UNITED NATIONS

ECONOMIC AND SOCIAL COUNCIL

Distr.
GENERAL

E/CN.3/452
14 June 1974

ORIGINAL: ENGLISH

STATISTICAL COMMISSION
Eighteenth session
Geneva, 7-18 October 1974
Item 6 of the provisional agenda

STATISTICS OF THE ENVIRONMENT

Report of the Secretary-General

CONTENTS

INTRODUCTION

1. To meet the request of the seventeenth session of the Statistical Commission, this paper sets forth a draft programme of international work in the short and medium term on statistics of the environment.[1] It does not discuss the resources required to carry out the proposed programme, a major portion of which are not now available. Before giving the draft programme of work, the paper discusses the following topics in order to help assess the proposals: (a) the long-term objectives of international work on statistics of the environment, (b) the character and scope of these statistics, (c) their uses and structure, (d) special indicators of the quality of the environment and (e) the objectives of an international work programme on environmental statistics in the short and medium term, which the proposed programme of work is designed to meet.

2. In preparing this paper, use was made of the documents, discussions and conclusions of the Meeting on Statistical Requirements for Environmental Studies and Policies that was held in Geneva 19-23 March 1973 and of the Seminar on Environmental Statistics that took place in Warsaw 15-19 October 1973.[2] The former meeting was convened under the auspices of the Conference of European Statisticians; the latter seminar was jointly sponsored by the Conference and the Senior Advisers to ECE Governments on Environmental Problems. Discussions were also held with the secretariats of the United Nations Environment Programme and of interested specialized agencies of the United Nations and with other specialists in the environmental field.

I. ACTION BY THE COMMISSION

3. Major elements of a system of environmental statistics are necessarily drawn from other spheres, designed for other purposes, and it is very difficult to set unambiguous boundaries on what is or is not properly classified as environmental statistics, as such. In line with its exploratory character, and to provide perspective, this paper contains a very comprehensive treatment of the subject. The Statistical Commission may wish to comment on (a) the directions in which the treatment of the subject could be improved, and (b) the proposed work programme and priorities described in sections VI and VII of the paper.

II. LONG-TERM OBJECTIVES OF INTERNATIONAL WORK ON ENVIRONMENTAL STATISTICS

A. General considerations

4. As in the case of other areas of statistics, a major purpose of international work on environmental statistics is to draw up international guidelines on the data to be gathered, and the concepts, definitions, classifications and tabulations of the data. In carrying out this work, account must of course be taken of the purposes for which the statistics are to be collected and used nationally and internationally.

1/ The paper was prepared almost entirely by a consultant, Mr. R.U. Ayres.

2/ In particular, "Statistics for environmental studies and policies", CES/AC.40/2, 13 February 1973 and "Report of meeting held in Geneva 19-23 March 1973", CES/AC/40/5, 26 March 1973, First session, Meeting on statistics for environmental studies and policies, Conference of European Statisticians; "Steps toward a system of environmental statistics", CES/SEM.6/2-Env./Sem.1/2, 4 September 1973 and "Conclusions of the Seminar on Environmental Statistics, Warsaw, 15-19 October 1973", CES/Sem.6/11-Env./Sem.1/11, 27 November 1973, Seminar on Environmental Statistics, Conference of European Statisticians and Senior Advisors to ECE Governments on Environmental Problems.

5. The statistics are required for environmental studies for purposes of formulating government policies nationally and internationally. The studies may be required to elucidate the current and likely future condition of various elements of the natural environment (atmosphere, oceans, underground minerals, soils, biological organisms) or the man-made environment (housing, industry, urban and rural infrastructures), to delineate the cause-effect relationships between the environment and human activity or to determine the costs and effectiveness of preventive or remedial actions. It may be said that the general purpose of a system of environmental statistics is to facilitate the forecasting of the future environmental and human consequences of current trends and of alternative policies.

6. Regrettably, in the analysis of the human impact on the environment, we are now limited to piecemeal consideration of the discharge and dispersion of pollutants and the exposure of biological organisms to the pollutants. Knowledge of physiological, biochemical, genetic, ecological or climatological consequences is still very limited. In the case of the analysis of the impact of environmental policies on socio-economic conditions, however, we are somewhat better off; as will be discussed later, policy models based on elaborated statistical inputs are now being widely used.

B. The interrelationship between environmental statistics and other statistics

7. As they are wanted for studies of complex interrelationships among environmental and other factors, the statistics to be covered in the guidelines should form a system of data rather than discrete sets of statistics on the various aspects of the environment. So that the system of environmental statistics may be used in conjunction with other systems of economic and social statistics, it should be co-ordinated with the latter systems with respect to concepts, definitions, classifications, etc. The implications of this will be considered later but two aspects are mentioned here:

(a) A system of environmental statistics of the wide scope contemplated in this paper will to some extent be closely related to both the systems of national accounts and balances and the system of social and demographic statistics. While the data of the two systems in question in the overlapping areas may not necessarily be the same, appropriate links should be forged between them.

(b) The systems of national accounts and balances and the system of social and demographic statistics are designed to serve as frameworks for the evolution of co-ordinated and linked, if not integrated, economic statistics and social and demographic statistics. The system of environmental statistics could provide a similar basis in the case of environmental and environmentally-oriented statistics on agriculture, industrial activity, etc., and on social conditions. In drawing up the guidelines on the system of environmental statistics, the need to co-ordinate with existing international guidance on the latter fields should also be taken into account.

C. National and international requirements

8. As in many other areas, there is interest in statistics which may be used to compare and correlate trends in the broader aspects of environmental conditions and

problems in different countries, on which international discussions and action will probably focus. These studies call for data which are comparably defined and compiled by countries. There appears to be general agreement that the requirements for such data should be covered in the international guidelines.

9. Some environmental conditions and problems are themselves international in nature, for example the pollution of international rivers; they may only be resolved by co-operation among the countries concerned. The solution of such problems also calls for internationally comparable data, perhaps much more detailed than the statistics needed to compare trends in the case of various countries. As far as is possible, these more detailed statistics should also be covered in the international guidelines; it may be difficult to draw up guidelines on the statistics required to deal with the more detailed, diverse and particular questions involved in various situations.

10. In the case of statistics primarily required for national purposes only, there appears to be less need to standardize concepts, definitions and classifications internationally. Indeed, while many environmental questions are common to a considerable number of countries, the nature of the problems, their causes and effects, and the action needed to deal with them reflect, to a significant extent, the diverse national circumstances of each country. On the other hand, most countries are at an early stage of developing their environmental statistics and should find international guidance beneficial. Moreover, the interrelationships among various elements of the physical/biological environment are not well delineated in all cases and internal problems may develop into unexpected international ramifications. It is therefore proposed that the international guidelines should also deal with environmental statistics required nationally. The differences in national requirements should be recognized by allowing for flexibility in the definitions and classifications of data.

D. Costs and methods of collection

11. The cost of producing statistics may also vary significantly, depending on how they are generated. As a rough generalization, it may be said that there are two different cost categories:

(a) Mass-produced statistics. They are easily and routinely compiled from readily available basic data (especially administrative information), using prepackaged available data-processing techniques. These statistics are often generated in bulk, primarily because they are cheaply obtained. They are typically published in compendia on individual subject areas and deposited in secondary data banks.

(b) Tailor-made statistics. They must satisfy certain definite standards and criteria or furnish answers to pre-specified questions. The development of the measurement or survey techniques, of the questionnaires, of the sampling, if appropriate, and of the processing of the gathered data to be used, often involves considerable costs and efforts initially. Obviously statistics that are tailor-made in the beginning may become cheaply and widely disseminated as the collection and compilation of the data becomes routine.

12. The methodologies of gathering and compiling mass-produced statistics vary considerably among countries, depending on national circumstances; this topic is therefore not to be covered definitively in the international guidelines.

13. A number of environmental studies however call for tailor-made statistics. This will probably be the case in the practical implementation of explanatory models of economic/environmental relationships. The sources and methodologies of gathering tailor-made statistics may be quite different in some instances from those used in other areas of statistics. It therefore seems desirable to include a discussion of the advantages and disadvantages of various sources and methodologies in the international guidelines, without making specific recommendations. Standardization of measurement techniques seems to be outside the realm of the professional statistician; they can, at best, attempt to become aware of some of these problems.

E. Conclusions regarding long-term objectives

14. In conclusion, it is proposed that the long-term objectives of international work on environmental statistics should be to formulate a system of environmental statistics, covering the data required both to monitor and assess the conditions and quality of environment and to develop and evaluate environmental policies and remedial programmes. The system should be co-ordinated and linked with the systems of national accounts and balances and social and demographic statistics, and should provide a framework for developing environment-oriented data on economic and social activities and conditions. In drawing up the international guidelines, account should be taken of national, as well as international requirements, for environmental data, but the guidelines concerning national requirements should be sufficiently flexible to allow for differences in the needs and possibilities of individual countries.

15. The international guidelines should concern the items of environmental data needed and their definition, classification and tabulation. Attention might also be given to the sources, methods and costs of gathering and compiling the data, insofar as they are particular to environmental statistics. Specific recommendations on methods of measurement, especially in the case of physical data, seem inappropriate at this juncture.

III. CHARACTER AND SCOPE OF ENVIRONMENTAL STATISTICS

16. As noted above, environmental statistics should, broadly speaking, furnish a basis for the study of (a) the condition (quality) of various elements of the environment and changes therein, (b) the effects on these conditions of various human activities and conversely and (c) the costs, benefits and other impacts of preventive and remedial action.

17. In the paragraphs below, the major questions of the character and scope of environmental statistics are considered further. The discussion will be rather general in character; questions of the specific items of data required in respect of each topical heading will be taken up in the later discussion of the proposed programme of work on environmental statistics.

A. Elements of environmental statistics

18. Environment in its broadest sense is a multidimensional concept, covering a great number of different resource elements including the natural elements (air, water, soil, biota, underground minerals, etc.) and man-made elements (roads, dams, urban and rural settlements, housing, cultural structures, etc.) and certain aspects of the natural and man-made processes of transforming materials and energy into alternate forms. In general terms, it can be stated that environmental statistics will be concerned with stocks and flows (or changes) or these resource elements.

19. The preceding definition of environmental statistics is broad and general in character. A more specific description and classification of the elements of

environmental statistics is needed in order to delineate the content and structure of the system and in order to provide background for the proposed programme of work in the short and medium term. The preliminary classification of the elements of environmental statistics set out in table 1 below is intended to serve these purposes. It will be seen that the statistics of the system are inevitably a combination of statistics from other spheres (e.g. natural resources and population) and of statistics specially required for environmental studies.

Table 1. Preliminary classification of elements of a system of environmental statistics

A. Natural elements of the environment

1. The atmosphere: the state, use, pollution and treatment of the atmosphere and of air resources.

2. The hydrosphere, marine biosphere and underground water: the availability and state, use, pollution and treatment of water and water resources.

3. The land surface and terrestrial biosphere: the availability, expansion and use, pollution of agricultural, forest, wilderness, etc. land and wild life.

4. The lithosphere: The extraction, processing and generation of pollutants, and recycling of mineral resources - metal ores, fossil fuels and other minerals.

B. Man-made elements of the environment

Human settlements and networks: The relative geographic distribution and density of the population and economic activities, land use in urban and rural settlements, their infrastructure - water supply, housing (including transitional settlements and slums), transport, communication, sanitation, recreational, cultural and social, etc. facilities - noise disturbances and the state, generation and reduction of other pollution, of the settlements and networks.

C. Pollutants and wastes: The generation, recycling, use, disposal and impact on living conditions of various kinds of pollutants and wastes.

D. Biomes: The uses, pollution, etc. of ecological systems.

E. Natural disasters: The monitoring, alleviation and prevention of natural disasters, the destruction and other disfunctions they cause in the natural and man-made environment and the recovery from them.

20. It is evident from table 1 that there is overlapping between the proposed categories (modules) of environmental statistics because these data are classified from significantly different points of view. Thus, the category on pollutants and wastes overlaps to varying degrees the various categories on the natural and man-made elements of the environment not only because various pollutants and wastes may pass from one environmental medium to another but also because they may be generated in using mineral resources, land, water, etc. and in the activities carried on in human settlements. For purposes of monitoring and dealing with environmental problems, it is necessary to trace the disposition to, and flow and transformation through, environmental media of various types of pollutants and wastes as well as to determine the state, discharge and reduction of pollution in the case of each natural and man-made medium. The category on biomes overlaps those on the natural and man-made environment because in studying the nature and balance of an ecological area account must be taken of the presence, character and interrelations of all environmental elements (media) in the area. Because of the differences in the purposes which the overlapping information of the aforementioned categories of statistics are to be put, the frames into which they are incorporated will of course differ. For the same reason, the items of data sought in respect of the overlapping information may also be more or less different.

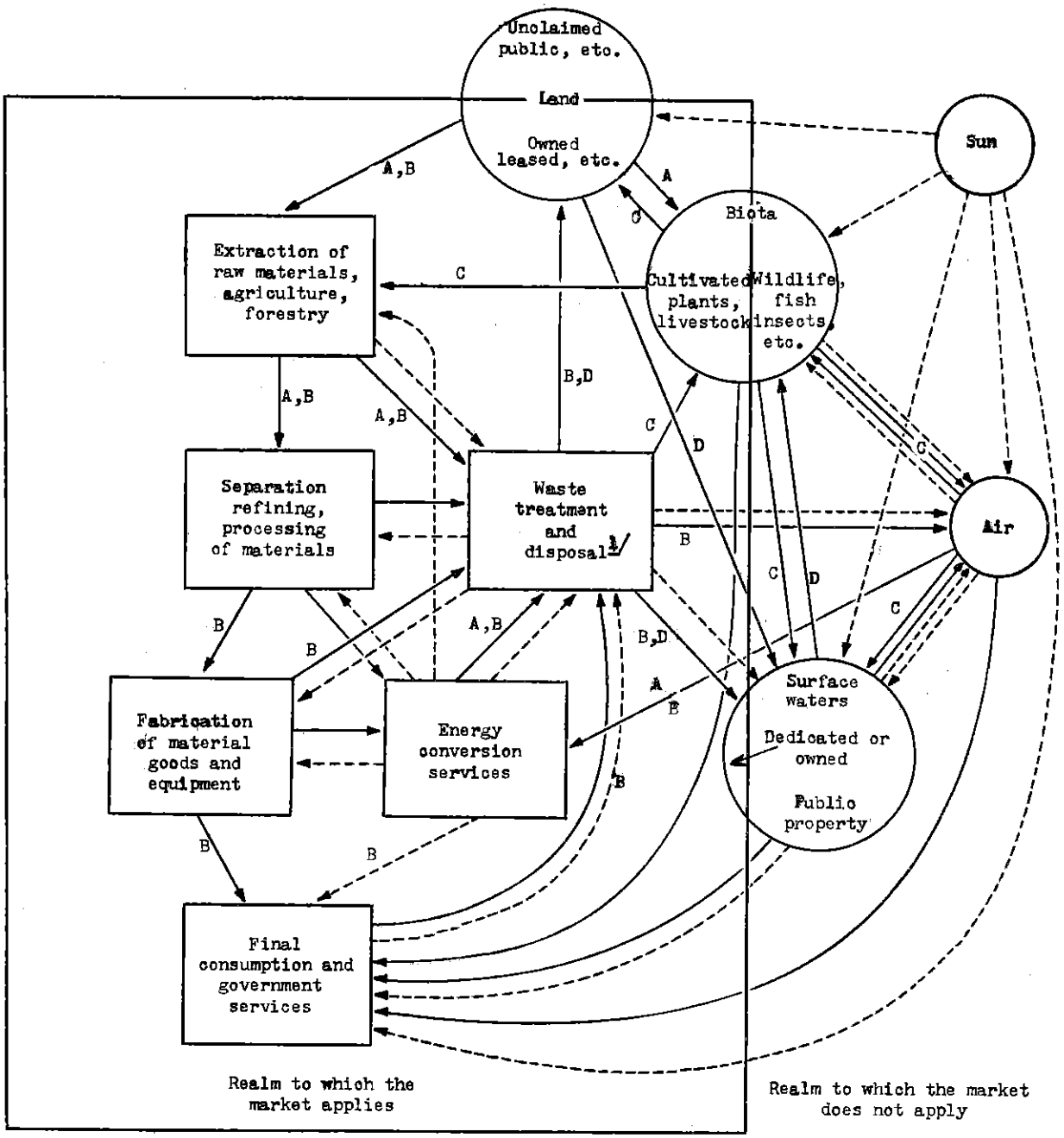
B. Relationships and contrast between environmental and economic statistics

21. It is useful to discuss the character and scope of the system of environmental statistics in relation to that of the United Nations system of national accounts (the SNA). The discussion below is centered on figure 1, which depicts schematically flows of energy, materials and services (or disservices) between major elements of the physical-biological environment and socio-economic activities. The square boxes in the chart represent highly aggregated economic aggregates and correspond to categories in the SNA; the circles represent environmental elements, land, air, water, biota, sun.

22. The boxed area in figure 1 represents the realm of economic activities and of the market place. Land, some surface waters and immobile or domesticated biota are included in this realm as they are subject to rights of ownership or exclusive use, which may, in principle, be exchanged for money in a market. (Whether the exchange in fact occurs or whether the market is "free" in the strict sense, does not matter). Commodities or services which may be exchanged in the market can be, and often are, priced. As a consequence, it is possible to convert all stocks and flows within this realm to a common unit of account, namely a monetary value. As economic transactions form a quasi-closed circuit in the case of an open economy, for example from production to distributed factor incomes and finally to disposable income and back again as outlays on consumption and capital goods and services, it is possible to define receipts and outlays as equal in the case of certain economic aggregates by creating balancing items on changes in stocks and borrowing and lending funds. These are the well-known accounting identities which underly the accounts and matrices of the SNA.

23. The fundamental conditions for exchange and pricing are missing in the case of air, many mobile forms of biota, the oceans, the sun and are difficult to apply in the case of such resources as public streets, parks, or cultural monuments. Materials, energy and services (or disservices) provided by these resources are outside

Figure 1.



Legend:

A - Geochemical distribution
B - Technological capabilities, chemistry
C - Biological and biochemical capabilities
D - Geomorphology, hydrology, climatology, etc.

——— Flow of material or waste product
------ Flow of energy (non-material forms)

1/ By convention, all wastes pass through the box for waste treatment and disposal whether or not any abatement occurs. Demand for abatement is generated through political decisions rather than through strictly market activities.

the realm of the market place.[3/] It is usually not feasible to establish or simulate market mechanism to determine monetary values though these values might perhaps be set arbitrarily by national or international authorities. In general, all environmental disfunctions that are listed in table 1 generate externalities (or disservices) to humans (consumers in the broadest sense of the term) which are outside the realm of the marketplace and hence cannot be valued in conventional terms. This not only suggests why environmental concerns extend, in part, beyond the reach of standard economics and its statistical underpinnings but also illuminates the interface between the two realms.

24. In general, economic statistics mainly measure the quantitative allocation of stocks and flows of scarce resources, goods and services and incomes among economic agents, including environmental protection and improvement. One of the areas of overlap between environmental statistics and economic data is the measurement of these resource flows and the resulting changes in the costs and benefits of environmental resources. Clearly, a major concern of environmental statistics should be the quantitative allocation of stocks and flows of various forms of energy and physical materials among and between economic and environmental elements. It is interesting to note that as these quantities are subject to the basic laws of physical conservation, accounting identities and input-output matrices may be used to describe stocks and flows of energy and materials. However,, only one unit of account and one classification scheme may be used in the case of each matrix. In addition to conserved units of account, the system of environmental statistics may also incorporate non-conserved units such as entropy, chemical form or physical form. There the use of matrices offers no particular accounting advantages.

25. In sum, environmental statistics consist, to a considerable extent, of non-monetary measures of the magnitude of the services or disservices. In other words, the system of environmental statistics must incorporate a variety of measures of effects on physical systems, for example on lakes, rivers, the atmosphere, structures and "built elements", urban areas, ecosystems and individual biological organisms. This greatly complicates the statistics required for environmental analysis as compared to those needed for economic analysis, where a common denomination provided by monetary values is given in the market.

C. Technical aspects of environmental statistics

26. A further dimension of complexity is also suggested by reference to figure 1. Each flow of materials or energy is labelled by one or more of the letters A through D. The purpose of this designation is to identify the major technological determinants of that flow. Thus the flow of raw materials to first stage processing depends on available technological capabilities, in relation to the existing geochemical distribution of elements in the earth's crust and in relation to the existing biological and biochemical capabilities of plants and animals, as well as on the final demand for the goods and services produced from the semi-finished products. If all of these factors were constant in time they might be disregarded, but in fact they are capable of rapid change as a result of human interference, both intentional and unintentional.

3/ However, it is not inconceivable that the innovation of certain concepts might make it feasible to extend the realm of the marketplace.

27. The rapid changes in man's technological capabilities are legendary and need not be documented here. It is perhaps less obvious, hence worthwhile to emphasize, that the geochemical distribution of elements on the earth's surface, and the biochemical capabilities of plants and animals may also change significantly during periods of the order of decades.

28. In the case of geochemistry, the progressive exhaustion of high quality ores of certain types is an obvious case in point. The so-called chalcophile elements (copper, zinc, lead, tin, silver, cadmium, mercury, arsenic, etc.) are all used much more widely in industry than their relative abundance would justify.4/ This is because the elements were easy to identify and to separate from ores through simple roasting or smelting. One consequence is that high grade ores, especially of copper, silver and tin, have been largely used up and much more elaborate and costly refining processes are now required. Another consequence is that large quantities of sulfur oxides and trace quantities of toxic metals, such as cadmium, mercury and arsenic; are released to the environment during the processing of lead, zinc, copper and silver ores.

29. The trend toward using lower and lower quality copper, silver and other ores may well exacerbate this environmental problem. But it may also accelerate a shift to other metals, especially aluminium, which has very different environmental implications.

30. The variability of biological and biochemical capabilities is most evident positively in the case of the so-called Green Revolution. Research resulted in developing important new strains of wheat, corn and rice in the past few decades. However, there are also progressive changes of potential negative significance, for example the evolution of highly resistant strains of pests in many parts of the world, perhaps due to excessive dependence on chemical pesticides. Another area of changing conditions is in the diversity of species in natural communities. Many formerly rare species have now become extinct and a much larger number of species is now endangered.

31. Changes in geomorphology, hydrology and climate are also taking place. The pressure of human settlement has apparently been instrumental in converting much of the land around the Mediterranean basin from forest to near-desert. A similar process of deterioration is presently occurring along the southern tier of the Sahara. Erosion and silting as a result of cultivation and overgrazing, irrigation, forest fires or prevention, and large-scale construction of roads, dams, etc., may lead to changing vegetation, surface temperatures, wind velocities, surface runoff-rates and even rainfall.

32. Even final demand is clearly not an endogenous variable determined entirely by economic conditions. While personal income, unemployment, taxes, government spending and income distribution are clearly relevant, it is equally clear that other factors such as population size and composition, education, leisure time, human tastes and preferences also affect the demands for, and hence the supply of, goods and services.

4/ Sulfur-loving metals which tend to be found as sulfide ores often linked together in by-product and co-product groups.

D. Conclusions concerning the character and scope of environmental statistics

33. Environmental statistics, in general, concern the measurement of the stocks and flows of, and the values or effects attributable to, environmental resources and disfunctions. A number of aspects of these topics lie outside the realm of economic statistics because certain kinds of environmental resources are not the subject of ownership and exchange; they and environmental disfunctions are not valued in the market. Environmental statistics will necessarily need to deal with the technical factors which generate changes in, or which differentiate, the stocks and flows of resources. Thus, statistical categories will be needed in respect of geochemistry, climatology, hydrology, biology, ecology and technology.

IV. STRUCTURE OF ENVIRONMENTAL STATISTICS

34. This section of the paper deals with the micro structure and macro structure of a system of environmental statistics.

A. The micro structure

1. The statistics

35. One may place most of the existing statistics on such subjects as health and accidents, demography, housing, transportation and the weather in the category of the mass-produced statistics discussed earlier. Many of these available mass-produced statistics have certain values as indicators of environmental conditions and trends. For example: the incidence of various types of cardiovascular or bronchial diseases has been linked with certain kinds of air pollution; chromosomal aberrations and embryonic malformations in the case of various species, both in vivo and in vitro, correlate with the presence of radio-nuclides and/or teratogenic chemicals; the presence of harmless Escherichia Coli or Streptococcus Faecalis in water suggests the likelihood of other more dangerous bacteria such as some strains of Salmonella; and five-day biological oxygen demand (BOD-5) is an approximate indicator of the quantity and biodegradability of organic matter in water. Such data are routinely used as proxies for measures of environmental circumstances. Mass-produced data on population distribution and density, housing, transportation and other aspects of human settlements furnish direct measures of the quality of the man-made environment. Data of this type may also be gathered and compiled on the quality of the natural environment, for example on atmospheric particulate concentrations, on the extent of suspended biodegradable and persistent pollutants in water or the degree of salinity of agricultural land. Individual series of statistics can be, and are, compiled from these measurements. These statistics furnish indicators of the quality, as well as some of the disturbing effects, of the environment, which are of interest to policy-makers and the public, at least to monitor the need for action. However, the value of the statistics for purposes of analysis and long-term assessment of problems is limited because of the lack of information on relationships and causal factors.

2. The multiple factors in environmental conditions

36. In most conventional statistical work it is convenient and reasonable to assume that all relevant exogenous factors may be adequately taken into account by combining a determinative relationship and random variable. Thus, the relationship between personal income and educational attainment might be approximated by a simple linear relationship between median income and median educational attainment, treating all deviations as though they were accounted for by a random (hidden) variable distributed according to a normal distribution function.

37. In the case of environmental analysis, this question is constantly recurring. For instance individual air pollution dose-exposure observations at a given location vary widely from day to day and from hour to hour. At least one major secular trend is generally present: the slowly increasing total quantity of emissions over the area. There are also diurnal (day-night) and seasonal (summer-winter) fluctuations to be considered along with the geographical distribution of sources. Meteorological factors, such as the wind direction, wind velocity at various levels, temperature gradient and atmospheric stability, also contribute to the "real" dose-exposure distribution function.

38. An obvious question arises: which and how many of the factors mentioned above should be explicitly incorporated in a system of environmental statistics and which should be lumped together and treated as a random variable with an underlying frequency distribution function? Fortunately, a final answer to this question need not be given at the present time. In fact, for many years to come it may be assumed that the available data on all of the factors which determine the relationship between the distribution of residual emissions in space and in time and the distribution of their physical, biological and sensory effects, will be significantly incomplete. It is also likely that the completeness, and thus the reliability of the available data, will, in the case of many countries, increase as the years pass.

39. The phenomenological relationships between causes and effects which a system of environmental statistics will attempt to reflect may be expressed as a set of symbolic functional transforms, the detailed quantitative mathematical representation of which may not be known at the outset. In any case, it may be expected that the theoretical understanding of these relationships will gradually improve. It is important, however, to ensure that the development of statistical time-series will facilitate the unravelling of these complex relationships and not simply add to the confusion.

3. The need for a basis in physical or socio-economic theory

40. In practical terms, the above discussion merely suggests that data incorporated in a system of environmental statistics should have a definite physical or economic interpretation. In other words, the mathematical procedures used to process raw data into individual statistics should have a basis in physical or economic theory. The purpose of this is primarily to permit retroactive modification of the statistics, as gaps in the underlying theory are later filled in or erroneous assumptions are later corrected.

41. At first sight this recommendation may seem unnecessary. However reflection on the relatively brief history of the classifications used in national accounting should provide an adequate justification. The difficulties and frustrations of reconciling national accounts data for different years, or for different countries,

because of shifts in the categories and levels of aggregation, are well known. These difficulties are, to some extent, inevitable as it cannot reasonably be expected that all classifications and definitions adopted at the outset will prove to be useful indefinitely. However, if the likelihood of needed future modifications and alterations is admitted, the problems of reconciliation facing future users of the system should be minimized as far as is possible. The suggestion that environmental statistics should have a definite physical interpretation is based on the notion that the interpretation itself would remain constant though the computational methods chosen may need to be modified from time to time.

B. The macro structure

1. Policy requirements for data

42. As is emphasized in the summary of conclusions of the Seminar on Environmental Statistics, in Warsaw, there are two quite different perspectives in making decisions on environmental problems, each of which calls for essentially different types of statistical information.5/ The first may be called the short-range perspective, which is oriented to a particular or local problem involving unresolved scientific questions, for example, damage effects. For this type of situation it is useful to have access to a large collection of mass-produced statistics gathered together in a secondary data bank, for example a special series of files or a library, for decision making. The second perspective may be described as broad focus, comprehensive problem assessment, which is oriented to the long-range impact of major shifts in economic and/or environmental policies at national or international levels.

43. To the extent that it is appropriate to utilize comprehensive, long-term input-output models in environmental analysis, the immediate need is to develop the necessary environmental statistical inputs. These inputs will, almost by definition, constitute a system of environmental statistics, in constrast to a collection of individual statistics or a secondary data bank. Such a system would presumably encompass measured stocks and flows of energy and physical materials, including pollutants, among elements both of the economy and of the natural environment.

44. It may be possible, to some extent, to compromise somewhat between the short- and long-range perspectives in respect of decision making. In principle, one can seek to develop a set of individual statistics designed for the purpose of providing reliable short-run ad hoc guidance on the current state of, and major trends in, the environment which, will also satisfy the more rigorous requirements of comprehensive short-range regression, or long-range input-output, models.

2. The character of the statistics and the accounts

45. To this end it was concluded by the seminar in Warsaw that the most profitable approach is to consider the environment as consisting of resources of a general character, subdivided into various classifications of their elements which reflect the purposes at hand. Most of these elements are at present outside the realm of the exchange economy and therefore are not easily assigned market value. However, despite the lack of an objective means of determining values, both the stocks and flows of these elements might, in practice as well as in principle, be measured, at least approximately. Thus accounts may be initially developed in physical terms, as in the case of the input-output tables derived from the material product accounts of the centrally planned economies. The general scheme for this purpose is indicated in table 2. Examples showing the method of constructing accounts are given in table 3.

5/ See "Conclusions of the Seminar on Environmental Statistics" op. cit.

Table 2. Environmental resource accounts - Example

Sectors	Natural elements of the environment				Man-made elements	
Resource measures	Atmosphere	Hydrosphere and marine biosphere	Land surface and terrestrial biosphere	Lithosphere: underground minerals, fossil fuels and water	Human settlements and networks	Cultural and historical heritage
Stocks	Quantity of air and of components (O_2, N_2, CO_2, H_2O, etc.) Quantity of pollutants (SO_2, CO_2, particulates, etc.)	Quantity of water according to type; fresh - potable for agriculture, etc., salt. Area of fresh water surface for water recreation. Shoreline of beach for swimming: fresh, salt. Range of indicator species: salmon, trout, marine mammals, etc.	Area of land suitable for cultivation, in forests, grass, etc. (Biomes) Area or land cultivated, forested, wilderness preserved, etc. Timber resources Pulp resources Range of indicator species: birds, wild predators, etc.	Quantity of metal ores, fossil fuels and other minerals: known reserves recoverable at present price and at extrapolated higher prices; known reserves extrapolated by future discoveries.	Area and population Stock of housing, of other space, such as roads, streets, parks. Infrastructure nets: water supply, sewers, etc.; telephones, radio-TV. Materials and energy supplies, processing and capacity.	Number of historical/cultural sites preserved by category.
Changes	Year	Year	Year	Year	Year	Year
Flows	Inputs of SO_2, CO_2, particulates, etc. from natural and man-made sources Fallout on land, absorption in ocean, takeup by plants	Inputs of water - rain, runoff. Returns of treated water. Underground untreated water Desalting Losses of water: agricultural use, withdrawal for human use, etc. Harvest of fish, etc.	Conversion from one purpose to another, for example, to reforestation, to irrigation, to urban. Growth of timber; harvesting of timber Losses of timber due to fire, wind, disease, pests, etc. Erosion, artificial fertilization	Conversion from suspected reserves to confirmed reserves Increase in known reserves due to: price rise changes in technology Extraction for use Recycling Technological substitution	Housing built/lost Networks extended Industrial capacity extended Parks and recreation facilities extended	Increase in stock preserved by conversion to preserved status. Loss by destruction in war, vandalism, theft, deterioration, etc.
Total	Year	Year	Year	Year	Year	Year
Impact of pollution, etc.	Dose-concentration levels > "x", for various pollutants: area and population covered.	Area polluted to point of reduced function: area of fresh water, of shoreline and of seafood unfit for consumption.	Area of exhausted soil, desert, etc. Disappearance of species; contraction of range. Area of mono-culture. Area urbanized.	Gap between extrapolation supply and demand at: present prices, probable price increase.	Need for pretreatment of inputs, for example, water, air.	Rate of deterioration due to pollution.
Changes	Year	Year	Year	Year	Year	Year

Table 3. Extended resource accounts: Examples [a]

Resource category	Natural additions to known stock	New discoveries adding to known stock	Natural losses	Additions or substitutions to stock due to human activity - investment	Additions to stock due to increased prices during year	Reductions in stock due to withdrawal for economic consumption	Reductions in stock due to inadvertent human action, for example, pollution	Net change in stock during year
Potable water available for consumption in year	Rainfall and runoff	For example ground water supplies	Runoff to sea, surface evaporation, transposition, from plants	Impoundment: dams Transportation: pipelines Desalting treatment	For example, wider application of treatment, etc.	Gross withdrawals for consumption	For example, leakage, contamination	
Water available for agriculture in year	As above	As above	As above	Diversion to other uses	As above	As above	As above	
Water surface suitable for recreation: fishing, sailing swimming	Not applicable	Not applicable	Not applicable	Artificial lakes dams, etc. Diversion to other uses	Not applicable	Not applicable	Pollution	
Timber resources available for harvesting	Growth	Not applicable	Fire, disease, wind, insects	Conversion from or to other uses New technology	For example, possibility of exploiting new species	Harvesting of timber	Reduced growth rate due to pollution	
Forest area available as habitat for wild life	Invasion of new areas	Not applicable	Invasion by natural predators/disease	Diversion from other uses	Not applicable	Not applicable	Aircraft and traffic noise, highways, recreational uses	
Mineral resources recoverable under present conditions of price and technology	Nodule creation?	For example, new ore bodies	Not applicable	New technology of ore recovery or surveillance	Additional possibilities of recovery at higher prices			
Area of oceans frequented by specified species of marine mammals	Invasion of new areas?	Not applicable	Competition by natural predators	Not applicable				
Production from oceans	Growth	For example, new species/ locations						

[a] The table is incomplete beginning with the account for mineral resources recoverable under present conditions of prices and technology.

46. The delineation and measurement of environmental resources for accounting purposes need not be limited to any particular level of aggregation or any particular physical unit of measure. Examples are: land area available for recreation and land area available for agriculture; quantity of fresh water available for drinking and for agriculture during a year, area of water surface suitable for sailing, fishing, etc. and length of shoreline (beach) suitable for swimming; known petroleum resources recoverable at the current world market price. All of these measurements may be made or estimated through a well-defined procedure at any given time; the increases or decreases due to various natural factors or human activities may also be recorded annually. It should be emphasized that balances between the elements are an essential aspect of the scheme. For example as the total amount of land available for all purposes is relatively fixed, transfers from one use of land to another will appear as counterbalancing debits and credits. This holds true for other fixed or quasi-fixed resources such as air, shoreline, etc. Even if this were not the case, the increases or decreases in land, shorelines, etc. may be exogenously introduced, that is from the outside into the accounts.

47. In cases where decisions must be made on the basis of cost/benefit considerations, special economic analysis may often provide rough guidance on the difficult question of monetary valuation, for example through the use of shadow prices. A number of studies have already undertaken ad hoc valuation in order to balance tangible economic benefits such as agricultural production against less tangible non-marketed benefits such as recreation. While the validity of the answers may be questioned until a more generally accepted theory is developed, the value of the physical statistics themselves will be unaffected by these arguments.

48. It must be emphasized that, while the aforementioned approach is highly flexible - indeed, rather loose - it retains the essential feature of connectedness required for purposes of a statistical system. In fact, it is easy to see that the general stock-flow matrix introduced in the case of a system of social and demographic statistics is applicable to environmental resources as defined, for instance, in tables 2 and 3.6/

3. Uses of the data in model building

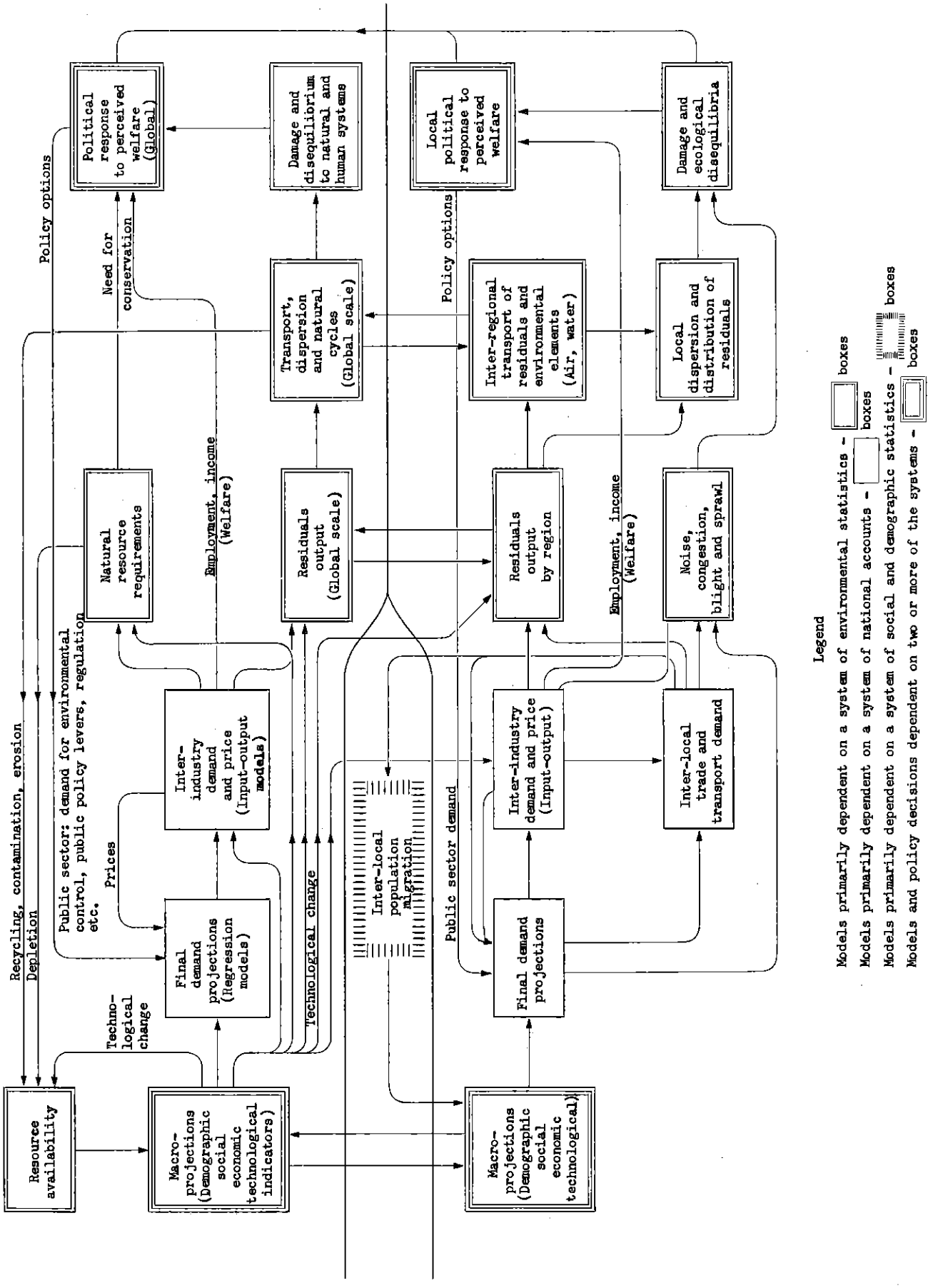
49. The extensive discussion in that document clearly suggests, by analogy, the mathematical basis for a variety of possible environmental models. Without doubt, many of the environmental studies that will be undertaken in the future will involve construction of simulation, projection or optimization models of elements of the environment, notwithstanding the fact - emphasized by Peskin - that policy-makers may not require very detailed information to choose between various available options.7/ An important category of intermediate users of environmental statistics will undoubtedly be model builders. Some general comments about the information requirements of such models will provide helpful perspective on the question of designing a system of environmental statistics.

50. Referring to figure 2, it is clear that three basic subject areas for modelling may be distinguished.

6/ "Towards a system of social and demographic statistics, Preliminary version", United Nations Secretariat, ST/STAT.68, 24 July 1973.

7/ Henry M. Peskin, "National Accounting and Environment", Artikler Fra Statistisk Sentralbyra, NR 50 (Oslo 1972).

Figure 2. Schematic presentation of models and of questions of policy



(a) Models dealing with the resource/residual implications of economic activity and of the economic impact of remedial efforts.

(b) Models concerning the involved natural phenomena for example the physical/biological transport, cycling and dispersion of pollutants and the perturbations of natural equilibria.

(c) Models dealing with the environmental consequences of non-economic human activities, including remedial efforts and the social consequences of environmental disequilibria.

51. Models of some topics in (a) and (b) above are fairly advanced, but excepting demographic projections, models in (c) are still quite primitive and scarce. Thus, to the extent that social models, that is on the topics of (c), are at a low level of development because of the absence of an adequate statistical base, it may be that evolving a system of environmental statistics coupled with a system of social and demographic statistics, would yield its greatest long-term benefits.

52. A comprehensive, interlinked family of economic, social and physical/biological models for environmental analysis, as shown in figure 2, may be envisioned. Some categories of models are quite well represented, whereas others are at present, essentially empty boxes. By and large, modelling capabilities are much greater at the aggregate national level than at the local level or than at the international level. Most of the occupied boxes are on the top row of figure 2.[8/] Generally speaking, economic models are operationally more advanced than physical models. The physical phenomena underlying some environmental conditions only, for example, the diffusion of pollutants in air or water, are well understood. Much basic data remains to be acquired with regard to atmospheric chemistry, biological uptake and concentration of heavy metals or chlorinated PCB's, etc. Many economic models are regularly used in actual policy assessments whereas few, if any, physical environmental models are yet used for this purpose. The physical transport and damage models are, in any case, almost exclusively local in scope. Their detailed capabilities are therefore not particularly relevant, until an adequate system of economic models becomes available to drive the physical and biological models.

53. The effort at international input-output modelling sponsored by the Department of Economic and Social Affairs of the United Nations, for which Mr. Wassily Leontief is the principal consultant, is an early step in the development of such an economic model at the interregional level.[9/] Further model building could be mutually beneficial with the development of a system of environmental statistics. The package of interlinked macro models exhibited in the upper half of figure 2 probably defines, as well as can be done at this stage, the linkages between the system of environmental statistics, on the one hand, and a system of national accounts (SNA) and a system of social and demographic statistics (SSDS), on the other.

8/ The terms "global" and "local" in figure 2 are, of course, relative. In practice, the largest scale of global modelling is generally at the national level. Truly worldwide models have yet to be built.

9/ The United Nations Study on the Impact of Prospective Environmental Issues and Policies on the International Development Strategy.

54. The models displayed in the upper half of figure 2 easily divide into three groups, depending on which statistical system they primarily draw data from; in a few instances they require data from two or more of the systems. For example economic models of final and inter-industry demands draw on the data of a system of national accounts, for example the SNA. Data for projecting the growth of the population and immigration, social indicators and so forth would come from a system of social and demographic statistics, for example the SSDS. Models on the availability and requirements for national resources and the output, dispersal and transformation of residuals would depend on a system of environmental statistics. Political response models would draw on the data from all three systems.

55. It is worthwhile to note that the link between inter-industry models and residuals output models has already been well developed, at least in the case of the United States. Tables of residual generation coefficients for kinds of industrial activity have been compiled by several research groups; this work is now being extended to the level of individual production processes or technologies.10/ The materials-balance concept has already proved to be a valuable tool for estimating residual outputs by indirect means where direct measurements or survey results are unavailable or untrustworthy. Peskin has recently demonstrated this use in uncovering classification errors and other mistakes in data provided by enterprises to the Central Bureau of Statistics, Norway.11/

56. The use of inter-industry models in projecting the output of residuals and abatement costs has revealed certain weaknesses in their usual form for this purpose and has stimulated their extension or modification, especially to take account of alternative technologies and substitutions. In the end, it is likely that some form of activity analysis or of materials-process-product modelling will be needed in order to provide a more natural link between materials flows and balances, on the one hand, and economic activities, on the other. This will not eliminate the need for input-output models; rather it will broaden their uses and statistical requirements.

C. Conclusions concerning the structure of environmental statistics

57. It is valuable for such purposes as monitoring environmental conditions to have summary measures of mass-produced statistics relevant to environmental matters. However these statistics usually consist of measures of symptoms or effects rather than of the underlying causes of the conditions. These data are therefore not adequate for a system of environmental statistics. A system of environmental statistics which will have consistent meaning over a period of decades must be based on general and unambiguous categories of stocks and flows such as quantities of minerals, water, biomass or energy. Unfortunately, such quantities are not always directly measurable; instead they must be computed. However, even when the method of computation is approximate, and changes from one year to the next, it is always feasible to compile comparable statistics for successive years or decades by recomputing earlier figures as improved computational methods are developed.

10/ Notably by the Environmental Protection Agency, the University of Maryland (Cumberland, et al.), the International Research and Technology Corporation (Gutmanis, Shapanka) and Harvard University (Leontief, Ford).

11/ Peskin, op. cit.

58. The macro structure of the system will depend on the uses to which the statistics are put. Short-term, localized or narrowly focussed problems require access to individual statistics on a range of aspects of the state of the environment. Analysing and dealing with long-term, non-local problems require the use of comprehensive analytical models. An attempt should be made to satisfy both requirements. Compiling a systematic set of environmental resource accounts, using available accounting balances for materials and energy flows, will serve these needs. The data of the system would then be useful for a range of monitoring, analytical and policy purposes, including model building.

V. SPECIAL INDICATORS OF ENVIRONMENTAL QUALITY

59. In the paragraphs above, the uses of environmental statistics for policy analysis has been emphasized. Another important use of the statistics is to inform policy makers, the public and others about the state of the environment. As has already been noted above, certain series of individual statistics which are already being collected may be used as indicators of the quality of the environment. Examples are data on residuals discharges, ambient concentrations of pollutants in air or water or on the incidence of health disabilities known to be due to environmental conditions.

60. There is also an apparent need for aggregated indicators, for example on gross national pollution or on the quality of the environment. Such indicators may constitute a special class of environmental statistics. The problems involved in constructing composite indicators are considered below, in the context of three areas of concern: pollution, noise disturbances and disfunctions caused by inadequate planning and misuse of man-made elements.

A. Pollution

61. The various forms of pollution result in a change in the physical composition (addition of pollutants) of environmental elements, for example air, water and soil. The quality of these elements may be characterized by the quantity and kinds of pollutants which are present. The selection of the particular types of pollutants for which indicators should be developed should be based on the extent to which the different pollutants are of major concern because they affect human conditions and activities. One difficulty is that the effects may be incommensurable: pollutants may be harmful or dangerous to human life, they may cause discomfort or aesthetic dissatisfaction to persons, without being harmful, or they may affect economic activity, for example production processes and productivity. Furthermore, in some instances two or more pollutants may be harmless separately but dangerous in combination. The critical difficulty in building composite indicators of quality is determining the weights to be attached to each of the incorporated individual statistics.

B. Noise

62. In the case of disturbances caused by noise the environmental process is different in character. These disturbances do not result in a change in the physical composition of an element of environment; noise is of course not stocked in the environment in the same way as pollutants. Environmental deterioration must therefore be measured in terms of the nature and quantity of noise produced during a given period. The disturbances caused by noise depend not only on the average intensity of noise

produced but also on its frequencies and duration and on the density of potential receptors (people) in the vicinity. In addition to separate data relating to each of these aspects of noise, a composite indicator is therefore needed on the combined impact of all of these aspects. The problem of constructing such indicators consists of defining and weighting the various dimensions of noise. In other words, there is ambiguity concerning the critical factors in the environmental damage resulting from noise.

C. Man-made elements

63. Disfunctions resulting from defective planning and misuse of built elements are similar to pollution in that the involved environmental elements undergo changes in physical composition. Moreover, the state of the man-made elements may be characterized in terms of their characteristics of quality. Many problems arise in identifying the characteristics that should be measured. The quality of a built-up area might be represented by a set of coefficients on the number and location of available facilities, for example schools, hospitals, cultural establishments, and on the number and character of the persons these facilities are designed to, and do, serve. The difficulty is: how should these coefficients be selected and to what extent may they be selected on the basis of objective criteria? Here the ambiguity is greater than in the case of noise; not only the underlying factors but also the effects of environmental damage are difficult to identify or quantify.

D. Conclusions concerning the special indicators

64. There is considerable international interest in developing special indicators of environmental quality, at least in the case of specific elements of the environment. These indicators are important for monitoring the state of the environment. However, their development may be slowed by the difficulties of identification, quantification and weighting. Environmental effects are diverse, incommensurable, often non-linear, for example antagonism or synergism between combinations of environmental agents. Moreover, there are unresolved ambiguities and uncertainties concerning the underlying factors and consequences of given disturbances. Some of these ambiguities may be eliminated as scientific knowledge advances, but others, especially in the realm of sensory and psychic effects, may be unresolvable.

VI. MEDIUM-TERM OBJECTIVES OF A PROGRAMME OF WORK ON ENVIRONMENTAL STATISTICS

A. Need for priorities of work

65. The design of a system of environmental statistics calls for detailed study and definition: (a) of the data, classifications and tabulations required for environmental monitoring, studies and policies, that is the contents of the system, and (b) of the ways in which and means with which these data should be organized into a coherent and linked framework, that is the structure of the system, its internal and external links, etc. This is clearly a long-term programme which must be carried out in stages. It is therefore essential to consider the priorities to be attached to the items of work to be undertaken, and in particular, the aims of the work in the initial stages of the programme.

66. While the main emphasis at the outset of the programme of work should be on the general content rather than on the structure of a system of environmental statistics, the latter point should not be ignored. This approach is appropriate for the following reasons:

(a) The need for statistics to deal with pressing environmental problems is urgent. The development of these data should not be delayed by devoting considerable resources to elaborating the structure of a comprehensive system. Indeed, it may be that these immediate needs are better served by a relatively simple set of statistics which may be devised and gathered and compiled rather soon, than by a more complete system which will take much longer to formulate and implement.

(b) The available methodologies and models, which should be the main determinants of the detailed structure of a system, are not yet sufficiently well defined to enable the working out of a comprehensive and definitive system. Indeed, it is doubtful that a statistical system can ever be complete and definitive. Research into users'needs is essential; the availability of a relatively simple set of environmental statistics at an early stage will promote this research.

(c) However, though users' needs may best be determined through experience in using the statistics, the purposes to which the statistics may be put obviously depend on the scope and internal and external co-ordination, linkages and other connexions of the data. Thus potential uses must be anticipated even at an early stage of the work,in order to maximize the utility of the system at later stages of evolution.

67. For the first two reasons set out above, the development of data should concentrate initially on the requirements for statistics in the case of selected, urgent problem areas of the environment. These statistics should be formulated in considerable depth and detail; efforts should not be made to deal with the entire area of environmental statistics in the same thoroughness.

68. It is clear that the formulation of, and international agreement on, guidelines on a system of environmental statistics will be a lengthy process. Not only will the final system call for a considerable range and volume of statistical series, of data processing and of analysis, but the contents, and perhaps even the scope, of the future system may only be defined over a period of time as environmental analysis progresses and the tradeoffs between the benefits and costs of various tailor-made statistics are explored.

69. The above is not intended to suggest that implementation of certain portions of the system should await final specification of the whole of it. On the contrary it is essential,and should be feasible, to define and develop given parts of the system in the near future. At the same time the groundwork may profitably be laid for future extension of the work to other parts of the system.

B. Priorities of work

70. An appropriate way of delineating a medium-term programme of work on statistics of the environment is to base it on the data called for by the urgent environmental concerns. These concerns relate: (a) to the environmental aspects of human settlements, (b) to pollutants in relation to man's activities and welfare, (c) to pollution in the case of energy and non-energy minerals and (d) to the quality of environmental reservoirs (elements).

1. Human settlements

71. As better living conditions are the ultimate objective of the International Development Strategy, the state of, and underlying factors in, the quality of human settlements and policies and programmes for their improvement are subjects of major concern. The pollution of urban areas generated by industrial activity is also an important consideration in the case of the Strategy. Similarly, the first session of the Governing Council of UNEP gave high priority to work on the environmental aspects of human settlements for two major reasons: the pressing problems generated by large-scale migrations of people within countries and the deterioration of both urban and rural settlements; and the great role of these settlements in the quality of life of the inhabitants.

72. The major topics on which data are required in order to deal with the concerns outlined above are enumerated below.

(a) The distribution, density, migration and growth of the population in the case of urban and rural settlements, in relation to that of economic resources, activities and opportunities and other underlying circumstances and factors.

(b) The supply as compared to demand and the quality of the facilities and services in urban and rural settlements, such as housing, sanitation, water and energy, transport and communications, education, recreation, culture and other community and social amenities.

(c) The state of pollution, the generation, disposals and abatement of pollutants and wastes and the transformation of pollutants, in the case of the environmental reservoirs of urban and rural settlements.

2. The emission and flow of pollutants

73. The international input-output study referred to in paragraph 53 above on the implications of environmental concerns for the International Development Strategy illustrates, at the world and major regional levels, the statistics required on the emission and flow of pollutants. The approach being followed in that study illustrates the way in which the various modules (components) of figure 2 may fit together into a large-scale model.

74. Three classes of statistics are called for by the study.

(a) Statistics from the systems of national accounts and balances (SNA or MPS), including input-output coefficients.

(b) Statistics for long-range forecasts for purposes of projecting the input-output model into the future. Demographic and social variables are mainly involved. The study will also incorporate certain long-range technological projections. The former statistics are included in a system of social and demographic statistics.

(c) Statistics on the flows of materials through the economy and environment reservoirs, especially pollutants into various environmental media as a consequence of economic activity. Data will also be wanted about actual and proposed pollution standards. These data should constitute a module of a system of environmental statistics.

3. Energy and non-energy minerals

75. Another area of United Nations activity that has high short-term priority is the environmental aspects of production and consumption of energy and non-energy minerals. The Stockholm Plan of Action, approved by the General Assembly, calls for a report on questions of supplies and demands and uses and pollution in the case of fossil fuels and other sources of energy; the Governing Council of UNEP assigned high priority to these questions. The recent special session of the General Assembly of the United Nations emphasized the importance of exploiting, and receiving a just return for, fossil fuels, metal ores and other minerals and of adequate and reasonably priced sources of energy to the economic development of less industrialized countries. These problems are central to the International Development Strategy. Questions of the adequate and economic supply of energy and of metal ores and of the environmental effects of producing, processing and using these commodities are also major concerns of developed economies.

76. Unfortunately, the existing statistics, particularly on metal ores and other minerals are very inadequate for purposes of dealing with the urgent problems outlined above. It is essential to remedy these deficiencies by formulating and developing a more comprehensive body of statistics on energy and non-energy commodities in the immediate future. These statistics, which are needed for a variety of purposes, would also be used in constructing a module of the system of environmental statistics which would cover the following topics:

(a) The supply - domestic extraction and conversion and import - and demands - domestic intermediate and final and exports: values, quantities and prices in the case of fossil fuels, in the case of other sources of energy and in the case of non-energy commodities.

(b) The generation, abatement and recycling and other means of elimination of pollutants in the extraction, processing and transformation of fossil fuels, of other sources of energy and of non-energy commodities.

4. Quality of environmental reservoirs

77. The Governing Council of UNEP assigned high priority to the Earthwatch programme, in particular to monitoring the state of, and trends in, pollution of water, air, soil and land, food and ecological systems. This information is an essential initial step in assessing and proclaiming the deteriorative effects of man's activities on the environment and the potential harm to the health and other aspects of man's welfare of the polluted environment. Thus the quality of air, water and other environmental reservoirs is receiving substantial and rapidly increasing local and national attention in the case of both developed and developing countries.

78. The formulation and development of data to monitor the quality of various environmental reservoirs (media) should be carried out in stages ordered according to degree of complexity and difficulty. The work should first concern measures of the ambience (degree of pollution) of environmental media at local levels. The second subject of attention should be appropriate measures of the average degree of pollution of environmental media in the case of regions, especially those common to the various parts of a region, for example a river basin. Finally, work should be undertaken on ways of correlating, that is building models about, the trends in the ambience of environmental media and the disposal and flow of pollutants into them. The geographic area covered in these studies would vary, depending on the scope of, and connexions between, the given reservoirs. Exploring the connexions between the quality of environmental reservoirs and the health, or other living conditions, of the exposed (at risk) population involves linking data from a system of social and demographic statistics with these environmental statistics.

79. The third task mentioned in the preceding paragraph involves the building of dispersion models. Evidently there is a tradeoff, still to be explored, between the size of the region and the validity of dispersion models. For a very large and diverse region the dispersion model would have to be exceptionally accurate to avoid suppressing significant details. It would be easier to develop meaningful results for a smaller region, for example a single city or river, but data of broader scope are also wanted. However, global atmospheric circulation models exist, at least for some air pollutants, for example particulates and oxidants. Thus, it is probably meaningful to consider the air pollution potential of a continental region such as Europe. Similarly, large-scale ocean circulation models either exist now or will be developed shortly. They would permit estimation of ocean pollution potentials in the case of pollutants such as petroleum residues, heavy metals, DDT and PCB.

VII. A PHASED PROGRAMME OF WORK: THE TASK LIST

80. This section of the paper deals with the tasks involved in carrying out the proposed medium-term programme of work outlined in the preceding section. It should be emphasized that these tasks can be undertaken only if adequate resources are made available for this purpose. As the tasks are developed the conceptual and classification framework will evolve and undergo modification.

A. An overview

81. Before describing each of the tasks (see paras. 88-109), it is useful to indicate how they fit together.

82. Tasks a through d are intended to furnish information for laying the groundwork of work for the other tasks to be undertaken in the short and medium term. These tasks are to be carried out in order to determine the specific requirements of governments for environmental statistics and models (tasks a and b), the data which are now available to meet these requirements (task c) and the additional statistics which it is necessary to develop (task d).

83. Tasks e through g concern the collection and compilation of the statistics of environment dealt with in the list of tasks, that is on the environmental aspects of human settlements, on materials balances, on energy balances and the quality of the environment, respectively. The result of carrying out task c and the early phases of the tasks on the aforementioned four areas of data would be to publish the first compendium of environmental statistics.

84. Tasks h and i concern the development of a module of the System of environmental statistics covering human settlements (HSSM - human settlements statistics module).

85. Two other modules are proposed: a "material balance statistics module" (MBSM) and an "energy balance statistics module" (EBSM). It is desirable and convenient to combine the tasks involved in gathering and compiling, formulating and developing the data of the modules on non-energy and energy commodities (MBSM and EBSM) into

tasks f and j through m because of the overlapping and similarities in the approach, framework, concepts and classifications of the two modules. Tasks j through m are closely related to, and furnish the basis for future extensions of, the United Nations Study on the Impact of Prospective Environmental Issues and Policies on the International Development Strategy, which is currently under way. The study currently in progress is a paradigm of the use of models for purposes of long-term problem assessment at the international level. Of course, many additional analytical elements will be added to the existing core system as model development and data resources permit. The work on tasks j through m should be closely co-ordinated with the statistical and appropriate substantive divisions of the United Nations headquarters and regional commissions and of the specialized agencies.

86. Tasks n and o relate to the formulation and development of statistics of the quality (ambience) of the various environmental reservoirs, in relation to the disposal of pollutants and wastes into them. The data are to be designed so as to furnish a basis for monitoring and assessing the impact of pollution on human health and welfare.

87. Tasks p and q are concerned with extending the data base for environmental studies and policy making and with plans for further work.

B. Tasks a - q

88. Task a. Statistical user requirements survey. A survey should be made of governmental and non-governmental users of environmental statistics to elucidate what policy-related questions have been, and are being, asked, their relative order of urgency, and what kinds of data are needed for these purposes. This task should be co-ordinated with the statistical and appropriate substantive divisions of United Nations headquarters and regional commissions and with the specialized agencies.

89. Task b. Environmental policy model inventory. In co-ordination with the survey above, an inventory should be conducted to determine the kinds of analytic models that are available or that are being designed and developed. Examples of the kinds of models to be distinguished are short- and long-range models of input-output projections, of regional population and economic allocation, of regional water quality and management and of urban transport forecast. In the case of each type of model, information should be gathered on the requirements for statistical and other inputs, the kinds of outputs, and their use and relative order of urgency in dealing with environmental problems and policy formulation.

90. Task c. Inventory of available sources of environmental statistics. Based on the results of tasks a and b, as well as the work on tasks h, j and n, a further survey and analysis should be undertaken to determine:

(a) The required statistics that are now available in, or that may be derived from, data already being gathered and compiled by members of the United Nations family, other international bodies and by governments.

(b) The probable costs of gathering and compiling existing statistics and of generating new statistics from existing data.

Relevant statistics may be gathered and compiled by IAEA, FAO, UNESCO, WHO and WMO and some of the United Nations regional commissions. "Earthwatch" is also of importance for this purpose.

91. Task d. Environmental statistical needs study. On completion of tasks a through c, a report should be prepared on the statistics of the environment required to monitor and assess conditions and problems, to build models, to make policy, etc. and on the availability of, and gaps, in these statistics. This report should be the subject of a round of consultations.

92. Task e. Collect and issue HSSM data. The re-orientation and extension of the population and housing statistics now gathered and issued internationally, to produce the data of the HSSM, should be started at a moderately advanced stage in the design of the module. This work might be phased over a number of years. The first stage would consist of collecting, re-compiling and analysing the data already gathered by the United Nations family and other international organizations on the population, economic activities, housing and sanitary services and other environmental facilities and services in the case of urban and rural settlements. Much more information is available internationally on cities and towns than on rural settlements. The next phase of the work would be mainly devoted to pollution and its effects on human settlements. The third stage would concern the improvement and extension of periodic collection and compilation of statistics on the environmental aspects of human settlements.

93. Task f. Collect and issue MBSM and EBSM data. This work should be undertaken in stages. The re-organization and extension of the statistics on energy commodities now gathered and compiled by the Statistical Office of the United Nations to yield the data of the EBSM on production and domestic use, and international trade, should be undertaken first. During the same time, work should be pursued on the re-orientation and extension of the statistics now gathered and compiled on non-energy minerals. As this project progresses, data would be sought and integrated into the module on the emission, abatement and recycling of pollutants from the production and use of both energy and non-energy commodities and the flow of selected pollutants through reservoirs.

94. Task g. Collect and issue data on ambience of environmental reservoirs. This work should be carried on in stages. The first step would be to gather and issue statistics of the quality of local, regional, etc. environmental reservoirs which are already available from governments. The second step is to develop and seek new data on the ambience of environmental media based on the work carried out on task n below. The final steps are to prepare and publish statistical studies of the dispersion potential of pollutants in systems of given media spread over wide areas and of the correlation between the disposal of pollutants and wastes in, and the ambience of, environmental reservoirs.

95. Task h. Develop framework and data base for the subsystem on the Environment of Human Settlements (HSSM). This task consists of the design and development of the framework, the concepts and definitions, classifications and tabulations, and the methodologies for collection and analysis of statistics on the environmental aspects of human settlements. The statistics in question will deal with: the size, growth and density of population, in relation to the magnitude and expansion of economic activities and of environmental and social facilities in urban and rural settlements; the supplies of, the demands for, and the adequacy and quality of, housing and sanitary services, water and energy, transport and recreational, cultural and

social services in these settlements; the pollution encountered and ameliorated. The task would be divided into subtasks concerning each of these sets of statistics. The work will result in international guidelines and technical manuals on the statistics to monitor and assess the environmental aspects of human settlements and to formulate policies and plans concerning the location, development and improvement of urban and rural settlements.

96. Task i. Pilot case studies on environmental statistics on human settlements. Pilot case studies should be undertaken, perhaps in three countries, in order to test and improve the framework and data base developed under task h above and in order to furnish data on the conditions, problems and solutions thereto, in the case of different types of human settlements. The pilot case studies would also serve as demonstration and training projects and yield useful data on the environmental aspects of human settlements.

97. Task j. Design of MBSM and EBSM. In connexion with this task the International Standard Industrial Classification (ISIC) should be examined in respect of the level of aggregation of ISIC categories; some categories may need to be disaggregated while other categories may need to be combined.

98. On the one hand, categories which cover significant transformations of materials and/or energy, may need to be subdivided according to a classification of technology processes which should be developed. For instance, truck transportation should be subdivided into categories based on type of engine, for example, diesel, gasoline. The generation of electric power in nuclear plants should be distinguished from that in fossil-fuel steam plants. Industries processing primary materials should be substantially disaggregated. For example, paper and pulp manufacturing should be subdivided to distinguish at least the so-called kraft, sulfite and magnefite processes of producing pulp and the wet and dry processes of producing paper. The by-products of intermediate chemicals such as sodium sulfite of magnesium sulfite might be classified separately or included in pulp production, if this is in fact the situation; in any case, it is necessary to have a consistent mode of classification. Similarly, iron and steel manufacturing should be subdivided to distinguish the steps of coking coal, of sintering iron ore, if performed in the mill, of blast furnace smelting, of steel making in open-hearth, basic oxygen or electric furnaces, of casting ingots in bulk or in continuous processes and of rolling-mill processes. For these purposes a standard classification of major industrial processes and technologies should be devised as an adjunct to the ISIC. This task should be coordinated with UNIDO.

99. On the other hand, the requirements of environmental analysis would be served if all economic activities which do not involve significant physical or chemical transformations of materials and/or energy, were aggregated. In other words, it is not necessary to disaggregate services which neither add nor subtract materials, viz. finance, real-estate, rental of goods, law, insurance, advertising, education, telephone, broadcasting, etc. Physical inputs and wastes of these activities, such as paper, typewriter ribbons and worn-out equipment, may be aggregated; this is also the case for electric power and fuels. Freight forwarding and warehousing and the distributive trades may, from the point of view of the environment, also be considered to be activities which consume and discard packaging materials.

100. In addition to the questions of aggregation and classification this task calls for defining the frameworks and substantially disaggregated, series of statistics of the MBSM and EBSM.

101. Task k. Develop standard classification of materials for the MBSM and EBSM. A classification is needed of materials, for example pollutants, which may flow between environmental reservoirs. Here the problem is the selection of permanently significant categories from a vast number of possibilities. The preparation of the list should be co-ordinated with the "Earthwatch" programme of monitoring; this might be delegated to an external group such as SCOPE.12/ A preliminary list might distinguish the following:

waterborne nutrients	carbon in rapidly degradable form (related to BOD and COD)	
	nitrogen	(N-content)
	phosphorous	(P-content)
toxic gaseous pollutants	CO	(C-content)
	NO + NO_2	(N-content)
	SO_2 + SO_3	(S-content)
	Hydrocarbons	
waterborne particulates (silt)		
airborne particulates	< 1 μ in diameter	
	> 1 μ in diameter	
other toxic or biologically active substances	pesticides	
	petroleum residues (in water)	
	toxic chemicals (including carcinogens, teratogens, etc.)	
	DDT, PCB, Freon II	
	heavy metals (Cu, Pb, Zn, Hg, Cd, Ni, Cr, etc.)	
	ions	
	radionuclides	
miscellaneous	CO_2	
	Oxygen	
	H_2O	

102. Task l. Develop standard classification of environmental reservoirs. A classification is also needed of environmental reservoirs for which statistics on stocks and flows of materials and energy are to be formulated and developed. An international classification would probably distinguish at least the following:

atmosphere	upper atmosphere (stratosphere)
	lower atmosphere (troposphere), including clouds
hydrosphere	land surface waters, for example lakes, rivers
	ground water
	upper ocean
	deep ocean
	glaciers and ice-caps

12/ Scientific Committee on Problems of the Environment. SCOPE is an entity of the International Council of Scientific Union (ICSU).

lithosphere	terrestrial dead organic matter (humus) inorganic soil marine dead organic matter (muck) inorganic ocean bottom silt
biosphere	terrestrial plants, except agricultural crops and commercial forests terrestrial wildlife, excluding livestock and humans livestock, including commerical fresh-water fish grown in ponds marine plants marine animals (If ocean marine-culture becomes important, the various marine crops and animals should form separate categories) humans

103. A regional subclassification will probably be needed in the future. These should be based on geographic and climatological features in order to coincide with characteristic land biomes, for example: taiga, tundra, coniferous forest, deciduous forest, tropical forest, humid grassland (prairie), arid grassland (savannah), thorn scrub, desert.

104. A marine subclassification if needed, should also be based on geographic factors which coincide with biomes, for example: arctic and subarctic continental shelf, temperate estuarine zone, temperate continental shelf, tropical estuarine zone such as cypress swamp, coral reef/tropical continental shelf, upwelling zone, deep ocean. The delineation should be co-ordinated with UNEP activities such as Earthwatch.

105. Task m. Implementation of MBSM and EBSM on a pilot basis. A pilot project should be carried out as part of the development of the MBSM and EBSM, preferably in a small country with a highly developed statistical data base. The success of this pilot project would provide a strong incentive for imitation in other countries. The pilot project itself should be carried out in phases. A desirable first phase would be to devise, and to begin compilation of, a complete set of energy stock-flow statistics for the country. Later phases might extend the statistics to food and forest products, metals, chemicals, etc.

106. Task n. Define and develop statistical series on ambience of environmental reservoirs. The task should be carried out in stages. The first stage should concern the formulation and development of the simpler data on the quality of environmental reservoirs, for example individual series on concentrations of given pollutants in reservoirs at local or regional levels. The second stage of the work might deal with the definition and implementation of series summarizing the total state of ambience of reservoirs at local or regional levels. The simpler and more complex statistical series should be defined so as to take into account the size of the population exposed to the pollution.

107. Task o. Explore means of assessing the dispersion potential of pollutants. The task consists of devising ways of measuring and assessing, for example models of two types of phenomena. One is the dispersion of pollutants through systems of selected environmental reservoirs of wide geographic coverage, for example the atmosphere, river basins, oceans. The other is the correlation between the disposal of pollutants into environmental reservoirs and the ambience of these reservoirs.

108. Task p. Feasibility of extending the environmental data base. The purpose of this analysis will be to determine the feasibility of gathering additional data to fill the gaps in the available statistics internationally. The approaches to be considered in detail are as follows:

(a) Adding questions to existing questionnaires sent to governments.

(b) Devising supplementary questions.

(c) Generating new statistics from data-banks now, or potentially, available, for example from the global monitoring of "Earthwatch".

Work on this task is likely to be spread over several years.

109. Task q. Plan for subsequent activities. Concurrently with the other tasks listed above, plans should be drawn up for further work.