close collaboration, based on international agreements, should be maintained among the neighbouring countries. The first, urgently needed, step towards coordination of national activities involved in the pollution abatement in rivers flowing through several countries should be the coordination of the water quality standards and analytical methods used.

For example, Hungary is a typical downstream country; all major water courses discharge to Hungary from other countries, mainly through the Danube river basin (70% of all surface water resources), which is subject to international pollution, and Hungary has no opportunity for checking and controlling pollution at the source. The proper quality of the Danube is of vital interest to Hungary, and it is in her interest to develop a surveillance system in collaboration with the neighbouring countries and based on an intergovernmental agreement. Another example is the River Rhine, which is an important waterway for the Netherlands and is used as a source of drinking water. A special international body, the International Commission for the Protection of the Rhine against Pollution, has been created to maintain

[1] See also: Resolution WHA 25.43, Off. Rec. Wld Hlth Org., 1972, No. 201, p. 20.

close collaboration among France, Germany, Luxembourg, the Netherlands, and Switzerland, with the aim of taking all possible measures to improve and maintain the quality of the river water.

When streams traverse international boundaries it is generally necessary to establish international bodies to introduce pollution control regulations. Such bodies should meet at regular intervals to review operations and management of the stream or streams involved and, if needed, to prescribe further mea sures.

Pollution of food may also have international repercussions and serious problems in this respect exist in many parts of the world, especially in highly industrialized or urbanized regions.

8.2 Exchange of information and surveillance

All measures related to the management and control of pollution which are applicable within individual countries have to be applied in international problems: identification of sources, pollutants, and effects, and setting up of criteria, standards, and acceptable levels of contamination. Methods and means of controlling pollution need to be as similar as possible on both sides of the frontier. Systems for permanent mutual information regarding monitoring and surveillance have to be set up. Competent authorities have to be designated and empowered and equipped to take enforcement action whenever it appears necessary. Partner countries should have the same concern about the effects of pollutants in whichever country they occur, and be ready to take appropriate measures as the need arises.

8.3 Role of international organizations

International organizations have various types of responsibilities in this field, among which transfer of technology and information exchange occupy a major position. Other important examples are:

Setting up criteria and standards. According to the type of organization, international criteria and standards may be formulated either as recommendations or as binding directives. WHO, for instance, is expected to all Member countries to provide recommendations of worldwide application.

Monitoring. This applies particularly to air pollution but can also be envisaged for the pollution of rivers, inland seas, estuaries, or food.

Regulatory role. In some specific cases, international organizations may be responsible for setting up regulations, either as guidelines for national authorities or as supranational rules; in the latter instance there is a need for means of enforcement.

Management of programmes. Managerial responsibilities may be given to international bodies that are set up to ensure the control of pollution in international rivers.

Research. In many instances necessary research can best be performed on an international basis, as when the size of the problem, its complexity, or its specificity calls for collaboration, coordination, or financing at the international level.

9. CONCLUSIONS AND RECOMMENDATIONS

(1) In the planning of national environmental pollution control programmes, health aspects must be given a high priority. Health agencies should be authorized and adequately equipped to fulfil the functions outlined in this report, particularly with respect to competent manpower. Appropriate technical units in health or other agencies should be strengthened or, when necessary, established, to carry out these functions, including monitoring and evaluation of environmental pollution levels and health effects.

(2) Environmental pollution control programmes are of a multidisciplinary nature and require coordination within national government departments. Only through coordination at the national level and with international collaboration is it likely that the authorities will be able to master the problems concerned without impeding economic and industrial development. A concerted effort should be made to ensure the collaboration of all interested parties - public authorities (local, regional, and national), industry, and the public. Without such collaboration communities may suffer damage that could be irreparable.

(3) National environmental pollution control programmes should be designed not only to ensure adequate pollution control and abatement, but also to prevent pollution as far as possible. The planning, organization, administration, and evaluation of national environmental pollution control programmes have to be carried out systematically by means of modern management methods, and risk/benefit, cost/benefit, and cost/effectiveness studies. Continuing education and research are essential components of such programmes.

(4) The prevention of environmental pollution should be carefully considered by developing countries even if such pollution does not yet present a major problem. A sound principle is to provide for the incorporation of environmental pollution control in all industrial, agricultural, and other economic development projects, including regional planning, from the outset.

(5) The Committee stressed the need for balanced programmes taking into account the traditional problems of pollution from community wastes as well as the chemical and physical pollution arising from industrial development, growing needs for energy,

and the application of chemicals in households, agriculture, and other activities.

(6) Health effects of long-term low-level exposure to environmental pollutants deserve particular attention, and programmes should be developed for testing all new important chemicals for chronic toxicity, including teratogenicity, carcinogenicity, and mutagenicity, before they are introduced on the market.

(7) WHO should expedite the preparation of criteria documents, which should be made available as soon as possible to all relevant national institutions and agencies. Assistance should be offered in the application of these documents in national environmental pollution control programmes.

(8) WHO has an important role to play in setting up, coordinating, and strengthening programmes for the monitoring and surveillance of pollutants (including emission surveys and inventories) and their possible effects, with emphasis on health priorities. Particular attention should be given to the promotion of acceptable comparable methods of measurement and of programmes for inter-laboratory data quality control.

(9) Technical assistance to strengthen national environmental pollution control programmes should continue to be provided by WHO, particularly as regards scientific and technical advice on matters relating to pollution control, development of training programmes, and stimulation of and assistance in research. The use of inexpensive, simple routine measurement instruments and the use of local materials should be encouraged in the initial stages of regulatory programme development.

(10) WHO also has a role to play in compiling scientific and technological information on environmental pollution and in disseminating this information to national institutions. In this respect there is a need for guidelines on programme components and constraints, techniques for the planning of health-oriented environmental pollution control programmes. the preparation of implementation plans, health education and information of the public as they relate to environmental pollution, risk/benefit and cost/benefit analyses and evaluation, international transport of toxic substances, and other technical problems.

(11) Scientific appraisal by international groups of experts of existing information on environmental pollution could help to place pollution problems in a proper perspective and to avoid exaggerated reactions from the public, while at the same time stimulating public awareness of current environmental pollution problems.

(12) In developing programmes mentioned in recommendations (7-(11), adequate use should be made of appropriate information

developed within the framework of the United Nations Environment Programme, the specialized agencies, the International Atomic Energy Agency, and other intergovernmental or nongovernmental organizations. Existing collaboration among these agencies should continue and the coordination should be strengthened.

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"The Environmental Impact Statement as Practiced in the United States"[a]

by

Remi Barre

Introduction

As a result of the growing concern about the quality of the environment--a concern rooted in the first conservation movement of the late ninetenth century and expressing itself in the 1960's in powerful organizations like the Sierra Club and through the political process--Congress passed The National Environmental Policy Act of 1969 (NEPA), a comprehensive national policy for "restoring, protecting and enhancing the quality of the environment."

The purpose of this paper is to describe the major tool for implementation of this policy, The Environmental Impact Statement review process, a process incorporating an environmental perspective in the decision making of federal agencies; and to discuss the efficiency, interest and difficulties linked with that tool by an evaluation of its first four years of application.

1. Overview of NEPA. Definition of the Environmental Impact Statement. (See Appendix A)

Basically, NEPA seeks better environment through better federal decision making by calling for the articulation of the reasons behind decisions, for the elaboration of the risks which proposed action entails, for discussion and consideration of alternatives as a test of soundness of the decision taken, for a wider review of the public interest, and for increased public participation. The two major aspects of NEPA are the creation of the Council on Environmental Quality and the Environmental Impact Statement review process.

In its Title II NEPA created the Council on Environmental Quality (CEQ) in the Executive Office of the President in order to "review and appraise the various programs and activities of

[a]A lecture prepared for the International Program in Environmental Aspects of Industrial Development, University of North Carolina, 1975.

the federal government in the light of the policy set forth in this Act," to "develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health and other requirements and goals of the nation," and to provide for an annual progress report[1].

However, the originality of NEPA is its Title I, section 102, which is its action forcing procedure. This section requires all federal agencies of the United States to "insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations."

The means of achieving this is specified in section 102 (C) which requires the federal agencies to "include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment" an environmental impact statement (EIS) prepared by the agency responsible for the recommendation for legislation or action. The EIS will be commented upon by "any federal agency which has jurisdiction, by law or special expertise, with respect to any environmental impact involved," and made available to the President, the CEQ and the public, and will "accompany the proposal through the existing agency review process."

Recognizing the far-reaching consequences of the Environmental Impact Statement procedure, Section 103 requires all agencies of the federal government to review their administrative regulations, current policies and procedures in order to ensure that they will permit full compliance with the purpose and nature of this new decision making process.

It is on this Environmental Impact Statement review process, the mechanism incorporating an environmental perspective into the decision making process of federal agencies, that we will now focus.

2. The CEQ Guidelines for the Preparation of Environmental Impact Statements (See Appendix B)

On August 1, 1973, the CEQ issued a revised set of guidelines for the preparation of EIS in order to translate section 102 of NEPA's broad language into more concrete terms incorporating much of NEPA's legal evolution in the courts and reflecting the experience gained and lessons learned during the three previous years.

2.1 Characterization of the Revised Guidelines

The proposed new guidelines emphasize that environmental consideration should be taken into account from the beginning of

the decision making process, enabling those responsible to increase the degree of public participation, itself the other major emphasis of the guidelines.

They encourage the use of program or generic impact statements to cover a number of related individual actions (policy impact statement), and they explicitly require agencies to discuss the secondary environmental impact of their actions, particulary on energy consumption, population concentration, and growth (sewers and highway construction, for example).

2.2 The Environmental Impact Statement Review Process (Summary of the guidelines, Appendix B)

i. Type of actions covered

"Major federal actions significantly affecting the quality of the human environment," are covered by Section 102(c) of NEPA. Action here means legislative and administrative action. Along with the requirement that the agencies continually review their policies, procedures and regulations to ensure full compliance with the purposes of NEPA, it is also required for them to develop specific criteria and methods for identifying those actions likely to require EIS, in consultation with CEQ.

In order to insure public information, those procedures must be regularly published and up-dated in the Federal Register. Along this line, agency procedures are required to include an early notice system for informing the public of the decision to prepare a draft environmental statement of proposed administrative action, and for soliciting comments that may be helpful in preparing the statement.

If the agency decides not to prepare an EIS, this information is to be published in the Federal Register with a notice setting forth the agency's reasons for such a decision.

ii. Preparing draft environmental statements; public hearings

Prior to the first significant point of decision in the agency review process, a point which must be defined in the agency's procedures for compliance with NEPA, a draft EIS should be prepared and circulated for comment from the CEQ, federal, state and local agencies, and the public. This must permit the agency decision makers and outside reviewers to give meaningful consideration to the environmental issues involved. To the fullest extent possible, whenever appropriate, public hearings should be held. The agency's procedure should indicate explicitly the kinds of decisions which utilize public hearings.

All comments received are carefully evaluated and considered in the decision process. A final EIS with substantive comments

attached is then issued and circulated.

iii. Content of an EIS

The information must be easily understandable to the non-specialist. The agency should indicate how the information has been obtained. Emphasis is put on the importance of a multi-disciplinary approach which would insure the integrated use of natural and social sciences for the preparation of the EIS as well as for the whole planning process.

The EIS itself covers the following points:

1. A description of the proposed action, a statement of its purpose and a description of the environment affected.

2. The relationship of the proposed action to land use plans, policies and controls for the affected area.

3. The probable impact of the proposed action on the environment, both direct and indirect (highway and sewer investments inducing local and population growth.)

4. Alternatives to the proposed action in any proposal which involves unresolved conflicts concerning alternative uses of available resources. Sufficient analysis of such alternatives and their environmental benefits, costs, and risks should accompany the proposed action through the agency review process in order not to prematurely foreclose options which might enhance environmental quality or have less detrimental effects.

5. Any probable adverse environmental effect which cannot be avoided.

6. A discussion of the extent to which the proposed action involves trade-offs between short-term environmental gains at the expense of long-term losses, or vice-versa, and the extent to which the proposed action forecloses future options.

7. Any irreversible and irretrievable commitments of resources that would be involved in the proposed action, should it be implemented.

8. An indication of what other interests and considerations of federal policy are thought to offset the environmental adverse effect of the proposed action.

iv. Review of draft EIS by federal, state, and local agencies and the public

Comments may be made on the draft EIS within 45 days. Such comments should emphasize the assessment of the environmental impact, the acceptability of that impact, and may recommend modifications to the proposed course of action.

Commenting entities are the federal agencies with jurisdiction, by law or special expertise, with respect to any environmental impact involved. The Environmental Protection Agency (EPA) has a duty to make comments regarding the compatibility of the action with the Clean Air Act and NEPA. State and local agencies can comment, too, as can the public. Draft EIS should be made available to individuals and organizations on request; and its existence should be publicized in local newspapers, for example.

v. Preparation and circulation of final EIS

All substantive comments received on the draft should be attached to the final statement and should make a meaningful reference in the final EIS of any responsible opposing view not adequately discussed in the draft statement, and should indicate the agency's response to the issue raised.

vi. Transmittal of statements to the CEQ

Copies of the final EIS are made available to the CEQ and relevant commenting entities. No administrative action can be taken sooner than thirty days after this moment. The CEQ publishes weekly in the Federal Register the EIS received during the week that are available for public comments. We can notice here that CEQ does not approve or disapprove federal actions on the basis of EIS submitted to it, nor does it review all EIS. It is the Environmental Protection Agency (EPA), through its administrator, that is required to review and comment in writing on all those actions subject to NEPA impact statements, and to determine whether the action proposed in the statement is environmentally satisfactory. If it is found unsatisfactory, EPA draws the attention of the CEQ to the problem so that the final decision will be made on a higher administrative level.

3. The Enforcement of NEPA; the Role of the Courts

Since NEPA, like many other reform legislation, is cast in terms of a general mandate and broad delegation of authority, it has been the responsibility of the courts to ensure that the legislation becomes a realtiy. This is due to the specificity of the U.S. Judicial system which gives the courts the responsibility for interpreting statutes and other pieces of legislation. This is all the more important that the interpretations made by a court of appeals automatically acquires almost the power of law,

because its interpretation has to be followed by all lower courts. (This system is specific to England and ex-British colonies.) It shows why it is important to review the major interpretations of the courts, all the more that, five years after its enactment, NEPA caused 500 law suits covering almost all possible controversies.

3.1 Standing

Since the mid 1960's, there has been a very noticeable expansion of the requirements for standing (to stand is to bring a law suit which is receivable by a court). The NEPA cases have still expanded the requirements creating new legal interests and grounds to sue, like the public's right to know, to participate and have the future generations protected. In other words, the courts have ruled that practically any citizen is allowed standing in NEPA cases. This is very important because it allowed environmentalists groups to sue and, as the courts interpreted NEPA rather strictly as we will see, it greatly increased the impact of NEPA on the actual decision making process of the federal agencies.

3.2 The Requirement of Strict Compliance

NEPA contends that "to the fullest extent possible, the policies, regulations . . ."[3] The phrase "to the fullest extent possible" has become the touchstone of NEPA interpretation; it has been given a forceful interpretation in the case of "Calvert Cliff's Coordinating Committee vs. The Atomic Energy Commission," which led to giving special vigor to the action-forcing provisions of NEPA. This case set the tone for many other court cases. In other words, the courts have decided that section 102 of NEPA was subject to a strict standard of compliance and consequently many agencies have been ordered by the courts to re-do their EIS, resulting in the backlog of 110 nuclear power plants. In 102(B), NEPA uses the words "consideration of the environment," which have been interpreted in Calvert Cliff's in terms of a balancing or trading-off of environmental factors against economic and technical ones. Hence, the details of the manner in which an agency conducted its final decision making process will be subject to close judicial scrutiny under NEPA. The courts can review whether the decision gave sufficient weight to environmental values. However, subsequent cases showed that it doesn't mean a cost-benefit analysis is required; this leaves some room for subjective interpretation, as shown in another major court decision, "National Helium vs. Morton" which said that an EIS is acceptable if:

1. it discusses all of the five procedural requirements of NEPA,

2. it constitutes an "objective good faith" compliance with the demands of NEPA,

4. NEPA in Practice[4]

In five years, more than 6,000 EIS have been done; 85% of them by the Department of Transportation, the Corps of Engineers, the Departments of Agriculture, of the Interior, and the Atomic Energy Commission, ranging from the impact statement of the sale of oil and gas leases on the outer continental shelf, to the one of a priority system for the allocation of low sulfur petroleum products and to the impact of the Washington D.C. mass transit system.

Let us look at the context and the concrete results of this massive application of the EIS procedure.

4.1 Evolution of the Scope of NEPA

The 59 concerned federal agencies, including the CIA, have developed their own procedures of decision making process to comply with NEPA, on the model of the guidelines of the CEQ discussed earlier. The agencies have conducted numerous training sessions, workshops and seminars to familiarize their staffs with the new procedures. Furthermore, since 1970, 21 states have adopted EIS requirements for state agencies similar to those set forth by NEPA. Some cities having legislative power, such as New York, have adopted acts similar to NEPA to regulate city agencies. Six states even require an economic impact statement added to the EIS, and some states require the EIS for private actions or investments, California being the state with the strongest provisions in that sense. This general trend of broadening the scope of NEPA has created some material problems of limited funds and staff allocated to implement the requirements, but one can say that, even though integration of a state EIS into a state's decision making will take some time, the process has already begun.

4.2 Evolution of the practice of NEPA

At the very beginning, most agencies thought the EIS requirement was not applicable to most of their programs, and that, anyway, it could be prepared by their administrative staffs as a finishing touch when the project went forward for final agency approval. The Trans-Alaska pipeline case gave reality and importance to NEPA, and focused the attention on the EIS process.

From mid-1970 to mid-1973, there has been a transition period marked by the development of successive CEQ guidelines which helped each time reducing the uncertainty over NEPA requirements by integrating the rapidly expanding base of agency experience and codifying the major court decisions that were being handed down. In July 1971, in the "Calvert Cliff" case, one of the major NEPA decisions, the court declared that the procedures of the Atomic Energy Commission were unacceptable. This decision significantly broadened the range of issues which the agencies

3. it contains a reasonable discussion of the subject matter involved in the five required areas.

The court insisted one should look for "adequacy and completeness of an EIS, not perfection."

3.3 Content of an Adequate EIS

The starting point is the statutory phrase "detailed statement." A first interpretation has been for the courts to declare that a statement's adequacy, in the end, is measured by its functional usefulness in decision making; an EIS should enable a decision maker to consider environmental factors in good faith. A second type of interpretation says that the EIS is reasonably detailed if:

1. it is understandable and non-conclusory,

2. it refers to the full range of knowledge,

3. it discusses certain impacts which are typical of some types of action.

This has led the courts to require that the final EIS should include the comments and points of view even of those the agency disagrees violently with, provided they are based on scientific grounds. Courts have also required the detailed statements on "alternatives to the proposed action," one of them being to take no action at all. The statement should include a discussion of the environmental consequences of those alternatives. In the line of the strict compliance with NEPA, courts have rejected EIS which had not been circulated for comments. Furthermore, the comments must be meaningfully employed in the preparation of the final EIS, and be discussed.

In fact, the courts do review whether the agency acted within the scope of its authority, whether the decision reached was arbitrary, capricious, and whether the agency failed to consider all relevant factors in reaching its decision.

3.4 Conclusion

The courts have been vigorous in reviewing compliance by the federal bureaucracy with NEPA, and, even more, they have been the major architects of NEPA's requirements.

There are, of course, many other important interpretations made by the courts which we have not time to discuss here,but, what we have seen is enough to assert that, for better or for worse, NEPA and its action-forcing procedure, the EIS requirements have actually been, mainly through the decisive action of the courts, forced into the heart of the federal agencies' decision making process. As it has been said, NEPA, as it operates today, is truly the stepchild of the judiciary.

the first EIS were lengthy laundry lists: checking the potential impact on all kinds of plant and animal species with little attention to the secondary effects of the project under consideration (inducing industrial growth, for example), and little effort to synthesize the scattered impact findings.

The quality of the EIS has improved significantly since then, partly because the CEQ guidelines emphasize the notions of secondary impact and EIS as a continuing effort all along the decision making process; partly because the courts have sometimes ordered the agencies to do so and they have had to quickly increase the manpower effort devoted to the preparation of the EIS; and partly because our scientific and methodological knowledge has increased. To be more specific about this point, environmental assessment consists of two separate processes: environmental impact analysis which involves indentifying and forecasting environmental change, and describing the implications of such change, and impact evaluation which involves making tradeoffs among impacts and arriving at a preference ordering of alternative actions.

Impact analysis consists mainly of identifying the scope of the problem both in spatial and temporal terms, identifying the basic elements concerned, and then taking explicitly into account the interrelationship between those elements, addressing the problem of "feedback-loops" and the fact that many causal linkages occur only over extremely long periods of time.

Impact evaluation raises the question of the relative roles of the decision makers and the "experts" because, at this stage, no judgement--even those of the "experts"--can be value free. One has to decide what the relevant variables are, decide the "worth" of each impact and its "importance" in order to somehow aggregate those impacts and arrive at a final evaluation. If one adds to these "decisions" to be made, the facts of lack of data and knowledge and the need to assume linear relationships between factors, it will be seen that we are far from scientific judgement. There is plenty of room for improvement.

The Environmental Protection Agency is developing methodologies for analyzing the environmental aspects of different types of projects, along with the Institute for Ecology. Major efforts are made in the developing of a reference document containing the latest information on the environmental effects of every type of energy system.

These efforts and others like them will result in increased ability to prepare useful and accurate environmental forecasts. Nevertheless, the lack of accuracy of the methodologies and the lack of data are still a very real threat to the credibility of many EIS. This is likely to last for the next few years.

were required to consider, and led to increasing development of technical expertise, necessitated the development of new technical and cost benefit analysis concepts, and led to the adoption of new approaches to public hearings.

By 1973, the initial uncertainty and disruption had been more or less overcome. The promulgation of the revised CEQ guidelines, on August 1, 1973 showed the process for the integration of NEPA into agencies' operations. This accent is put on the development of policy impact statements as well as the integration, step by step since the early stages of the planning process of the EIS requirement, the involvement of the public, and the decision making process, specifying the role of the draft EIS, the importance of the careful evaluation of the alternatives to the proposed action and the need to take the secondary impacts into account. The trend is now the expansion of the EIS process towards state agencies and the private sector operations.

4.3 The Concrete Results of NEPA

Rather than sudden spectacular material alteration of the federal programs, one has the subjective impression that NEPA has begun to cause some fundamental changes in the agencies' decision making process, so that the machinery for proper agency review of actions is in place, even if it has not yet been extensively used to achieve better substantive results. If NEPA's ultimate goal is a better environment through better federal decision making, then some steps in the right direction have already been done. This is not to say, of course, that no direct results have already occurred. For example, over the past three years, there have been many modifications in nuclear plant design, including redesign of intake structures and major cooling systems, modifications of the thermal flume and the radiological and the chemical waste systems, rerouting of transmission lines, installation of fish screens, redesign of causeways and new studies of alternative cooling systems. Many reservoirs and stream channelization projects have been delayed, modified, or even abandoned. But, as CEQ's former Chairman, Russel Train put it, NEPA's implementation is iceberglike: the showy, controversial tip that involves public attention is complemented by the massive bulk of change that lies beneath the surface, hidden from view, but fundamentally altering the way the federal government responds to environmental problems. And here lies the hope of environmental improvement in the future and in the long run.

5. Learning from NEPA; Critique and Perspective

5.1 The Quality of the EIS; the Methodological Problem

Admittedly, the first EIS were of poor quality. There was little understanding of how to do environmental forecasting. This, in turn, reduced the benefits of the EIS process. Most of

5.2 The Cost of NEPA

First of all, there is the expense of manpower. The Atomic Energy Commission, for example, invests two to five man years for each EIS. And the cost of this labor is very high, being highly skilled. Secondly, there are all kinds of costs related to the delaying of federal programs. Some studies are actually being done on the consequences of the EIS procedure on the cost of energy. Even though the price increase is a very small percentage of the total price, it still cannot be overlooked. More important, perhaps, increased delays increase the complexity and risk of inaccuracy of the whole planning process: planners have to prepare plans for a more distant time horizon if they add the EIS time to the planning and construction time. In the actual period where many parameters change so quickly and so suddenly, this might prove to be a grave handicap by decreasing the rapidity of response of a society to a problem. A third type of cost is organizational expense: such a change in the planning and decision making process of long established agencies has been quite disruptive in many cases decreasing the efficiency of work. Even though agencies have now adpated to the new system, there might be some traces of disruption and sterilizing internal conflict for long.

The response to this critique, based on the cost of NEPA, is that the reform of federal decision making which NEPA brings about will eventually save more time, money and bother than the NEPA procedure wastes. In short, it might well be that NEPA is "cost effective" because it brings careful analysis of the effects of government action and reduces the risk of ill-advised projects which can waste much more money than any EIS.

5.3 International Development

NEPA, and its action forcing procedure, the EIS, was the first law of its kind to be passed in the world. Now Australia and Canada have similar legislations. NEPA has also attracted a lot of attention in several European countries.

The question is whether other countries, and especially developing countries, could profit by EIS type of procedure. Whatever the answer, it is clear that the U.S. Judicial System is so particular that any procedure designed to improve the decision making process to better take the environment into account, would be very differently elaborated and enforced. Furthermore, any reflection about the usefulness of an EIS-type process must be based on an appraisal of the costs and benefits which would occur. As the same resources are not scarce in all countries, an EIS process might not be cost effective in all cases. In many countries the scarce resource is skilled manpower and capital, whereas in the U.S., it is the assimilative capacity of the environment.

Other consequences which might be of some importance are the international trade modifications. The United States has argued

that it would not be fair for them to be less competitive in international markets because of the rigor of their environmental standards (Stockholm, 1972), and some countries have feared that they tie their "aid" to projects which have been through an EIS-type of process.*

Conclusion

In our opinion, the major interest of NEPA and its action forcing procedure, the EIS, is that it improves the decision making process:

i. by a systematic accounting of consequences of a project and assessment of the general public needs and preferences;

ii. by enabling to appraise what are the trade-offs among the various conflicting objectives in the detailed review and evaluation of the various alternatives of the project;

iii. and, generally, by insuring that the final project fulfills and embodies as much as possible the set of priorities and objectives which a given society sees as best suited to increase its general welfare.

NEPA is an example of a powerful procedural tool which has improved the decision making process by reducing the gap between the actual decisions on action or projects and the objectives of a society, which is usually the major inconsistency in that process. Whether a society chooses to emphasize the environment or something else is another matter. The important point is that, no matter what the emphasis is on, no matter where a society chooses to place its "optimal pollution point,** an EIS like process is a useful means to reach it more consistently and rationally.

*Cf. the paper "Environmental Management, Economic Development and Social Welfare," Appendix B.

**Ibid.

Footnotes

1. The first, second, third, fourth and fifth Annual report of the Council on Environmental Quality, U.S. Government Printing Office, Washington, D.C. have already been published.

2. This chapter is inspired by Hugh J. Yarrington, "The National Environmental Policy Act," in Environment Reporter, monograph No. 17, vol. 4, no. 36, January 4, 1974, published by the Bureau of National Affairs, Inc. and Frederick R. Anderson, NEPA in the Courts, published by Resources for the Future, Inc., distributed by the Johns Hopkins University Press, Baltimore and London.

3. See NEPA, Appendix A.

4. Inspired by the Fifth Annual Report of the CEQ, U.S. Government Printing Office, chapter 4.

The environmental impact statement requirement has not been adopted without some problems. Common objections have been that it delays projects, increases project cost and stimulates litigation. Upon close examination, however, it appears that these problems have largely been eliminated. The major need today is to improve the value of the Environmental Impact Statement process to federal decision makers by making the Environmental Impact Statement less cumbersome as a document, by improving its focus on significant impacts and alternatives, and by developing better federal agency response to the environmental concerns of state and local governments and members of the public.

I. Background on NEPA

The National Environmental Policy Act of 1960 established a federal government duty to protect and enhance mankind's environment and to make environmental concern meaningful in all federal actions and policies. The Act responded to widespread awareness that traditional interest in economic development, the pressures of population, and industrial and urban growth had caused severe dislocations that needed immediate and long-term correction.

NEPA's major provisions were broadly conceived and stated. The Act required basic reform of government operations--through more public and comprehensive agency decision making--and establishment of priorities--through consideration of environmental factors along with fiscal and technical concerns. It had three major components. First it declared a national policy "to use all practicable means...to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic and other requirements of future generations of Americans." The Act specified several ways that the federal government should improve and coordinate its policies and programs in order to protect, as a trustee, the diverse cultural and natural environments and natural resources that are needed to serve present and future generations.

Secondly, the Act required all federal agencies to realize these goals by taking an interdisciplinary approach to decision making and by seeking to bring presently unquantified values and amenities into their planning and decision making. Most notably, it required in section 102(2)(c) that all agencies include a detailed environmental impact statement with their "proposals for legislation and other major federal actions significantly affecting the quality of the human environment." The Act specifically required that this detailed statement cover five points, the most important of which is the impact of the proposed action and analysis of alternatives. Section 102(2)(C) also required agency consultation with other agencies, states and local governments before preparing the statement, and that the statement be made available to the public.

Background Paper for the CCMS Round Table Discussion on the Environmental Impact Statement Process of the United States[a]

Round Table Discussion on the Role of Environmental Considerations in the Decision Making Process

by

North Atlantic Treaty Organization

Summary

Under the National Environmental Policy Act (NEPA) of 1969, the United States has established what has become a far reaching process that requires U.S. federal agencies to analyze the impacts of their proposed decisions and their alternatives. Before taking major actions with significant impact on the human environment, federal agencies must prepare these analyses as part of a public document known as the Environmental Impact Statement (EIS). Federal actions covered by the Environmental Impact Statement requirement of NEPA include federal construction projects, regulations, grants of money, and permits or licenses for private projects. More than 7,500 federal actions have been subject to impact statements since 1970 and the requirement has become an integral part of the United States decision making.

The EIS requirement has forced federal agencies to develop considerable internal expertise in many disciplines including the social sciences. It has helped identify data gaps in important environmental concerns. It has helped rationalize and coordinate national environmental policy both within the federal establishment and with the state and local governments. It has, in addition, provided the means for hearing and responding to public as never before. For all of these reasons the Environmental Impact Statement requirement has significantly improved and federal planning and decision making process. Partly as a result it has been widely imitated by approximately half the states in the union and has been adopted in modified form in other fields. Recently, federal agencies began preparing inflation (now called ecnomic) impact statements on their proposed regulations. The Defense Department is required to prepare disarmament impact statements on its major weapon development programs.

[a]NATO Committee on the Challenges of Modern Society, Spring Plenary, February 8-9, 1977, Dusseldorf, Federal Republic of Germany.

Lastly, NEPA established the Council on Environmental Quality (CEQ). The Council must, among other things, advise the President on environmental matters, review agency compliance with NEPA, and prepare for the President an annual report on conditions and trends in the nation's environment and government activities and a program to remedy any deficiencies.

Executive Order 11514 of March 1970 more clearly spelled out the duties of the agencies and the CEQ under NEPA. It directed agencies continually to monitor, evaluate and control their activities to protect and enhance the environment; to develop programs to meet such goals, and to assess their progress in doing so. It also required agencies to develop procedures for making available to the public information on agency plans and programs having environmental impacts. The Executive Order directed CEQ to issue guidelines for agency preparation of impact statements.

II. The EIS Process and CEQ's Guidance to Agencies

Since the Executive Order, CEQ has issued three sets of guidelines on impact statement preparation. The current guidelines were issued in August 1973. The guidelines complemented and followed the construction of NEPA and its EIS requirement that were continually being developed by agency practice and by the federal courts. These court decisions emphasized and enforced the requirement that agencies evaluate and disclose fully, honestly and in a timely way, the impacts of their proposed actions and the reasonable alternatives.

CEQ's guidelines seek to bring EIS procedures into line with agency needs and experiences as well as court decisions. The guidelines specifically state that the EIS should be a concise, nontechnical document focusing on the impacts of a proposal and its reasonable alternatives. The EIS should be designed to help decision makers and the public address these questions:

First, what are the goals of the project and the need for them?

Second, what is the extent of the environmental damage it will cause?

Third, can agency goals of the project be met through some alternative path that would cause less damage; and

Fourth, if there is no feasible alternative, what steps will be taken to minimize the environmental damage?

The guidelines establish the basic structure for the EIS process which must begin with a federal agency's determination that a proposed action will, or will not, have significant effects on the human environment. Then the agency must notify the public that it will prepare a draft EIS. Once a draft is

prepared it is sent to the Council, other federal, state and local agencies, and to interested members of the public for comment. The comment period must be at least 45 days. The agency must then analyze any comments it receives, revise the draft and prepare a final statement, which must also include a record of all comments. The final EIS is circulated to the same parties who received the draft and the agency must wait 30 days before taking any action. The entire process, from issuance of the draft to the taking of an action, must formally be not less than 90 days.

The guidelines require that the EIS process be applied to a wide range of federal actions with significant environmental impacts, whether a loan, grant, permit, license, contract, land use plan, construction project or regulation; and that each EIS should consider the full range of significant environmental effects, including cumulative, synergistic, international, social, and economic effects. Most agencies conduct environmental assessments of many thousands of actions in order to determine which actions need EISs. This assessment process fosters improvements in projects to alleviate environmental damage and thus underlies the whole EIS process.

Since federal programs and administrative practices vary so substantially, the guidelines require agencies to develop their own specific procedures to tailor the guidelines and the EIS process to their particular activities. Today approximately 70 federal agencies have developed such procedures. Most recently the Agency for International Development (AID) has established a formal EIS procedure for its foreign assistance programs. In line with this, the CEQ is now asking that environmental impact analyses be prepared on any overseas federally sponsored activity relating to impacts on the global commons or on the U.S. itself. CEQ guidelines, agency NEPA/EIS regulations, and judicial opinion provide the basic policy direction and framework for the EIS process, but more is necessary. Agency handbooks, practice manuals, policy memos and priorities, and legal counsel's advice are the materials that most directly guide agency staff, especially in the field. Similarly, CEQ's other guidance to agencies--such as general memoranda to heads of agencies, letters on specific cases to various levels of agency staff, and legislative reports and testimony--often has a more direct and immediate effect on agencies' practices than the broader guidelines themselves.

In 1975, CEQ conducted an intensive year-and-a-half review of agencies' use of the EIS process in decision making, their compliance problems, and possible improvements that CEQ and the agencies might make. To learn about agency experiences with the thousands of EISs prepared, CEQ sent a questionnaire on the EIS process to all agencies in November 1975, followed by a second on their NEPA litigation experiences. CEQ staff followed up with meetings with the agencies most involved in the EIS process. The staff also sought the written views of all the states on the NEPA process, received responses from 27 and reviewed these with a special committee of the National Governors Conference.

In March 1976, CEQ published its review report. The report cited the major accomplishments of NEPA and noted the many improvements that are needed to make the EIS process more effective. These accomplishments and problems are summarized below.

III. Accomplishments of NEPA

A. The NEPA Process Has Significantly Changes and Improved Federal Decision Making

The NEPA process has had a major beneficial effect on federal agency planning and decision making since 1970. In the early years of the Act, agencies' attention was focused on the requirement that they produce the requisite environmental impact statements. Over the past seven years this requirement for formal and public environmental analysis that has had a significant effect on federal agency plans and decisions.

It is virtually impossible to measure this effect with precision. Attempts to make such assessments through critiques of impact statements, and their length, content and use, do not reveal the most important effects of NEPA. The process of preparing a draft EIS may cause a good deal to happen within an agency to change and improve a decision affecting the environment. Expereience shows there are many situations in which the EIS, in draft or final form, has helped bring about project changes. Several notable examples can be given.

Among the earliest effects of the EIS process on federal decision making was the Interior Department's second draft EIS and its final EIS on the 800-mile Trans-Alaska Pipeline. Virtually all parties involved agree that the intensive environmental review of this project prompted important project design changes and other improvements in routing and construction techniques.

Several years ago two major radioactive waste disposal proposals of the former Atomic Energy Commission (AEC)--one at Lyons, Kansas, and the other at the Savannah River in South Carolina--were abandoned because of uncertain environmental impacts identified by AEC and public analyses conducted through the agency's EIS process.

In early 1975, one of the AEC's two successor agencies, the Energy Research and Development Administration (ERDA), reviewed criticisms of the AEC draft program statement on commercially generated radioactive waste management. The draft had proposed that surface storage facilities offered the best interim solution but, after the commenting process, ERDA concluded that NEPA and the public interest would be best served by another analysis in a new program statement and so withdrew its storage facility budget request.

The other AEC successor agency, the Nuclear Regulatory Commission (NRC), used the AEC impact statement on the breeder reactor and its own subsequent EIS on the plutonium recycle proposal as definitive bases on which to develop stronger measures to safeguard against the misuse of nuclear materials. Like the former AEC, NRC's reactor licensing directorate has integrated the EIS into its licensing decision making process and, as a result of this environmental work, has modified project decisions in numerous cases.

The U.S. Army Corps of Engineers decided to drop or abandon work on over a dozen of its proposed water resource projects because its NEPA process--not litigation--revealed that significant environmental damage would result. Eleven other projects have been stopped until environmental analysis is complete. The Corps has also modified or recommended for deauthorization many more projects due in large part to NEPA and the EIS requirement. These actions have resulted in widespread environmental benefits which are real and substantial but cannot be tallied in monetary terms.

The Corps has also used the EIS process effectively in deciding whether to grant permits for private projects involving water and related land resources. In 1976, after completing an extensive EIS, the Corps rejected two of three required permits for a proposed recreational and retirement home development in southeast Florida on the grounds that it would have destroyed 2,000 acres of valuable wetland.

Illustrating the range of NEPA's effects, the EIS process has also altered building projects of the General Services Administration. GSA's draft EIS on the Kennedy Museum and Library in Cambridge, Massachusetts, focused attention on the traffic and other adverse changes that would affect the area. As a result, the Kennedy Library Corporation decided against that proposed museum site and examined several other alternatives while planning to keep the Kennedy archives on Harvard University property.

Over the past several years NEPA has had an increasingly significant effect on the extensive land use planning efforts of both the National Park Service and the Forest Service, each of which manage large portions of the U.S. public lands. Environmental assessments and statements have been used routinely by both agencies, permitting decision makers to evaluate the impacts of various plans and alternatives for the use of national parks and forests. The Park Service Director recently reiterated and emphasized the decision making importance of the NEPA process in a directive to all Park Superintendents. Last year the Forest Service illustrated what is perhaps the most far-reaching use of the EIS process when it issued a draft and final EIS on its long-range (10- to 40-year) program for national range and forest lands. The Forest Service began its EIS process by seeking and responding to extensive public and governmental inputs in defining program alternatives.

B. NEPA Has Improved Interagency and Intergovenmental Cooperation and Coordination

Interagency cooperation and planning have been encouraged by NEPA and have developed considerably over the past seven years. NEPA requires that agencies conduct interdisciplinary analyses in their planning and decision making. This frequently results in interagency cooperation in the preparation of EISs. An excellent and current example is the comprehensive EIS on banning nonessential uses of fluorocarbons being prepared by the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and the Consumer Product Safety Commission (CPSC).

CEQ's guidelines establish a mechanism for having a lead agency take direct responsibility for an EIS when several different agencies are involved in a single action. CEQ has formally recommended lead agencies in a number of situations to help reduce paper work and decision delays. Cooperation between lead and subordinate agencies has been a regular feature of the EIS process and has been fostered by a number of formal interagency agreements on EIS preparation, most notably those involving interaction between the Nuclear Regulatory Commission and other agencies.

The Act also requires that federal agencies with jurisdiction and expertise, and relevant state governments, receive and have an opportunity to comment on EISs prepared by other agencies. Draft EISs which are circulated to federal, state and local government agencies and the public, have elicited such comments formally, and final EISs have required the initiating agency to respond to differences, often by resolving them. Prior to NEPA no other mechanism of government so broadly and publicly subjected important proposed agency actions to interagency and public scrutiny.

While a great deal of work must be done to make this review and comment process more effective in decision making, it is important to realize how federal agencies have come to use it to test and improve their proposals, and it has been heartening to review the responses of the 27 states responding to CEQ's questionnaire on this subject. With few exceptions, the states have reported that the federal EIS process helped their planning or decision making process or was, on balance, well worth the costs they incurred in reviewing federal EISs.

C. NEPA Has Provided a Constructive Avenue for Public Participation in Governmental Decisions

The public has been able to participate in governmental decisions effectively through the NEPA process, as specifically intended by Congress when it passed the Act. Public comments on proposed federal actions, along with the comments of other federal, state and local agencies, now receive formal consideration

by means of the draft and final EIS process. In addition, many agencies have held public hearings or informal meetings on proposed actions before or after writing an EIS. These hearings and meetings have given federal agencies valuable information on important issues, have helped them anticipate and avoid controversial actions and have provided the public with a constructive outlet for frustrations against our immense, often impersonal, and sometimes unresponsive, government. It is testimony to the importance of these opportunities for public participation in environmental management that a recent poll of over 100 environmental leaders, reported by the American Forestry Association, named NEPA as the most important environmental statute of the century.

IV. Apparent Problems with the EIS Process

The most common objections to the EIS are these: it delays projects, it increases project costs, and it stimulates litigation. Close analysis gives these "problems" a different look.

In the first year or two after NEPA was passed, delays did occur. Virtually any new policy entails some delay, as federal managers adapt traditional procedures to change rules. But this predictable pause for a shifting of gears was prolonged in the case of NEPA because Congress did not insert a "grandfather clause" in the act.

This means that agencies with projects well into the planning or even construction phase had to halt work on any project that would have significant environmental effects, and prepare an EIS on each of them--in a very short time. In 1971 alone, for example, the Department of Transportation (DOT) filed 1,293 draft environmental impact statements--the great majority on projects authorized or undertaken before NEPA was passed. In 1975, by contrast, the Department of Transportation filed only 229 draft EISs--about one-fifth the number of the peak year. In 1971, federal agencies filed a total of almost 2,000 draft EISs--twice the number they filed last year. This sudden workload, imposed on agencies that had little opportunity to staff for NEPA, created a backlog that undeniably did lead to delays in project approvals.

But the lack of a "grandfather clause" exempting well advanced projects from NEPA requirements also created a more subtle problem--one that hampers the effective operation of the EIS process to this day. First of all, it led to bad habits: federal managers who had already invested considerable time and money in a project wrote their EISs to justify decisions that had already been made. Second, it inhibited any genuine questioning from an environmental perspective of the economic and technical assumptions on which a project had been based. Thus, the delay occasioned by EIS preparation seemed doubly useless--and the EIS itself acquired a reputation, in those early days, for being an

irrelevant exercise in meaningless, expensive paperwork. It has not yet entirely outlived that reputation.

These days, the intial backlog of EISs is virtually gone. Those submitted now are overwhelmingly for actions proposed after NEPA was passed.

Nevertheless, the criticism of NEPA-occasioned delays persists. Because CEQ is charged with supervising the EIS process and thus has an interest in making it work properly, it looked into this. It asked federal agencies to estimate the time required to prepare a draft EIS. Given the variety of projects undertaken by the federal agencies the times varied greatly--from a minimum of one month for several agencies, to a maximum of several years for others.

The crucial point to be made about this period is that in a properly run agency that takes NEPA seriously, the preparation of an EIS does not add months to those necessary for the normal planning process; rather, environmental analysis proceeds in tandem with technical and economic analysis. It need not be an addition to normal planning but initially may require additional resources.

This point was brought out in testimoney before Congress in September 1975 by Brigadier General Kenneth McIntyre, Acting Director of the U.S. Army Corps of Engineers. From CEQ's survey, it was learned that the Corps spends an average of nine months on preparing a draft EIS and another ten-and-a-helf months on review and revision prior to filing a final EIS--a rough total of 20 months. Adding time for review of the final EIS, it can be assumed that the whole process takes 24 months. This is a substantial period, and if it all represented delay, it would be an extremely costly one.

But General McIntyre testified that the average length of time required for a corps project is 15 to 16 years. Of these, he indicated, only about five years would go into actual construction; the rest would go into an initial study of the feasibility of a project, followed by a request for project authorization and funding by Congress and planning and design work prior to construction. Finally, General McIntyre testified, since the passage of NEPA, the Corps places EIS analysis among the matters to be considered first--as part of the feasibility study--rather than leaving it until after the proejct meets other criteria. The Corps found that the key lesson was the necessity for handling the environmental factors as an integral part of the overall planning process. The EIS must not be made the end in and of itself. Environmental data must be provided in a timely manner to the decision maker so as to be considered to the same depth of understanding and detail as the economic and engineering concepts and information.

To repeat, environmental analysis need not delay a project if it is undertaken as an integral component of the planning necessary for any federal action.

There are, however, other causes of delay related to NEPA and the EIS process. One of them has been the tendency of some federal agency heads not to take NEPA seriously--and this attitude is passed on down the line, either explicitly or by executive osmosis, to project managers. Not all managers accept this point of view; indeed, in many cases, middle level managers have tried very hard to live up to NEPA in the face of indifference or even hostility from the top.

But if managers adopt an indifferent or hostile attitude toward NEPA, they often wind up creating delays. They conclude, following a show of environmental analysis, that a proposed action will have no significant impact--and hence, that no EIS is necessary. Sometimes agencies decline to prepare an EIS simply because the action does not seem to be controversial. Frequently such decisions lead to litigation and, in the end, a court order to prepare an EIS. In that case, the project is halted--not by NEPA per se, but by attempts to bypass it.

Another reason for delay is changing public preferences for certain kinds of projects. Twenty years ago, dams, highways, and airports were popular items. These days, many such projects are greeted skeptically--not because of NEPA, but because of our experience with the unanticipated side effects of seemingly worthy activities.

Finally, some projects ought to be delayed. Complex projects with potentially far-reaching effects on the environment deserve a thorough look, and are often improved as a result of comment--and even opposition--by the public and by other governmental agencies.

As part of CEQ's survey on NEPA, it also checked into the amount of litigation that has arisen in connection with the EIS process. There is no doubt that NEPA stimulates some litigation; if it did not, it would be a pointless, toothless piece of legislation. But the claim that NEPA-related suits interfere with the timely exeuction of a substantial number of federal actions simply does not stand up.

In the five-and-half years between January 1, 1970, and June 30, 1975, a total of 654 actions were brought, alleging a NEPA issue. During that same period, federal agencies initiated tens of thousands of projects; in 1975 alone, agencies assessed more than 30,000 projects for environmental impacts. Since 1970, about 6,000 draft EISs have been submitted. Only 291--less than five percent--were challenged in court as being inadequate.

Of the 333 cases completed by June 30, 1975, about one-third were dismissed at the trial court level. Roughly 60 resulted in

temporary injunctions, which ranged from a few weeks to the time required to prepare an adequate impact statement. Only four cases resulted in "permanent" injunctions--and not even in these was the agency precluded from proceeding with its project or program after it complied with NEPA.

V. Improvements Needed

The major improvement needed in the Environmental Impact Statement process is to make it more useful to agency planners and decision makers. There are a number of steps that need to be taken to achieve this result.

A. The statements themselves need to be far more concise and should focus on the significant environmental impacts of a proposed action and its alternatives. As a general matter, few EISs need to be more than a single volume long. Agencies should distill the information produced by environmental analysis and the statements should focus on those relatively few questions crucial to deciding the acceptability of a project. Detailed information and exhaustive analysis are essential to the preparation of an EIS, but this supporting material should be placed in appendices or in other ways made available to the public. CEQ has taken a number of steps, including supplementary guidance to agencies, to insure that the EISs are not the cumbersome documents that many have been in the past.

B. Federal agencies will need to improve the application of the EIS requirement to their broader program and policy actions. A central purpose of NEPA was to reform piecemeal decision making by requiring more comprehensive and systematic approaches to the environmental analysis.

Program impact statements continue to be used as a means of analyzing impacts of major programs and their alternatives. As of March 1976, 24 of the 33 departments and major agencies had used program statements. In 1975 CEQ received final impact statements on 38 broad federal programs covering a range of topics. Examples are the Emergency Watershed Protection Program of the Soil Conservation Service, the National Wildlife Refuge Program of the Fish and Wildlife Service of the Interior Department and the Coal Conversion Program of the Federal Energy Administration.

Occasionally, however, federal decision makers take actions without considering their effects on relationships to other actions. Special problems arise when different federal agencies propose different actions affecting a similar region as, for example, when different federal agencies license energy projects that can have significant cumulative impacts on a common resource or river basin. CEQ and the courts have both attempted to develop better guidance for agencies on what is an appropriate

range of proposed actions to be covered by a given impact statement. The most sophisticated practices to date are found among agencies which prepare broad scale impact statements covering a proposed program followed by more specific statements on individual actions with significant impacts that are not addressed by the broader statement. The "tiered" approach of the Forest Service begins with a statement on national management goals, followed by statements on areawide land use plans or, if necessary, by site-specific statements.

C. The impact statement process can more effectively satisfy the numerous environmental review requirements of laws other than NEPA. A vast number of environmental laws, for recreation, water resources, air and water pollution, historic and cultural preservation and endangered species preservation, require certain consultation and certification requirements by specific federal agencies before federal actions can be taken. The Environmental Impact Statement process can be an effective way of assuring that these consultations take place as a part of normal project review. Administrative guidance to federal agencies is necessary, however, to avoid duplication and to make the EIS process an efficient overall review procedure.

By the same token, the federal EIS process can and should be better integrated with existing state requirements for impact statements for other environmental reviews. Solutions to this coordination problem largely depend on individual federal agencies' efforts with the various states, each of which has different environmental procedures.

D. Federal agencies will need to give greater attention to the environmental review processes that should occur before an EIS is prepared and after it has been prepared. Several agencies, notably the U.S. Army Corps of Engineers, the Forest Service, and EPA have led the way in helping integrate environmental impact analysis with agency planning. They have given particular care to planning in the early environmental survey process, including the use of a written assessment or expert consultation in order to minimize adverse effects and improve project design before any actions are proposed. Such processes should be encouraged and developed within a large number of other agencies.

E. The filing of the final impact statement should not, however, be the end of the environmental review process, as is commonly the case. Agencies do not now have to explain their decisions if they deviate from the results of their EIS analysis. In fact, they do not even have to inform interested parties of their decisions to do so. They usually do not provide the continuing review and monitoring of the effects of their actions nor the standards or criteria which will trigger agency response in the event of adverse effects. In short, agencies generally do not use their EISs as a standard to which their subsequent conduct can be held accountable. The need for a new mechanism to

review and monitor the effects of actions after the completion of the EIS process remains a troublesome difficulty that needs new attention in the future.

VI. A Few Conclusions and Questions

First, the obvious: The United States' Environmental Impact Statement process works. Of the many environmental protection efforts undertaken in the United States in the last decade, the EIS procedure is most often singled out as being the most important. However, the EIS system is not without its faults, both real and apparent. Most would agree that its present real problems will be solved by evolutionary changes within the scope of present legislation.

Second, the most significant aspect of the EIS process surprisingly has been political, not environmental. The publishing of the detailed factual base on which decisions should be made and inviting other federal agencies, state and local governments and public citizens to participate in the process has been revolutionary. This process has not only given other agencies and the public greater information and outlined alternatives, but it has helped to point out the key political facts of "who pays" and "who benefits." Opening these central political questions to public scrutiny has produced in the context of an environmental procedure a small revolution in democratizing decision making within the United States.

Third is the truism that the Environmental Impact Statement process, despite its successes, does not replace basic environmental protection laws and regulations. Much of the criticism directed at the EIS process arises when proponents of strong environmental protective measures seek to use the NEPA procedures as a substitute for nonexistent federal, state and local legislation. When, for example, regulations regarding the stripmining of coal are antiquated or nonexistent, the EIS has become a substitute political arena -- a role the NEPA was not specifically designed to fulfill.

Lastly, it should be emphasized that since the EIS requirement tracks the decision making process, it is only as good as the decision making process itself. When decisions take place on a case-by-case basis, the EIS results are consequently limited. The EIS process itself has pointed out the inherent problems in applying case-by-case analysis in areas of broader concern. The EIS results suggest a need for a more comprehensive planning process in many areas coupled with strong public participating. How far and how fast the federal agencies move toward more comprehensive planning remains to be seen. What is clear is that the environmental impact statement process will both push toward and serve more comprehensive decision making procedures. Increasingly broader planning is being undertaken at the federal level in public land management and coastal zone management. However, in

several other critical environmental areas, there is neither a federal inventory of scarce environmental resources nor development of long-term utilization plans. Questions regarding the high cost and uncertain benefits of comprehensive planning plus fundamental political questions regarding public planning of private resources still remain to be answered. We do know that the Environmental Impact Statement process works in large measure because the Congress laid down with foresight a legislative dictum which has been enforced by the courts. In addition, the federal agencies have, on the whole, shown a remarkable willingness and ability to adapt to the new EIS requirements. On the other hand, whether the long-term push of the environmental impact statement process will lead to more comprehensive and effective environmental planning through an evolutionary process remains an open question.

GUIDELINES FOR INCORPORATING ENVIRONMENTAL PARAMETERS IN PROJECT APPRAISALS

by

Paul V. Hebert[a]

The quest by the developing nations of the world for higher standards of living often involves the deliberate modification of the natural environment to achieve economic objectives. However, such activities as the construction of roads, dams, water supply and sewerage systems, airports, irrigation systems, power plants and industrial facilities sometimes result in detrimental impacts on ecological, health and social/cultural values and, in the long run, increased costs to society. Such impacts, which vary widely in magnitude, may result from the failure adequately to consider environmental consequences during project planning and design, or from the lack of knowledge and information necessary to predict the eventual impact. Even if undesirable effects are forecast, information on cost-effective environmental safeguards may not be known, or economically competitive project alternatives are often unavailable.

To the extent that these losses occur or go unmeasured, the level of development is inflated. Often the difference has to be paid with a higher price and at a later stage of development. Higher costs of future remedial action may be avoided by prudent planning and early preventive measures. It is important, therefore, that all who are involved in a proposed project - planners, decision-makers, engineers, lending institutions - have as clear an understanding as possible of the potential positive and negative environmental consequences of development activity at an early stage of project planning. Based on such knowledge, it may be possible to avoid or mitigate undesirable effects, or promote positive consequences, by incorporating pollution control technologies, redesigning the project or selecting another site. The associated costs can be used as a basis for modifying the project and, at the very least, assigning the costs to that agency most appropriate to meeting the costs. The identification and analysis of environmental considerations in all of these projects require trained expertise at all levels.

Specifically, by incorporating environmental parameters into project appraisals two main objectives are sought: (1) to pre-

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vent the deterioration of natural resources so that they can continue to provide the basis for sustained economic development; and (2) to predict the potential side effects of project development, which may result in social costs not identified in the ordinary review process. The following guidelines provide an approach to incorporating environmental parameters into project appraisals.

A. The General Framework for Considering Environmental Aspects in Project Appraisals

1. Types of projects subject to appraisal

- new industries and industrial expansions, including power plants
- mining
- agricultural development, including agrobusiness
- dams for water supply, irrigation and hydropower
- water supply, sewerage, and wastewater treatment
- urbanization, including housing developments, commercial centers, etc.
- electrification
- transportation
- communication
- ports and harbors

2. Areas of environmental analysis

a. Baseline data on existing resources and environmental conditions in project locale and the total area of project influence

- existing natural resources of potential use by the project
- existing flora and fauna and general ecosystem classification
- existing conditions and assimilative capacity of the environment for waste products
- existing human settlement patterns

- conditions of general health, and disease status, of the local population

- land use in the locale of proposed project

- environmental monitoring capabilities

- human resources available to serve the project, including the spin-off activities

b. Environmental appraisal of the completed project alternatives during project during project planning and design

- impacts of alternative use of resource inputs

- impacts of alternative project siting

- impacts of process alternatives

- impacts of alternative operating schemes

- impacts of alternative waste treatment schemes

c. Appraisal of project construction impacts

- impacts of alternative construction procedures

- impacts of work conditions during construction

3. Environmental impacts subject to appraisal

a. Impacts on the physical environment

- impact on existing resources used as inputs to the project

- impacts on ecosystems and specific flora and fauna

- ability of the environment to assimilate specific wastes

- impacts on physical appearance of the project area

- impacts on local land use

b. Impact on public health and safety

- industrial hygiene relating to the project workers

- impact on endemic parasitic diseases, and other diseases

- potential toxic chemical emissions to the air and water or land

c. Socio-cultural and economic impacts

- disruption of human settlement patterns

- impacts on urbanization and population increase due to migration

- influence on local small scale industry and/or local agricultural practices

d. Long term considerations

- does the project preempt any future resource options either by its presence or operation?

- what additional urban or rural infrastructures may be required to cope with increased population and service demands of the project?

- impact of possible future expansions on the local environment

- institutional arrangements for serving the project including the training of necessary support personnel for environment control

Procedures for Conducting Appraisals

For each specific proposed development project, baseline data in the proposed project area would be gathered against which the potential environmental changes brought about by the completed project alternatives would be judged. Appraisal of the completed project and the construction of the project would be made considering project components previously listed and considering the five categories of potential environmental impacts. During the analysis, primary or direct impacts and secondary or indirect impacts would be distinguished. The primary impacts for example are those caused directly by the project, such as detrimental effects on water and air quality due to waste discharges from the project, or increase in a specific parasitic disease caused by increased amounts of water available in a new irrigation system. Indirect impacts might include the increase in air pollution caused by more automobiles in the area due to population increases or changes in land use due to the increase in migration to the area and subsequent demands for more peripheral housing.

An example of the development of a water project considering the construction of a dam and reservoir for the purpose of hydropower and irrigation will be used to illustrate the procedure for

including environmental considerations in project appraisals.*

Environmental Considerations in the Appraisal of a Large Dam Project for Hydropower and Irrigation

A. Baseline Data Collection on the Environment of the Area of Project Influence

1. Existing resources in the impoundment area and downstream including in addition to water resource data: timber, mineral and wildlife resources, agricultural lands, fisheries, human settlements, recreational facilities, etc.

2. Ecosystems and flora and fauna of the dam site, impoundment area and downstream.

3. Current uses being made of the natural flowing waters.

4. Archeological and important historical sites, number of nomadic peoples frequenting the project area.

5. Current land use patterns in the proposed project area.

6. Conditions of general public health in the total area of influence.

7. Water quality and natural erosion conditions in the water body for proposed impoundment.

B. Environmental Appraisal of the Completed Project Alternatives: Impacts in the Impoundment Area and in Vicinity of Dam

1. Impacts on the physical environment

a. Loss of natural resources in the impoundment area including timber and mineral resources, agricultural lands and other valuable plants.

b. Impact on fauna and flora, specifically: fisheries: probable increase in fish production in reservoir

*Much of the information on dams and their environmental impact was taken from Peter H. Freeman, Large Dams and the Environment, Report for the United Nations Water Conference, Mar Del Plata, Arg., International Institute on Environment and Development, 1977.

- disease vectors: anopholes, shistosoma, and their intermediate hosts

- waterfowl

- water hyacinth and other aquatic plants

c. Nutrient and sediment build up from natural inflow and from building around reservoir.

d. Water quality changes and concomitant results.

e. Climatic changes due to different water regimes.

2. Socio-cultural impacts

a. Changes in general settlement patterns, relocation and settlement of people.

b. Destruction of archeological and/or historical sites.

c. Disruption of traditional farming practices or other economic activities in the impoundment area.

d. Disruption of transportation routes.

e. Recreational potential of the reservoir.

3. Public health and safety

a. Increased exposure among lakeside dwellers to endemic diseases which are water related: intestinal bacillary diseases, schistosomiasis, malaria, onchocerciasis.

b. Migrating populations serving as reservoirs of new disease.

c. Existing medical facilities and programs' abilities to cope with disease problems.

4. Long term considerations

a. Can local governmental infrastructure cope with the drastic changes in the area with potentially increased population and other secondary development?

C. Downstream Impacts in River Channel and Flood Plain

1. Impacts on the physical environment

a. Modifies downstream hydrograph

- reduces peak flows and floods resulting in decline of seasonal fish spawning and breeding in flooded areas and decline in associated wild life such as water birds and fish-eating mammals

- reduces peak flow channel scouring

- groundwater recharge from flood waters ceases

- flushing of debris and weeds from river channels, oxbows and flood plains ceases

- reduces capacity for diluting, flushing and transporting wastes

- provision may be made for increasing and stabilizing minimum flow with various effects for waste dilution, local ground water recharge, navigation, and water withdrawals for irrigation, homes or industry

- introduces abnormal and variable flows caused by project operation, such as creation of flood control space, periodic generation of peak power, or exposure of shoreline to control the propagation of insect pests and vectors

b. Modifies river erosion

- causes shift from an erosion-deposition cycle to one of continual erosion. Channel scouring and degradation take place immediately downstream from the dam.

- reduction of peak discharges halts periodic transport of large quantities of sediment

- channel stabilizes and vegetation may become established on banks; channel may deepen

- where not held by vegetation or protected, banks may steadily erode

- flood plains no longer receive annual increment of silt

c. Alteration of water quality

- temperatures are lowered during usual low-flow period

- water released from deeper portions may be rich in iron and manganese, and low in dissolved oxygen in certain seasons
- water may contain H_2S in certain seasons

- augmented flow during dry period may improve quality by providing more dilution, especially of irrigation return water

- rapids may be created which produce breeding environments for Simulium damnosum, vector of onchocerciasis or river blindness in places where it occurs.

d. Modification of aquatic productivity and fisheries

- seasonal peaks in fish production cease as consequence of cessation of flooding and creation of backswamp fisheries

- productivity may decline as consequence of negative changes in water quality (turbidity, salinity, and fewer nutrients).

- stabilized banks and bank vegetation may increase productivity for some species and for wildlife

- migrations of some fish are impeded

e. Impacts in delta, bay or ocean

- reduction of seasonal peak discharge stabilizes the freshwater-saline water boundary and salinity gradient with possible detrimental consequences for shellfish adapted to a changing boundary and for species which have evolved to migrate to or through estuaries during peak runoff

- reduction of total inflow due to irrigation or other consumptive withdrawals results in upstream displacement of the freshwater/salt water boundary

- reduction or cessation of the seasonal flush of organic debris nutrients and fresh water to the estuary and offshore areas is likely to cause decline in aquatic productivity of these areas

- cessation of annual sediment deposition leads to wave erosion of delta

- increased farming in flood protected areas may result in higher nutrient inflows to estuaries following application and leaching of chemical fertilizers; contamination by pesticides is also possible

f. Impacts in areas of irrigation projects

- flood control allows development of irrigated farming and establishment of new settlements. Wildlife habitats in reclaimed areas are lost

- application of irrigation water raises water table, possibly resulting in water logging and salination if drainage is not adequate

- agricultural chemicals, molluscicides and salts in return water and discharged into the river downstream from project, with various results

- canals provide stable habitat for weeds and vectors of human disease

- distribution canals and diversion dams may provide recreational uses, and water for domestic consumption, whether intended or not

- atmospheric humdiity may increase locally

2. Socio-cultural impacts

a. Disruption of settlements due to possible land requirement for large scale irrigated agriculture

b. Migration and population increase due to increased employment opportunities

c. Changes in traditional agricultural practices due to potential for perennial irrigation

3. Health and safety

a. Potential for the introduction or increase in transmission of various parasitic diseases including schistosomias, onchocerciasis, and malaria due to flowing water and the year round availability of suitable habitats for intermediate host

b. Impact on provision of basic sanitation due to potentially larger population

4. Long term considerations

a. Will the land being perennially irrigated be subject to salting, thereby limiting future productivity?

D. Direct Impacts During Construction

1. Impacts on the physical environment

a. Siltation caused during dam construction and during building of access roads

b. Creation of dust, with accompanying disease transmission

c. Sanitation problems in work camps