CHAPTER ONE

CONTEMPORARY ISSUES IN ENVIRONMENTAL HEALTH

The environmental health problems of developing countries fall broadly into two categories: the problems arising out of poverty or the inadequacy of development, and the problems that arise out of the process of development. The severe environmental health problems in developing areas (e.g., inadequate potable water supplies, unhealthy excreta deposition, etc.) can be overcome by the process of development. However, poorly planned and unregulated development can have critical negative consequences for the health of the people of a developing nation as well as for the ecological system that affects the rest of the world.

A large literature has been collected demonstrating that health problems can limit development potential in serious ways. Chronic disease and malnutrition reduce productivity and availability of labor; undernourished ill children do not learn normally and subsequently are not easily trainable; chronic disease produces a financial drain on a society and directly reduces its economic resources. Investors are reticent to locate factories, tourist facilities, and other economic ventures in areas lacking good sanitation, a relatively healthy work force, or where significant health hazards exist.

An enormous waste of resources occurs when poor health conditions restrict settlement in areas with fertile land or other natural resources. The presence of onchocerciasis in Western Africa has restricted access to land and resources (World Bank, 1975). Studies of Nepal, Sri Lanka, and parts of Mexico demonstrate instances where malaria eradication has allowed a movement of labor and capital into resource—rich districts from less resourceful areas, with a net increase in the total output (Taylor, 1967). A successful settlement scheme was carried out similarly in the Anchan Corridor in Nigeria after sleeping sickness had been controlled (McKelvey, 1973).

Many attempts at economic development indicate that it is a mistake to equate the goal of development with the narrowly conceived objective of economic growth as measured by a rise in gross national product. The development process has been broadened to include the attainment of certain social and cultural goals. The incorporation of environmental issues and environmental health concerns in the expanded concept and goals of development has important implications for planning and for policy making.

Health planning carried out as an integral part of a nation's or region's socioeconomic plan is the ideal. This is rarely the case in reality. Environmental health objectives compete with individual plans and objectives submitted by various sectors. Most often a "trade-off" between health and broad growth objectives must be made. This manual provides assessment methods to identify specific environmental hazards to health, and information about alternatives in technology to control those hazards. In the writing of this document, an emphasis has been placed on the costs of various interventions and the elaboration

of how the economic goals of development can be supported by various technologies in the field of environmental health. It is believed that a more complete understanding of the goals of socioeconomic development and its implications can aid the planner concerned with environmental factors and health in presenting alternatives in technology that persuasively meet those goals and also support health.

In the process of planning to enhance economic growth, any country should ascertain the nature of its environmental problems and assets. Environmental hazards to health constitute one set of such problems. In addition, the environmental side effects and their health consequences which are encountered in the development of various sectors should receive selective treatment. These must be evaluated in terms of the development priorities which guide the planning considerations of any country. Those side effects and health consequences that directly frustrate the development objectives should be given immediate attention for remedial action.

The section will briefly discuss the environmental side effects of some of the consequent health effects that have been found to accompany the process of development in agriculture, industry, transport, and human settlement. These side effects can be grouped into several categories.

Resource deterioration: the deterioration, for example, of mineral, soil, or forest resources;
Biological pollution: the pollution represented by agents of human disease, and by animal and plant pests;
Chemical pollution: including air pollutants, industrial effluents, pesticides, metals, and detergent components and similar agents;
Physical disruption: as reflected, for example, in thermal pollution, silting, and noise; and
Social disruption: of which congestion and loss of a sense of community are examples.

Agriculture

The process of agricultural development often involves the transformation of low productivity systems of agriculture into systems where productivity is relatively high. In this transformation process, cultivation practices on existing lands are improved, the infrastructure of facilities and services for agricultural production is expanded, and new lands are made suitable for cultivation through irrigation systems and river basin development. These changes are crucial to the development process but they may also generate side effects of varying importance, many of which have consequences for health. The environmental effects known to accompany these changes will be briefly presented here. Health consequences associated with these environmental side effects will be discussed in later sections.

Traditional agriculture in many tropical regions is characterized by a range of environmental hazards. These include leaching, particularly the rapid leaching of nutrients and degradation of planted farmland following the removal of a forest; rapid soil depletion resulting from permanent cultivation of a relatively infertile soil which cannot be supported without the addition of nutrients; soil erosion through variable and heavy rainfalls and prolonged droughts or flash floods; and indiscriminate loss of forest resources through slash-and-burn techniques. Although some of this kind of environmental deterioration can be corrected if unlimited funds are available, some are so costly to correct as to be essentially irreversible. The fragility of tropical

ecosystems may cause environmental deterioration to proceed rapidly and recovery to be slow. In one instance, the establishment of an agricultural colony failed when deforestation resulted in the hardening of lateritic fields within five years. In another country, previously ungrazed savanna was destroyed by over-grazing in two to three years, and will probably be lost to production for a very long period. There are opportunities for preventing some of these environmental hazards through proper planning and anticipatory action. For instance, under-employed labor in rural areas may be mobilized in terracing mountain sides and in reforestation programs.

The environmental hazards in the case of modern agricultural techniques arise mainly from the chemical control of weeds and pests and from irrigation works. The side effects resulting from the toxicity of insecticides and pesticides to fish and birds as well as humans make them a major hazard. The enormous problems that can arise out of the improper use of chemical pesticides has been demonstrated in Ghana. Agriculture is the mainstay of Ghana's economy. The rapid increase in both amount and number of pesticides in that country has aided in its development.

The multiplicity of pesticides in the hands of people who may not be aware of their toxicity has led to problems. For example, in 1973 a total of 144 cases of alkylmercury poisoning, with 20 deaths, were reported in rural southern Ghana. Out of ignorance, the patients had eaten maize which was dressed with ethyl mercuric chloride. Some of those involved were aware of the toxicity of the pesticide but from their past experience with DDT believed that thorough washing of the grain with warm water would remove all the poison. Agricultural pollution requires close coordination with health services to ensure high agricultural productivity without health hazards to people and livestock. The problems that can arise from the improper use of chemical pesticides and the pollution of food and water sources by these substances has led to searches for alternatives to chemicals in pest control systems. These alternatives will be discussed in the pest control chapter.

The use of irrigation systems is often necessary to increase cultivatable land. Unless matched by drainage facilities, irrigation projects can result in soil salinization and water-logging. The extension of irrigation and of rice cultivation also provides large surfaces of water for the breeding of disease vectors. Examples of this include the breeding of Anopheles in Africa and the Americas, Culex tritaeniorhunchus in Asia (Cruishank, et. al, 1976) and the proliferation of bilharzia (schistosomiasis). Man-made lakes and irrigation projects also attract birds and rats, the reservoirs of numerous arboviruses.

River basin development projects are instruments of major importance for economic and social development. These projects are often an essential part of development programs but serious environmental health consequences have been associated with the construction of these projects. This underscores the importance of careful study, analysis, and planning in the design of dams and the selection of dam sites.

The Aswan Dam offers an example. While more than doubling Egypt's irrigated farmland, the Aswan Dam also greatly reduced the fisheries in the eastern end of the Mediterranean. In addition, rich nutrients that formerly fed the fish, and other elements, produced a rapid silting behind the dam and a profusion of plant growth in Lake Nasser (Dahlberg, 1974). The expansion of irrigation through canals in Egypt has led to increases in the incidence of bilharzia (schistosomiasis).

The formation of the Volta Lake provides another example of the critical importance of planning for health concerns in river basin development. An epidemiological survey of the Volta River area showed the endemicity rate of schistosomiasis among school children was five percent in 1960-61. After the construction of the dam, surveys showed a 90 percent rate in school children (Derban, 1975). The increase in disease in certain localities after the development project occurred was found to be due to (a) biological explosion of aquatic weeds which are a habitat for the snail vectors and (b) an increase in snails, and their migration into the area of fishing communities already suffering from urinary schistosomiasis (Derban, 1975), The Volta Lake eliminated many of the major breeding sites of the blackfly, Simulium damnosum, that carries onchocerciasis (river blindness). However, the fast flow below the dam created the well-oxygenated water needed for breeding. In some areas below the dam, and also near the rapid streams, prevalence rates of onchocerciasis among all people over 15 years old are as high as 90 percent (Derban, 1975). One health benefit of the formation of the lake has been the decrease in African sleeping sickness. The tsetse fly (Glossina palpalis), its principal vector, was harbored in large areas of forest that were drowned by the lake.

River basin development also requires massive displacement of populations and the loss of wildlife and mineral resources. The emergence of some of these adverse effects is gradual. Some of these can be readily corrected, but others are practically irreversible.

As is evident from these examples, some of the consequences of agricultural development can be on a very large scale and may greatly frustrate progress toward the goals of the development project. Careful planning with close attention to consequences for the environment and the health of the people of the area is necessary.

Industry

Pollution emanating from industrial development represents more of a potential than an actual threat at this time in many developing countries. However, there are a number of instances of industrial pollution, even in the cities of these countries. The developing countries have an advantage in so far as they can learn from the experience of the developed nations. By making sensible decisions on the location of industries and their waste disposal, and by instituting social controls under which the private sector must function, they can avoid some of the worst environmental problems that have arisen in connection with industrial pollution. Developing countries should give careful consideration to the question of location of industries and formulate concrete guidelines in the context of their own national situation, which would prevent the rise of major environmental problems.

The problems of air pollution created by urbanization and industrialization have affected major cities in several developing countries. In India, a recent study made by the Central Public Health Engineering Research Institute, Nagpur, reported that the problem of air pollution in four major cities studied is comparable in some parts to those problems of the most polluted cities in the world. This is particularly the case with suspended particulate concentrations and the levels of carbon monoxide and sulphur dioxide. The concentration of carbon monoxide found at street level in Calcutta varied from as high as 33 parts per million to less than ten parts per million. These levels of carbon monoxide are comparable to those found in New York, Chicago, and London. (Ramalingaswami, 1973). Another factor in India and most developing countries is the smothering smoke from burning cow-dung, firewood and raw coal.

Transport

The needs and consequences of transportation systems increase with the development process. Examples from developed countries illustrate many of the problems that can occur, particularly where reliance is placed primarily on owner-operated vehicle systems. These include, first of all, the effects of automobile exhaust on health, vegetation, and landscape. Additional consequences include accidents, pressure on urban space, and distorted configurations of human settlements. Many of these problems can be reduced by developing well-planned systems of mass transit.

Human Settlements

The predominant part of the population in most developing countries still lives in the rural areas. The stress of rapid population growth has aggravated the environmental hazards associated with poverty. This growth in population has also brought forward problems of employment. The expansion of economic activities in the urban areas will not suffice to provide employment opportunities for the full increase in the work force. A substantial part of the population still needs to remain in the rural areas, and it is vital that employment opportunities be created in these areas.

In the urban areas of the developing world, environmental quality is intimately related to social welfare. Urbanization within a country can, of course, be accompanied by increased economic and social welfare, and urban concentration of dynamic enterprises can serve a valuable function as "development poles," generating growth throughout wider regions. However, the carrying capacity of any city submitted to rapid population growth is eventually overextended. Disease, water supply shortages, lack of sewage treatment, congestion, and deteriorating housing are all manifestations of environmental stress. The more developed urban areas are now confronted with chemical contamination of air and water and the hazards of social disorganization.

The major cities of the developing world experienced a fourfold increase in their populations between 1920 and 1960. Today, in many developing countries, the influx of population is straining the existing capacity of cities. Their failure is symptomatic of imbalance in the development process, which could produce total breakdown, in some instances, in the coming decade. Each city has its own carrying capacity, which changes over time. This depends on the level and combination of population, economic and human resources, and infrastructure, which are, in turn, in constant evolution. But once that carrying capacity is exceeded, degradation proceeds very quickly. There is, however, a high possibility of reversibility in this trend, which is not the case with natural systems. Government actions can reverse the city's deterioration if sufficient resources can be mobilized.

Land Use Planning-Urban

Land use planning considered within the framework of the urban planning process is that sector of planning concerned with the location of various urban activities and the intensity of those activities. But, insofar as land use creates the physical setting for economic and social system activities it should be guided by strategic planning that considers the promotion of environment quality and the quality of life of the human being affected.

In the field of land use planning there are several alternative approaches being taken on three fronts of innovation. The three categories of innovation are:

In the redefinition of comprehensive planning to incorporate a concern with land use/environmental quality relationships;
In the inclusion of environmental system information related to health and development, and evaluation criteria in land-use plan and policy development;
In the emphasis on implementation and in the development of a more integrated planning process— guidance system planning.

Alternative Planning Approaches

There are two basic ways in which comprehensive planning has been reshaped to incorporate environmental objectives including concerns for health. The first method is to add a new sector to the total planning program which focuses specifically on environmental systems in a manner parallel to that of other sector planning like economic development or transportation. The second method involves a more fundamental realignment of comprehensive planning. This requires an examination of the relationships among the objectives of the various sectors or systems that constitute the urban area.

These relationships are supportive and conflicting. The focus is to develop some resolution among them that will guide planning within each of the sectors toward a more coordinated goal set. Community or regional objectives are realigned in the light of an awareness of the environmental and health implications of the utilization of land and the people who inhabit it. Environmental quality is viewed as an integral element in all planning endeavors.

These two methods of redefinition of comprehensive planning goals differ primarily in purpose. The addition of a new sector is aimed at the development of an action program to achieve agreed upon environmental objectives such as national or regional water quality standards. The time frame of this planning strategy is short range. In the second method, the objective is to develop an understanding of the complex interdependencies among environmental systems and people. These two approaches need not be viewed as mutually exclusive. Personnel responsible for considering and planning for environmental quality concerns could be built into different sectors to facilitate a coordinated set of goals and relevant action programs.

There are three general schools of thought which have affected current approaches to defining an environmental system information base. The first focuses on an inventory of the key natural subsystems in the planning area which pose resource constraints on urban development. Another approach is also based on an inventory of the subsystems but interprets these and considers them as interdependent processes in the ecosystem. The third approach also considers the key natural subsystems but interprets their significance in terms of the visual perception of the environment. The first approach has been called a natural system inventory analysis; the second has been called ecosystem analysis; and, the third is labeled as visual landscape analysis.

The information generated by each of these approaches may be used at various stages in the planning process to monitor current environmental needs or trends and to predict future conflicts in order to focus planning priorities. In addition, it can be used to determine optimal land use allocations from an environmental quality input along with other economic and social system demands for land-use planning. The information is also used to determine the environmental impact and potential consequences for health of alternative plans or policies and to determine the design of a project in order to plan for environmental health concerns and environmental quality.

A natural systems inventory analysis approach leads to the development of a base of information on the natural environment. This base may be used in the planning process as a rationale for determining optimal space allocations for land-use. The central principle is that certain features of the natural environment exhibit an intrinsic suitability for particular land uses. Common environmental sybsystems that are inventoried include geology, pedology (soils), hydrology, meteorology, climatology, plant associations, and fish and wildlife.

There appear to be two fundamental objectives in this planning process: first, to determine environmental constraints to development, and second, to protect the environment from development. Another less common but important objective is to insure and provide for suitable health consequences to human beings.

Guidance system planning represents a new land-use planning process that emphasizes implementation. The ultimate aim of this process is the infusion of goals and information which reflect an environmental system or natural process orientation, into the urbanization process. It is clear that concern for the environmental system as it affects health and disease are compatible with these aims. Furthermore, information and analysis related to those concerns could be incorporated into this planning strategy.

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CHAPTER TWO

PRINCIPLES OF ENVIRONMENTAL HEALTH ASSESSMENT

The assessment process will begin with an initial briefing, first in Washington and then within the country itself. Meetings will be arranged with ministry and embassy officials, usually in the capital city. At this time some preliminary data may be provided by the government officials. Other contacts should be established, however, with alternative sources of data, such as private industries or universities. At all times, whether within the capital or in the outlying regions, power structures should be evaluated and, if possible, relationships with influential people should be cultivated. This should be helpful in gaining some understanding of the national political situation.

With this general background as a framework, one should determine national policies and objectives, specifically with regard to health and the environment. Political associations related to environmental health should be identified as well as any programs currently in progress. Relevant bureaucracies and industries functioning within the environmental health sector, particularly in the decision-making process, should also be determined.

An evaluation of all past programs should be made. To accomplish this, one can look at any available records that were kept. In addition, one should try to talk to several people who had been involved in the programs. Those people should provide useful information on the actual resources utilized, those social and cultural factors that may have a significant effect on program effectiveness, what populations were actually affected, and their overall evaluation of the successes and failures of those programs. Another important factor to ascertain on all levels is the amount of funding available. Records of past and present levels of funding are, clearly, a key determinant in the workings of any program. These will ultimately be used in financial projections for the future.

Once the social, political, and financial picture has been assessed (to whatever extent possible), the technological components of a system must be assessed. Data should be gathered on the technological capabilities of the country. This should include the ability to manufacture necessary equipment locally, availability of resources, manpower, costs to train personnel, etc. In addition, the feasibility of using certain technologies must be assessed in terms of terrain, climate, maintenance requirements, social and cultural constraints, and availability of equipment. The spectrum of technologies available should be assessed and, with the above factors in mind, alternatives chosen. Another critical factor to consider is the rate of growth at which the country (or its officials) wish to proceed. This will directly affect the choices made.

Closely related to the technologies chosen are environmental conditions that exist and the infra-structural requirements that will be required to

maintain the system. Environmental data should be collected from many sources. If data are available, they should be obtained and verified, if possible, by spot check surveys of existing environmental conditions.

The assessment process, as an integral part of the planning process, provides necessary data for both program planning and evaluation. Each step in program planning involves certain assessment practices, all of which then provide the basis for evaluating the effectiveness of the program. The bases and data sources for these assessments will be described in the following section. These include the following: description of the area and/or existing programs; medical and sanitary data; resources available - past programs and existing data; surveillance and monitoring activities.

Description of the Area

A general description of the physical characteristics of an area is a necessary prerequisite for the planning of any environmental health program. The relative importance and emphasis placed on these data will vary from program to program.

Typical data include: location, topography, climate, character, communications, maps. Geology and hydrology must be considered, with particular reference to nature of top and underground layers of the soil, its porosity, presence and abundance of ground water (if any), direction of flow, level of groundwater table, its appearance and potability, estimation of yields of springs and rivers. Population should be listed, including number, age groups, sex, density, growth. Industries and agriculture, with particular reference to irrigation, drainage, and soil fertilizing practices are important.

Medical and Sanitary Data

Preliminary medical and sanitary data are critical to the design of any environmental health program. These data should not be restricted merely to the presence or absence of disease or sanitary facilities, but should involve assessments of qualitative factors.

General health of the population includes special emphasis on communicable diseases and on intestinal infections, helminth infestations, and trachoma and acute conjunctivitis in infants and children. Vital statistics include mortality, and morbidity data. Health and sanitary administration refers to organization, personnel, budget, and activities of voluntary or other agencies in the field of sanitation.

Existing sanitary conditions in the area includes reference to description of private and public latrines, their distribution and use, to wells, springs, and other systems of water supply (including such information as number of persons served by piped water supplies, and by wells, the consumption and uses of water, number of dwellings with private water supply, etc); to wastes collection, disposal, and composting; to milk and food sanitation; to insects (flies, fleas, lice, mosquitoes); to health aspects and standards of housing; and to school sanitation.

Sociological and cultural patterns refer to community and family organization, leadership, customs, beliefs, and habits bearing on personal hygiene and community sanitation. Present methods (if any) of health education of the public.

Resources Available

The availability and adequacy of resources required for the implementation of any environmental health program are clearly of key import in its success or failure.

Types of resources to be assessed include the general economic level of the population; average per capita income. Cooperation expected from

agricultural, educational and other agencies or groups for training and health education of the public.

Housing and vehicle transport may be key resources, as are vehicle and equipment repair and maintenance facilities; sources of power (electricity, fuel); local construction materials and their costs; local craftsmen and wages; and potential resources for self-help.

Surveillance and Monitoring Activities

Once a program is in existence many of the data in the three previous selections will still be periodically collected. The types and frequency of data collection, methods of sampling and analysis, criteria and standards, facilities, and manpower are assessed in an ongoing program of surveillance and monitoring. These activities may be performed by the agency performing the sanitary service or by a separate surveillance agency. Judgment in this respect must be made by individual governments, however, the World Health Organization (1976) recommends the establishment of a separate agency for the surveillance of drinking water quality.

A general outline of broad issues related to the assessment process would include: sampling and surveying, criteria and standards, facilities and manpower.

Sampling and surveying are monitored in terms of data sources, records kept and compiled, frequency of data collection, key sampling points with reference to shifting locations and sampling in problem areas, common tests performed, adequacy of facilities and personnel, alternative methods, and costs.

Criteria and standards assessment includes examination of the basis and validity of existent ones, and the degree to which they are being met by current practices.

Facilities assessment includes examination of adequacy of existent labs and other facilities and costs.

Manpower assessment includes examination of existing quantity and training of personnel, evaluation of existing and alternative uses of technical and administrative staff, and evaluation of alternative or supplementary training procedures.

Epidemiology: Its Relation to Environmental Health

Historically, epidemiology was first used as a method of determining the etiology of infectious disease epidemics in populations. However, at present, epidemiologists define the field broadly as "The study of the distribution and determinants of disease or disability in human populations." This definition extends far beyond the sphere of the communicable disease epidemic to further encompass a wide variety of chronic and acute disabilities, either endemic or epidemic, resulting from numerous noninfectious agents or phenomena. In the developing countries communicable diseases are the primary focus of the epidemiologist. There is increasing concern, however, with the health effects, both acute and chronic, of chemical and physical agents in the environment. It is this area which concerns the environmental epidemiologist who attempts to establish dose-reponse relationships between environmental phenomena and health in human populations.

Establishment of a cause and effect relationship, however, presents many difficulties. Consequently, the primary means available to the investigator is the combining of environmental monitoring data with existing health data, essentially mortality and morbidity (when available) to statistically establish a probability of causation. This method is called epidemiological surveillance. Alternative to this approach is the translation of animal toxicities from experimentation with laboratory animals. As yet, however, conclusions drawn

from animal studies reflect a certain degree of conjecture due to such factors as size and morphological differences.

Epidemiological studies rely on a variety of sources of population data when available. Records of mortality and morbidity are an essential component of many of these studies. Numerous potential sources of these may exist. For example, typical data sources of vital statistics utilized in the developed countries include death certificates, birth certificates, and census information while morbidity data are found in hospital records, records of private physicians. disease registers, and a variety of morbidity surveys performed from local to national levels. These are used to monitor the health status of a population, and their applications may be further utilized to maintain surveillance over the health status of a population or in the planning of programs for disease control.

As stated by the World Health Organization (1975): "There can be no doubt that the need for surveillance is becoming increasingly urgent as more and more potentially harmful chemical and physical hazards are introduced into the environment— into the air, water, and soil and into the food chain and pharmaceutical products— by the accelerating growth of industrial technology."

In that same document the goals of epidemiologic surveillance schemes are stated to include the provision of information for the protection and improvement of the health of populations in the following three ways: reducing exposure to known harmful factors; detecting and preventing exposure to new and potentially harmful factors; and testing the effectiveness of alternative environmental control programs.

For planning purposes, epidemiological surveillance is extremely valuable as a means of applying existing knowledge to the control of disease and disability. However, epidemiological surveillance is costly and the World Health Organization (1975) recommends that priorities must be established to limit the number of surveillance programs where manpower and resources are limited. Factors contributing to such decisions include: severity of the health effect, degree of exposure and age groups affected, persistence of the causal agent in the environment, degree of urgency expressed by the population for surveillance, feasibility of surveillance, likelihood of early intervention, and the possibility of utilizing pre-existing environmental and health data as well as pre-existing health care organizations, personnel, facilities and equipment in the surveillance process.

Surveillance strategies are customarily classified as being of two types. The first strategy begins with a substance or phenomenon suspected of perpetrating one or many adverse health effects. This approach attempts to establish the effects of the suspected factor. The second strategy begins with an existing adverse health condition in a population and attempts to discover which environmental hazards may be causal. In both strategies the eventual goal is to provide appropriate methods of intervention. The actual practical application of surveillance is often a somewhat less clearly defined compromise between the two strategies.

Epidemiological surveillance programs are most typically prospective cohort studies. In essence, these involve the identification of a specific population at risk and the accumulation and evaluation of both health and environmental monitoring data applicable to that population over a certain number of years. These studies have been found to provide the most reliable indications of incidence and relative risk. However, as is well known, they are extremely costly, often require many years of observation, and may produce ethical conflicts. For example, in studying the risk of cancer from a

particularly environmental pollutant, the investigator may withhold protection of the exposed group to obtain accurate results, at the same time possibly contributing to the production of cancer in those individuals. Additionally, in order to observe carcinogenicity, the study must continue for many years since the latency period of certain cancers is approximately twenty years or more. The cost, in money and time, of such a program would clearly be enormous.

For the above reasons, retrospective cohort studies are often performed for high risk, long-term hazards. These, of course, presuppose the existence of adequate data sources. If the data are available these studies are much less costly and do not require premeditated exposure of a population group to a potentially toxic or infectious substance.

Cross-sectional studies may also be useful and may be related to either prospective or retrospective data for comparison at a given point in time. The sources of bias in all of the above study techniques with respect to data collection, handling, and interpretation are known to be significant.

A primary consideration in an environmental epidemiology study or program is the establishment and maintenance of adequate environmental monitoring programs. Attendant to this requirement are numerous constraints that shall be considered here. Nevertheless, these constraints are not intended to invalidate existing methods and results, but rather to suggest a critical evaluation of past studies and to emphasize the benefits associated with the development of an extensive environmental monitoring program for the maintenance of health in a population.

Measurement of actual levels of a given pollutant may be compounded by the use of equipment of varying levels of accuracy. These levels may be compared and the differences taken to indicate environmental variability as opposed to variability in instrumentation. Furthermore, existing technology may not possess the capacity to measure certain pollutant levels accurately. In addition, pollutants themselves may exhibit certain properties that confound measured results. For example, certain pesticides have been found to adsorb to particulate matter in aquatic systems thereby preventing accurate detection of their levels. A great deal of information on the behavior of pollutants in the environment is still unknown. Often it is difficult to determine whether variable results are due to instrumentation or the natural periodicities exhibited by many substances.

The relationship of environmental levels to the actual exposure of individuals is critical to the surveillance process. However, the difficulties involved in the assessment of this relationship are great. For example, determination of the exposure of a population to DDT must include levels in air, water, and food encountered by individuals whose intake levels may vary. Additionally, levels of DDT in each of these media may vary. It is clear that measurement of these levels must be approximated based on average intake and exposure levels.

In determination of the actual effect of a substance on living material a primary consideration is that often there is a lack of knowledge of which effects are sought. These effects are often masked by a variety of confounding variables such as: biologic adaptation and resistance, sensitization, rare effects, and multiple effects produced by the same substance. Additional factors in populations, such as mobility, competing risks and the existence of high risk individuals must be considered.

For the developing country the opportunity exists to learn from the mistakes and shortcomings of other epidemiological programs for the assessment

of environmental health. Environmental monitoring, with an understanding of its shortcomings, is stressed as a key factor, along with the establishment of health records. The purposes of environmental monitoring are numerous, including the regular and continuous maintenance of control systems, the provision of a warning mechanism should levels become excessively high, the provision of periodic checks on efficiency and effectiveness of the control technology and on emission levels, long and short term environmental planning, and the establishment of records of trends in environmental levels.

Assessment material presented in this chapter does not attempt to be totally comprehensive, because assessment and planning sections are also included in appropriate topical chapters to follow.

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CHAPTER THREE

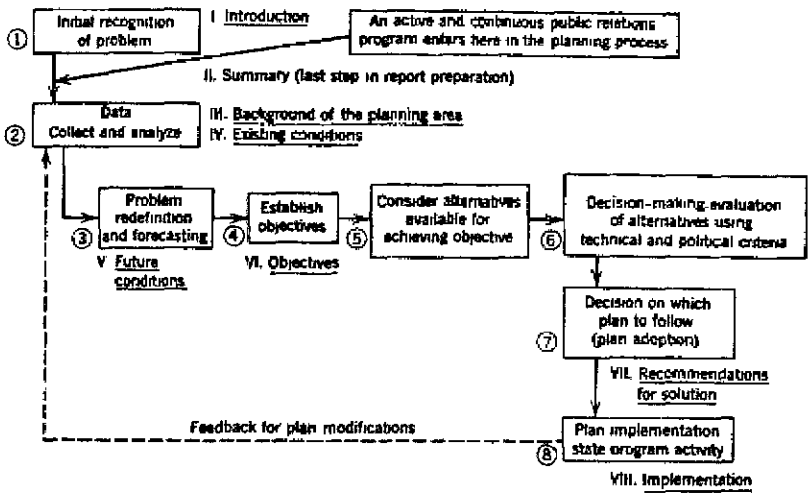
PRINCIPLES OF ENVIRONMENTAL HEALTH PLANNING

Planning is defined by Schaefer (1974) as an "orderly process of defining a problem through analysis, identifying the unmet needs and demands that constitute the problem, establishing realistic and feasible goals, deciding on their priority, surveying the resources needed to achieve them, and projecting administrative action based on the weighing of alternative intervention strategies for solving the problem."

Environmental health planning is often carried out by the same people who will administer the new program. It will often be desirable to call upon outside technical consultants for advice during assessment and during the planning process. At the outset, planners should become familiar with planning being done by other agencies and organizations within the government. This is particularly important in the case of economic growth and development. Through close coordination and cooperation with related planning agencies, an environmental health planner can obtain much information needed for his own planning, and expert technical advice. In addition, he can sensitize these planners to environmental health issues and long range health consequences of proposed projects.

Since systematic planning is simply a formalized and documented reasoning process, it is possible to identify certain logical principles which are adaptable to most planning situations, including environmental health program planning. Employment of these principles by an environmental health planner should result in programs which are realistic reponses to current problems and which lend themselves to acceptance by governmental decision makers, fund appropriating bodies, and the general public.

The following paragraphs set forth a suggested program planning procedure embodying these logical principles. Although presented in a step-by-step fashion, the sequence of steps may vary in some situations, and some of the steps will occur more or less simultaneously. In brief, the steps are: examine situation; set objectives and consider alternatives; design program; implement program; evaluation program. Exhibit 1 provides a schematic presentation of these steps in a basic planning model.



Basic planning model. (From Richard O. Toftner. Developing a State Solid Waste Management Plan, U.S. Public Health Service Pub. No. 2031, Depr. of HEW, Washington, D.C., 1970.)
The first step (1) in the planning process is awareness that a problem exists and needs to be solved. The second step (2) is to collect and analyze data relating to the problem. Such analysis makes possible a redefinition of the problem and a forecasting of future situation (3). Problem definition for both the present and future situation helps to suggest objectives (4) that if achieved would serve to solve the problems. Two or more alternatives (5) might be available for solving the problem and achieving objectives. The feasible alternative or alternatives (6) are selected by considering technical, political, social, and other factors. Once this decision has been made a plan for solution of the problems (7) can be adopted. Actual action for carrying out the plan (8) then follows. Effectiveness of the plan is measured during its implementation. These data are fed back into the continuing planning process to guide plan modifications if needed.

Before developing a new environmental health program or modifying an on-going one, it is necessary to acquire as complete a picture as possible of prevailing and projected conditions which have a bearing on the program. The planner needs to know the nature and size of the problem, the status of current control efforts, and the status of related environmental health problems and present and planned control activities. Present and projected resources available for a new or modified program must be determined. The population to be served as revealed by health status data, income data, and other demographic information must be learned. Economic status and trends of the area, including plans for development, are important. Physical nature of the area, i.e. geography, weather, man-made features such as industries, highways, public utilities and housing must be considered. Other situational factors which may affect an attack on the problem, i.e., political constraints, state-of-the-art in control methodology and technology, sociocultural demands, economic feasibility and long range planning cannot be ignored.

Sources of Data

Of the many kinds of data desirable for program planning, the most essential are those which enable a clear delineation of the health problems. Even planners with few resources should not proceed until they have adequate mortality data, morbidity data, data on environmental quality, and knowledge of conditioning factors (e.g., the susceptibility of populations in terms of age structure and nutritional status as well as knowledge of pertinent health and

and economic development policies). These data are critical for the definition of the problem so that it can be compared in size, severity and need with similar problems elsewhere. These data are also important for the quantification of the problem so that program progress can be measured. It is not always possible to satisfactorily describe the ultimate health problem. It may be necessary to deal with factors which contribute to the ultimate problem.

Once obtained, data require analyzing before they can serve the purposes of the program planner. They must be rearranged, combined, summarized, and interpreted. The data required and suggested strategies for analyses will be presented for each of the major environmental health subsystems in subsequent sections.

Certainly thorough statistical analyses of the health problem, resources and economic ramifications, etc., make subsequent planning decisions easier and result in sounder programs. However, nonstatistical information which does not lend itself to precise analysis is also an important factor in planning. Information regarding the economic and political influences that are part of the implementation and appropriation decision making process should be carefully considered. Additionally, sociocultural information related to the peoples' attitudes and behavior toward the health problems and the means they use to cope with that problem should be considered in the assessment and analysis process. Detailed and accurate information of this nature will be required if effective planning and implementation are to take place.

Objectives

Once the problem and other aspects of the situation have been clearly determined it is possible to establish what a control program can and should do. This may be stated in the form of a mission such as: "To restrict air pollution to a level that is not detrimental to human health and well-being." Much more essential and meaningful, however, is establishment of objectives which set forth specific accomplishments, within definite time periods, necessary for a successful program, both short range (within the next year or two) and long range (over at least five years). They should be consistent with overall objectives established by the agency which is to operate the program.

While setting objectives is described as a separate phase of planning, preceding program design, objectives actually are developed simultaneously with program design since it is unrealistic to attempt to set objectives without at the same time considering the general means by which they will be achieved. Wherever possible, objectives are stated in terms of ultimate effect on human beings. However, because a cause-and-effect relationship between program effort and health and well-being is often impossible to establish with our present state of knowledge, it is often necessary to establish objectives directed to problems which we assume to have an adverse effect on man. Thus objectives may be addressed to changes in environmental hazard levels, or in the behavior of polluters. An objective in occupational health might be to reduce asbestos dust levels to a certain applicable standard in a certain percentage of the asbestos-using industries in the state or locality by a certain year, whereas a more meaningful objective would be to reduce the incidence of asbestosis among industrial workers by a certain percentage within a specified time. In some cases, objectives are directed only to maintaining the status quo and thus are stated in terms of the prevention of the worsening of a problem during a specified time.

The importance of constructing objectives which describe specific accomplishments within a specified time cannot be overemphasized. It must be possible later to clearly determine whether or not they were accomplished.

It will facilitate program design if the objectives are ranked in priority order so that scaled-down alternative program approaches can be more readily constructed. Initial objectives will be fairly broad and few in number. While the program is being designed and even during initial operation, it is useful, in addition, to identify "action steps" which set forth shorter-term, more detailed program accomplishments necessary for attainment of the objectives. An action step is related to the program means, or activity while the objective speaks only of ends. An action step may involve a single activity, like training, which leads to accomplishment of an overall objective. (For example, an occupational health program action step might be to train a specified number of industrial employees in dust control techniques by a certain time.) Many program activities and consequently many action steps may be necessary for achievement of one objective. Identification of essential action steps helps guide program design by establishing requirements for certain kinds of program activities operating at a specified level and requiring specific resources. It will also facilitate evaluation of progress.

Program Design

The next procedure is to conceive and describe an integrated set of activities, procedures, and resources which make attainment of the objectives possible. This may involve conceiving and describing a completely new program or a modified version of an existing program. Objectives should be proposed to cover a period of at least five years: the program should be projected to cover the same period. While the program's general content responds to the objectives and action steps, details of its design are worked out with experienced program administrators versed in up-to-date control methodologies and knowledgeable in technical aspects of program operation. The program should be compatible with related ongoing activities and programs to minimize duplication, gaps or competition and to foster cooperation and coordination. It should be consistent with the policies and guidelines already established or understood. The program should be described in detail, with its requirements in manpower, money, facilities, and equipment clearly estimated.

There is usually more than one reasonable program design for meeting established objectives. Therefore, alternative programs should be designed. These may vary much or little with respect to activities, procedures, or organizational arrangements. Some may be highly innovative and others more conservative. Resource requirements should be worked out completely for each so that cost comparisons can be made. (For example, the objectives might be achieved by a program in injury control that included little more than public information, as opposed to an alternative which included development and promulgation of safety standards and training.) For each alternative there should be at least one variation which assumes a reduced scale of operation, and a lower requirement in funds and staff. This would represent a "fallback" alternative if sufficient funds for optimum operation do not become available. The lower scale version is based on dropping or scaling down some objectives or scheduling them for a later date in accordance with priority ranking.

Once alternative approaches are established it is necessary to provide a basis for choosing between them. The description of each alternative should include estimates of the total requirements in money, manpower, and other resources for each year up to at least five years. Thus, it is easy to compare relative costs of the various alternatives. Estimating relative effectiveness of alternatives, however, is a different matter. Here the same difficulty is in identifying the problem and establishing the objective, and of program effectiveness? Ideally it is the impact the program might have on the health and wellbeing of man. In some cases, present knowledge does not permit accurate determination of the effect on man and the measurement or prediction of the impact of an environmental health program on human health and wellbeing. To determine effectiveness, often the same measures employed in establishing the objectives are used. The question to answer is: Which alternative program approach will best meet the objectives for the least cost? Considerations of effectiveness, economic costs versus health benefits and maintaining equity are also important.

Predictions of the future effect of a program may be imprecise. However, if the same basic assumptions are employed in estimating the impact of each alternative, even though the assumptions may not be entirely valid, the resulting estimates should provide a valid base for determining the relative effectiveness of alternatives. Once a program is under way, adjustments are always necessary to allow for errors in the original planning assumptions. The assumptions involved will cover such matters as individual work output, changes in the nature of the problem with time, and susceptibility of the problem to control techniques. Where there is a basis in experience with similar ongoing programs or pilot projects, assumptions are more reliable since at least some factors, such as work output, have been measured already.

Once reasonable effort has been made to determine relative costs and effectiveness of the alternatives, it is sometimes possible to rank the alternatives in order of potential cost effectiveness, in order of economic costs versus health benefits, and in terms of number and type of people served as an assessment of equity or distribution of social justice. Often there are a number of choices that are equally optimal. The planner has conceived his objectives and designed his program alternatives with full awareness of constraints. He must now confront those constraints as final limiting factors. He must identify the alternatives that embody the highest potential effectiveness for the money and which at the same time are feasible. The optimum alternative in potential cost effectiveness may, all constraints considered, not be reasonably feasible. The alternatives chosen may represent a compromise between what theoretically is most desirable and what is attainable. Estimates concerning future availability of funds usually are a principal limiting factor. Since alternative funding and staffing have been worked out for each alternative, it is possible to recommend a fairly optimistic funding level, knowing that if that level is not realized it is possible to fall back to an alternative which provides for scaled down operation adjusted in terms of current priorities.

The plan may be formulated at different levels. At the local level there may be a maximum and minimum plan. A regional plan may be formulated through the integration of local plans. A national plan may be based on the integration of regional plans. The plan is often a compromise among three elements: the community, whose health need priorities will have to be established; the political structure, as decisions have to be made on allocations working within the limits of available resources; the health planner, who has the possibility of introducing rationality in terms of health policy and possible alternatives.

The final proposal should consist of a written document describing the problem and the situation, setting forth objectives and action steps, describing the recommended program approach, comparing cost effectiveness, and describing other factors that helped determine selection of the recommended approach. Since it must inform and persuade people with all kinds of backgrounds, it should be written in clear, nontechnical language.

Once a plan has been drawn up and formulated, it must be discussed so that all those who will be involved will have a say and an input in any possible modification before the final decision is taken for implementation. This decision must take into account many nontechnical factors which are political, psychological, and sociocultural.

It is important to note that this involvement is more than informative in value. To the extent to which those responsible for the implementation of a plan and its progress have participated in the plan preparation, there will be greater agreement as to the degree of implementation and satisfaction with the program. The plan should also be discussed with those who will be responsible for coordination of this plan with those for other sectors. It may be that the original plan will have to be revised to achieve greater support and ultimate success. It must be noted that the probability of implementing a plan will be higher if those responsible for finance have participated in the preparation or preliminary discussion of the plan.

When coordination of a plan is complete, the plan is typically submitted for consideration to the Minister of Health, the Minister of Finance, and the Cabinet or Council of Ministers. The final decisions are in the hands of the politicians who have the legislative and executive responsibility. For this reason and others documented in earlier sections of this manual, the health administration of a country should participate in the overall national development planning.

Program Implementation

The implementation of an approved plan will depend on the quality of the administration and the translation of the plan into an actual operating program. Precise actions required for implementation vary with the kind of program. Some of these strategic actions will be discussed in sections dealing with the environmental subsystems. Certain factors must commonly be considered: new legislation to authorize a new program or major modifications in an old one may be necessary, regulations, standards, and guidelines to be promulgated through the programs may have to be prepared. Arrangements must always be made for necessary short and long term financial support. This is often one of the most unpredictable of situational variables. If possible, the planner should provide in advance for an optimum plan and a "fall back" plan based on different scales of operation in the event of less than desirable appropriations.

Organizational arrangements are made either by establishment of a new organization or modification of an existing one. Staff must be recruited, selected, and oriented. Manpower shortages can frustrate the best laid plans. During program design, general availability of requisite manpower is considered in connection with determining feasibility. When severe manpower shortages are anticipated or materialize during implementation, it is necessary to initiate the program on a limited basis, employing a skeleton staff, until arrangements are made to reduce the shortage. Recruitment and hiring of staff usually is based on the existing system of the governmental agency which is to operate the program. However, the program manager can do much to facilitate meeting manpower needs. He may arrange for reclassification of unfilled positions to achieve higher salary authorizations needed to attract appropriately skilled

applicants. He may review manpower needs and arrange for employment of individuals with lesser training to perform functions traditionally performed by more highly trained manpower. He may upgrade skills of available manpower through on-the-job and short term training sponsored by the agency, and by sending employees to universities for study in appropriate subject areas.

Descriptions of the program should be disseminated to program leadership at each relevant level and detailed operating procedures should be developed to facilitate execution of procedures and activities. Most actions required in implementation are carried out in accordance with established procedures of the agency which is to administer the program.

One action which is not usually covered by an agency's standard procedures, but which is often of great significance to implementation, consists of obtaining the support of influential groups who have a natural interest in the proposed program. Particularly critical is support at the community level. Depending on the program, this might also include professional associations, civic organizations like mothers clubs, government agencies, and industrial groups. Obtaining such support is facilitated if the planner has consulted these groups during planning and has accommodated as many of their suggestions as program consistency and effectiveness will permit. Some influential groups may be opposed to any program which, in order to cope with the problem, involves inconvenience or added costs to them. The program implementer must be especially diligent in trying to involve these groups in the planning process and he may have to seek support from other groups to offset this opposition.

Program Evaluation

Program planning is not a one time affair. It provides a sound basis for initiation of new programs. Once a program is under way it must be continuously monitored and evaluated so that adjustments can be made to compensate for situation changes, errors in estimates and assumptions, and spontaneous changes in program operation. Every effort must be made to ensure that the program remains relevant and effective. While the program manager is interested in the administrative efficiency of the program, the planner is primarily concerned with overall effectiveness. To make continuous monitoring and evaluation possible it is necessary to arrange for the regular gathering and analysis of information regarding the problem, program impact, and program progress. This requires regular data reporting from participants in the program as well as from other sources. Continuous monitoring enables early detection of program deficiencies and permits timely adjustments on an ongoing basis.

The wisdom of establishing specific and measurable objectives and action steps becomes more apparent when the planner attempts to employ them as the test of program effectiveness. Objectives are concerned with program impact on the problem measured in changes for the better such as reduction in morbidity, accident rate, vector population, pollution level, or increase in rate of compliance with standards and— where possible— improvement in health status. Action steps should refer to activities leading to the objective such as number of inspections, reports, and persons trained. They permit shorter term indication of program progress. Completion of action steps, while a good indication of program progress, should not be confused with program effectiveness, which is measured only by changes to which the objectives are addressed. Regular monitoring and evaluation of the program is augmented by periodic in-depth reviews and analyses, similar to the original planning process. Once every year or two, the problem and other situational factors should be examined anew and new alternative approaches should be considered and compared. The selected

alternative may consist of the existing program, a variation on that program, or an entirely different program approach. It must, however, take into account the ongoing program. It is conceivable that, due to changed circumstances, planners may recommend termination of a program when the program seems to show no promise or when the problem has diminished to such a point that expenditure of further resources is not warranted. The assessment of effectiveness is only part of the evaluation procedure. A vital component of evaluation is the feedback mechanism by which the results of evaluation are fed back into the planning process at various levels.

CHAPTER FOUR

PRINCIPLES OF ENVIRONMENTAL HEALTH SECTOR EVALUATION

Evaluation consists of finding out the extent to which a set of program objectives has been attained, what unexpected consequences have resulted, and the general quality of a program. The evaluation process contains several general steps which are applied in different strengths depending on the purposes and focus of the evaluation. The general steps are outlined in this chapter along with germane issues to be considered at each step. Specific criterion to be applied and tests to be used in the evaluation process are defined by the objectives of an evaluation and can be found in the specific chapters describing environmental subsystems.

An evaluation follows the basic outline presented below.

Preliminaries:

- Review the history and development of the program or activity under evaluation. This should be done at an official and unofficial level. It should include determination of the reasons for the evaluation.
- Select an individual, agency, or group to do the evaluation. This person or group should not be integrally involved in the program, but independent.
- Introduce the evaluator (group or individual) to the history of the project and some key administrators or managers. An attempt should be made to create an air of cooperation here rather than fear or apprehension which might interfere with the accuracy and efficiency of the evaluation.

Define objectives:

- Identify the original objectives of the activity or program and any subsequent modifications. Obtain this information from the administrators who designed the program as well as those involved in implementation.
- Identify criterion by which the program is supposed to be and expected to be evaluated. Obtain this information from administrators and review it, if possible, with the implementers.
- Identify possible unexpected or implied objectives as well as unforeseen consequences which could be found.
- Objectives and criterion will be identified related to several subsystems within a program.
- Environmental objectives attend to changes in the environment which may have affected the outcomes of a program and the probability of meeting objectives, e.g., weather, migratory patterns of people or animals, changes in economy or social activities.
- Time objectives concern when activities were accomplished and what future time objectives have been set.

- Cost objectives include unforeseen events that may have affected costs. Financing practices and social or cultural needs that may affect payment or financing are considered.
- Personnel objectives include: anticipated training, self-sufficiency of personnel, personnel satisfaction, personnel morale, and personnel usage.
- Usage objectives include: attitudes toward program held by the intended users or people to benefit from it, problems associated with use, extent and frequency of use, beliefs about the program held by the people, and unforeseen consequences.

Select measuring instruments:

- Quantitative, operation or physical tests should be relevant and fair. These should be administered with the cooperation of those involved in the project.
- Qualitative or evaluative tests will involve general impressions of elements like the morale of personnel, efficiency of operations, attitudes of users, lines of authority, etc. Although these can also be assessed with surveys, informal conversations and observations also provide worthwhile input.
- The validity, reliability, objectivity and relevance of each measurement instrument should be considered before and after it is used. Validity is the degree of accuracy with which the instrument measures what it is constructed to measure. Reliability is the consistency with which an instrument measures a given variable. Objectivity is the degree of concordance between the judgments of independent and competent examiners as to what constitutes a good answer to each of the elements of a measuring instrument. Relevance is the extent to which the criteria established for selecting questions so that they conform to the aims of the measuring instrument are respected.

Interpret measurement data: Discuss the evaluation purpose and methods with operators and managers of those programs being evaluated. They will offer insight and information that aids in data analysis and interpretation. Possible program alterations and bottlenecks may also be identified.

Make judgments based on the evaluation process and take appropriate action. One necessary appropriate action is to provide feedback both official and unofficial to those whose programs or personal activities were evaluated. This helps to identify the most effective and suitable future actions and creates a stronger feeling of cooperation.

This outline offers the fundamental steps involved in any evaluation. Such an evaluation might come after an assessment and before planning occurs, after a program has been planned, or after its implementation. Information regarding the specific objectives to be set, criterion to use, instruments to select, interpretations that are possible and judgments to be made are presented in subsequent sections which provide these details for each environmental subsystem.