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ECOSYSTEMS APPROACH TO WATER MANAGEMENT

Revised draft report */

The ecosystems approach, as a concept for managing water resources, has been discussed in scientific circles for well over a decade, but had never fully achieved the status of a working principle until recently. It provides a holistic way of viewing planning, research and management of water resources, taking into account not only the sustainability of such resources but the environment as a whole. This report describes the concept in practical terms and illustrates some of its attributes. The aim is to promote its development and future application through the exchange of knowledge and experience. The paper reflects a first attempt to document the extent to which this concept has penetrated day-to-day water-planning management practices in ECE countries.

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*/ Prepared by government rapporteurs at an informal meeting, held from 5 to 7 June 1989 in Bergen, Norway.

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I. BACKGROUND

1. Environmental experts have propounded the ecosystems concept for many years from various angles. The concept is founded on a powerful yet simple premise: all elements of the environment (both living and non-living) interact with one another in a highly complex and infinitely adaptable way to achieve long-term stable ecosystems. The ecosystems approach relies essentially on working within those systems, understanding them and maintaining them. While the idea is not new, missing, heretofore, has been an attempt to apply these concepts at an early stage or to promote them in planning and management - particularly with regard to water.

2. Water is a vital resource if not the principal resource sustaining natural ecological processes. In this domain, however, the concept was fated not to gain wide acceptance until society was ready to recognize the limits and interrelatedness of all environmental components. The need to promote proper management from within rather than attempt to correct problems post facto is increasingly recognized in the field of water resources development. Pressure is being put on planners and decision-makers because people generally are more aware of the problems inherent in piecemeal solutions. This is so notably at the international level.

3. Long subsumed under overall environmental management, the ecosystems approach has now been given prominence in several ECE policy statements and studies. The ecosystems concept was implicitly recognized in ECE declarations, decisions and recommendations (see especially Two Decades of Co-operation on Water (ECE/ENVWA/2)) which gave special recognition to the benefits and advantages of ecologically sound development, maintaining the normal health of watercourses, and protecting aquatic ecosystems such as wetlands and moors against pollution. The ecosystems approach to water management has been explicitly cited as a salient aim for the 1990s in the ECE report on Water Use and Water-pollution Control: Trends, Policies and Prospects (ECE/ENVWA/10).

4. The most recent ECE policy statements - namely the Regional Strategy for Environmental Protection and Rational Use of Natural Resources (ECE/ENVWA/5) and the Declaration on Conservation of Flora, Fauna and their Habitats (ECE/ENVWA/6) - allocate a central role to the ecosystems approach in environmental and nature conservation management, thus revealing a new level of international awareness and a new sense of direction. Neither document, of course, provides specific operational or institutional tools.

5. In recognition of the need to give more weight to questions of quality and quantity within aquatic ecosystems, thus ensuring the smooth function of bio-geo-chemical cycles and natural biological populations, the ECE Regional Strategy calls for increased emphasis on the role of the water resource system in the natural setting. The Strategy stresses integration of both environmental and economic concerns in the solution matrix as a way of introducing the kind of reform needed in conventional water-resource management practices. The Declaration on Conservation of Flora and Fauna also reaffirms nature conservation and rational use of renewable resources as viable approaches to resource management. Effective safeguarding of ecological systems are the hallmark of environmental quality in the interest of present and future generations. In adopting the Declaration, ECE member Governments agreed, inter alia, to render economic activities compatible with the natural functioning of ecosystems.

6. The intention of the present study is to facilitate and expedite that process by promoting throughout the ECE region the application of an ecosystems approach to water management. This endeavour will be launched with an early exchange of practicable national experience. The ECE Seminar on an Ecosystems Approach to Water Management, to be convened in Norway in 1991, will provide an opportunity to consider the ecological basis for water management and the special role of water in the ecosystem (not forgetting the human component). These efforts are expected to help implement the relevant provisions and recommendations of the ECE Regional Strategy and Declaration on Conservation of Flora and Fauna, translating them into tangible action along with the aims of the World Conservation Strategy and the Report of the World Commission on Environment and Development (the "Brundtland Commission").

7. The study is based on a questionnaire circulated among delegations to the Senior Advisers to ECE Governments on Environmental and Water Problems. It also takes into account current literature on the subject published in ECE member countries and subsequent consultations among government rapporteurs. Responses to the questionnaire were received from the following Governments: Austria; Bulgaria; Canada; Denmark; Finland; France; Hungary; Netherlands; Norway; Poland; Switzerland; Turkey; and Union of Soviet Socialist Republics.

II. THE CONCEPT

8. Evaluating the status of an ecosystems approach to water management in ECE countries is admittedly a difficult task. Interpretation, application and promotion of this concept varies widely. Even where some results have been described, there are no specific criteria or formulae, let alone commonly accepted principle for evaluating an ecosystems approach. One immediate problem is the lack of an easy or commonly accepted definition of an "ecosystems approach". The key point to remember is that for the purpose of the present study it is not a scientifically comprehensive definition which is sought but rather one that is practical. The best definition will be one which water planners and managers regard as useful, acceptable and applicable in daily operation.

9. An ecosystem is commonly defined as a spatial unit of Nature in which living organisms and the non-living environment interact adaptively. Ecosystems support life on earth: atmosphere, water, soil and living creatures. Stable ecosystems are sustained by their ability to balance internal energy flows and minimize energy losses from the system. In ecosystems, everything depends on everything else and nothing is really wasted.

10. The major characteristics of an ecosystem are as follows:

- Universe of spatial/temporal existence;
- Integrity;
- Commonality of resource base (in this case separate components of an ecosystem perform as consumers of other components);
- Capacity to evolve;
- Tolerance and adaptability (to a certain extent) to changing environmental conditions.

11. The features of an ecosystem are usually determined by the interaction of its components. An external impact affecting one component of an ecosystem causes reactions among other components and may disturb the equilibrium of the entire ecosystem. The extent of the disturbance (reversible or irreversible) is conditioned by the tolerance of the components. Noteworthy in this context is the fact that virtually each element of an ecosystem is now used by man for economic, social or aesthetic purposes. In terms of their use, each component is to be evaluated as an environmental resource, that is, something that lies readily available for use or which can be drawn upon for aid; a supply of something to take care of a need.

12. Man does not simply use but very often over-uses and abuses environmental resources. This entrains adverse impacts on partial or entire ecosystems. Water is probably the most widely and deeply affected of resources, hence the particular importance attached to water in this connection. It is mainly through actual repercussions on humankind from this misuse that the need for well-informed ecological thinking and action is now rapidly gaining public recognition and support.

13. At present, "environment" is used almost interchangeably with "ecosystem" as if the two words were synonymous. In essence this blurring of distinctions is incorrect. The difference between "environment" and "ecosystem" may be subtle, but is a very important one none the less. It is akin to the difference between "house" and "home". In the former, we see ourselves as outside and separate from the system; in the latter, we are the main actors in the system. Social, economic and environmental interests are all included within "ecosystem" - recognizing that all living organisms are locked into one single life-support system.

14. A succession of increasingly integrative approaches to water management could be characterized as:

- Egocentric (indifferent to environmental values);
- Piecemeal (dealing with problems one by one; issue-oriented);
- Environmental (integrative management in respect of air, water, land and living resources);
- Ecosystemic (involving holistic management of a system).

15. The ecosystems approach implies, among other elements, an integrated set of policies and managerial practices that relate people to "ecosystems" of which they are part - rather than relating them to external resources or to "environments" with which they interact. The identifying characteristics include:

- Synthesis (integrated knowledge);
- Holistic perspective (interrelating systems at different levels of integration); and
- Actions (ecological, anticipatory, etc.).

16. The ecosystems approach is essentially a tool for maintaining sustainable development. The socio-economic importance of water - and its costs and revenue implications in particular - has given this attribute considerably more weight in real decision-making than its ecology-maintaining function.

There is every reason to consider water as a critical "proving ground" for sustainable development - not just in the economy-environment sense, but in a social-aesthetic sense as well. The latter point is especially relevant in societies that place a high emotional and aesthetic value on water in its pristine, natural state - just as other societies put special value on their forests, their garden-like countryside or their mountains. Values are thus an important element in judging sustainable development.

17. An ecosystems approach to water management may also enhance the sustainable use of water and, as a consequence, help satisfy the water demands of present and future generations. Sustainable use of water resources is especially required for agricultural production as well as in industry, energy, transport, recreation and tourism. Availability of water - in sufficient quantity and of acceptable quality - is an essential precondition for human health and welfare; it is vital for maintaining the necessary balance in any ecosystem.

18. No doubt the ecosystems approach could be most easily applied to river and lake systems that are still in their natural or near-natural state, as for instance those in national parks and nature reserves. But the approach is equally valid (and perhaps even more important) in dealing with situations where the existing systems are only "semi-natural" or even man-made. The ecosystems approach could also encourage a nascent movement towards "re-naturalizing" or restoring deteriorated waterbodies and wetlands. It could thus contribute to significant ecological improvements over time. In fact, an ecosystems approach seems essential for developing a "blueprint" for such "retrofit" applications.

III. APPLICATION OF THE ECOSYSTEMS APPROACH TO WATER MANAGEMENT

19. Traditionally, the objectives of water management have been understood to comprise, inter alia:

(a) Regulation and distribution of water resources in time and space;

(b) Supply of water for various uses such as domestic, municipal, industry, agriculture including irrigation, hydro-electric power generation, fisheries, recreation and tourism;

(c) Facilitation of transportation of goods by inland waterways;

(d) Collection and treatment of waste water; and

(e) Flood control.

20. In the domain of water-resources development, recently another water-management function has appeared. It consists of maintaining ecological equilibrium in nature, improving and restoring landscapes, and conservation and rehabilitation of large, natural complexes where water is a component of vital importance. In order to respond adequately to this demand the very objectives need to be examined and water-management systems themselves accordingly re-formulated.

A. Policies and strategies

21. The incorporation of ecosystems considerations - when policies and strategies are being defined with regard to water - should provide for:

- Interdisciplinary decision-making processes regarding the future use of water resources, taking into account both sectoral water demand and ecosystems concerns;
- Solutions to water problems within the compass of ecosystems, which do not necessarily correspond to traditional administrative, hydrographic or political boundaries;
- In planning and impact assessment, introduction of a time-horizon for effects covering a longer time-period than the current economic planning horizon;
- Management of renewable ecosystems resources according to the principle of sustainable yield;
- Creation of favourable conditions for the restoration of ecosystems that have been impoverished by human interventions;
- Protection of the watershed, especially the upper catchment areas, against human interventions having a detrimental effect on the aquatic ecosystem;
- Prevention and control of pollution, primarily at the source;
- Preservation of biological diversity and genetic resources of aquatic ecosystems;
- In transboundary waters, harmonization of methods and approaches;
- Dissemination of information for water managers, land-use planners and administrators along with public education and public participation in water-planning and decision-making;
- Integration of ecosystems' considerations into university curricula.

22. Relevant policies and strategies in response to these concerns should be based on regionally agreed principles as well as on appropriate legislation, guidelines and administrative support; public awareness; information diffusion (observation networks, monitoring, processing, analysis and dissemination of data, mapping systems); scientific and methodological bases for water-resources planning, design, construction and operation, assessment of water management, ecosystems evaluation, forecasting and modelling, standards and reference data.

B. Legislation

23. There are many examples in ECE countries of ecosystem principles being laid down in the form of policy statements and/or as legislation. For instance, the Austrian "Federal Act on Water Law" has recently incorporated criteria of appropriate ecological function of waters under the term "ecological functioning capacity". In Canada, specific reference to protection of ecosystems is made in the Federal Water Policy, adopted in November 1987. In Switzerland, the Netherlands and some countries with centrally planned economies, supplementary amendments to water laws are under elaboration aimed at creating a better basis for an ecosystems approach to water management.

24. The resolve to integrate better the qualitative and quantitative aspects of water, as reflected in current water legislation in most parts of the ECE region, usually is of a rather general character, such as stressing that account should be taken of the natural balance or the functioning of the ecosystem. Principles seldom offer concrete guidance for the planner or decision-maker in specific cases where trade-offs have to be made between ecosystem functioning, on the one hand, and essential short-term economic benefits, on the other.

25. An example of precise guiding principles may be seen in the Netherlands where water management is based on an integrated water system approach. It aims at optimal co-ordination of economic and social needs and the functioning of water systems, based on technical infrastructure and available legal instruments. Ecological functions are considered to be important in the water system. Depending on the importance of this "function" in relation to others such as shipping, water-supply and bathing, the objectives of ecosystem functioning are classified in legislation as basic, intermediate or high level. The basic level is the minimum requirement for all water bodies in the Netherlands. The intermediate level is not quite the natural state; a high level corresponds to the natural state.

C. Institutional arrangements

26. An appropriate adjustment of organizational structure in national water management is important for the promotion of an ecosystems approach. Fragmented structures where different ministries and different regional or local offices manage different sectors makes protection of ecosystems as a whole very difficult. Such a complex setting exacerbates problems of co-ordination; there is competition where some interests try to dominate over others, and there is room for confusion and confrontation.

27. In many ECE countries, responsibility for establishing water policies at the national level is shared among various ministries. In Norway, for example, at least five ministries are responsible for sectors of water management. This fragmentation in turn can mean that ecosystem requirements of other water-management authorities are not known to everybody. Obligations and goals continue to be dominated by sectoral interests only.

28. The organizational structure needed to incorporate an ecosystems' approach into integrated water management could be better promoted through the administration of water use and environmental protection by one ministry or one national water authority. Such an agency would promote common goals and understanding of the implications of the ecosystems approach and could act as a lead agency in this regard. This is the case, for instance, in Hungary where the newly established Ministry for Environment and Water Management has responsibility at the national level for both environment and water policies, or in Bulgaria, where co-ordination and control over water-management activities (including environmental issues) are vested in the State Committee for Environment Protection. In Finland, where different water sectors are administered by different ministries, an intermediate solution has been chosen. The Finnish Ministry of the Environment has overall responsbility for integrating the different types of water use and protection. The central implementation agency is the National Board of Waters and Environment. Not only does this agency manage some sectors, for instance water supply and pollution abatement, but it also serves a co-ordinating and advisory function with regard to sectors beyond its direct authority. In addition, the agency supervises and co-ordinates the activities of the district offices of the regional water and environment authority.

29. Authoriities dealing with promotion of consideration for the ecosystem at present often face the problem of limited jurisdiction or enforcement power. Important sectors of water management, for example hydro-power development are often not included in their area of responsibility. Important decisions, with great impacts on other users of the water resource and on the ecosystem, can be taken without consent of the special river or watercourse authority involved. Water management plans made by these authorities frequently lack enforcement power or legal status.

30. The ecosystems approach to water management could in many ways gain momentum through the channelling of management responsibility to regional and local authorities. The main reason for this assertion is that regional and local authorities are generally empowered with decision-making on land use. In many countries, they are also responsible for development and land-use planning. Land use and activities in the catchment area have an important influence on aquatic ecosystems. Co-ordination of land-use planning with water-management planning is an important tool in furthering the ecosystems approach.

31. An additional advantage of a high degree of local influence over water management is that this allows the knowledge and preferences of interest groups and the local population to bear on planning and decision-making. Local participation is widely considered a prerequisite to a realistic ecosystems approach.

32. The actual structure of the political and administrative bodies and the degree of decentralization of decision power and planning responsibility reflect political traditions in individual countries. It is worth noting, however, in this regard that some countries have organized special regional planning and administrative bodies based on ecosystem units, independent of county or municipal boundaries. The river authorities in France and the water boards in the United Kingdom are examples of this type of "ecosystem based" institution. In Canada, conservation authorities for the province of Ontario also function in this manner.

D. Planning

33. National master plans or strategy plans for the development and protection of water resources are used in the ECE region as a means of co-ordinating the interests of different water uses as well as to protect ecosystems, thus promoting sustained social and economic development. For

instance, in the Netherlands, a national report on water policies is under preparation aimed at achieving an ecologically sound long-term strategy. Focal points for a long-term strategy have been described in the report Living with Water, which sets out ecological objectives.

34. In France there is an inter-ministerial plan for the development of integrated and comprehensive management of rivers. Administrative regulations will be issued to the district authorities on this matter. In Hungary the third water-management master plan ended in 1984; in it the ecosystems approach was reflected in the concept "biological potential of water". The Long-term Programme for Environment Protection and Rational Use of Natural Resources in the USSR for the period up to the Year 2005 contains basic guidelines for ecologically sound water development, along with similar documents elaborated recently in Bulgaria and Poland.

35. There are many examples in the ECE region of particular planning activities based on entire river systems or whole catchment areas. These types of plans allow different uses of water and strategies for the protection of ecosystems to be placed on an equal footing. Conflicts between various uses and impacts of alternative solutions are analysed. There is a systematic search for an optimal solution to the future use of water resources. Examples of this sort of planning are a general master plan for multi-purpose water use and protection being compiled in Bulgaria, a master plan for long-term water use and protection elaborated in Poland and water master plans developed by the regional water authorities in Finland. General and river-basin master plans of multi-purpose water use and protection are compiled in the USSR. These plans are subject to continuous revision and updating. In regard to ecological concerns, master plans deal with the following issues: (a) pollution control of water bodies; (b) conservation of coastal sea water and large lakes; (c) watershed management; (d) environmental impact of water management; and (e) hazardous impact of water and measures for its alleviation.

36. In Canada, river-basin planning has, over the past two decades, included extensive studies on ecosystems components, but no ecological study in its own right has been completed. A move in this direction has been made, however. Particular attention is being paid to alluvial ecosystems in the Mackenzie River Basin, where these systems play a very important and hitherto unappreciated (and therefore neglected) role in the fragile northern ecosystem.

37. In Denmark, where water-resources planning is obligatory, such planning is an integral part of ordinary county and municipal plans. In this setting the same authorities and political bodies are responsible for economic and physical planning and for most water-use activities in a given geographical area. In Norway, the adoption of the new Planning and Building Act in 1986 made water-resources planning an integral part of land-use planning. The objective of the Act among other aims was to integrate land-use and water-use planning into the same planning framework.

38. Ecosystem-focused guidelines for sectoral planning and project appraisal are important for making the ecosystems approach operational in water management. There are many examples of such guidelines, in different sectors of water management and at different planning levels. The Central Water Authority of Denmark, for example, has published detailed guidelines covering planning for drinking-water abstraction and waste-water treatment at the regional and local levels. These guidelines also cover environmental aspects and the interests of other water uses. Most planning- and project-appraisal guidelines, however, cover only a part of the ecosystem. Normally they focus on the exposure of some elements of the ecosystem (e.g. plant and animal species, water quality, etc.) ignoring important but difficult questions of ecosystem functioning as a whole. No country reported the existence of separate comprehensive guidelines for the implementation of an ecosystems approach to water planning and project appraisal.

39. In general, both planning and appraisal for water development are seldom based on a clearly formulated long-term strategy or co-ordination of priorities and needs of other interests or conflicting sectors. Discussion of the future status and the development of the aquatic ecosystem in question is often neglected.

40. There are cases, however, of projects where an ecological outlook has been adopted fairly early, relying mostly on environmental indicators. Thereby ecosystem considerations are taken into account along with the interests of other users of water resources. In Austria and France, for instance, laws and regulations to a certain extent call for co-ordination and arbitration between environmental concerns and socio-economic development. So far, co-ordination mainly covers the authorization process in individual cases; water management planning and co-ordination is expected to be intensified. In the Netherlands, sector plans to some extent aim for a balance between long-term effects on other sectors. Drinking and industrial

water supply takes into account the shortage of ground water in terms of drought effects. In contrast the discharge of cooling water from thermal or nuclear power plants is accepted without looking at environmental effects.

E. Impact assessments

41. Environmental impact assessment (EIA) is an important policy instrument for an ecosystems approach to water management. EIA facilitates early integration of environmental concerns in the decision process. Most EIA systems have information and analysis requirements which imply an ecosystem perspective. Some countries (for instance, Austria, Hungary and the Netherlands) have formal Environmental Impact Assessment (EIA) procedures which cover major water-development projects. Even countries without a formal EIA system have requirements to evaluate impacts of water-development projects, in particular procedures connected with the granting of licences or concessions. This approach is applied, for instance, to hydro-power development projects in Finland, Norway and some other ECE countries.

42. At present most EIAs are done for specific economic development projects. This means that the EIA primarily influences the choice of project alternatives and the need for any mitigation measures. The EIA, in its present form, seldom questions the economic development per se, in relation to long-term goals for the well-being of ecosystems. What is needed, as part of an ecosystems approach, would be an EIA of different economic-development strategies.

43. When analysing the interaction of water management with ecosystem components, it is necessary to determine the effects produced by a particular water-use technology and those caused by water-resource systems and projects. This applies, in particular, to multi-purpose water management systems. Adverse effects of water-related activities on a local and regional scale may include: depletion and pollution of ground and surface water, destruction of landscapes and unique natural systems; water-logging; salinity and alkalinization of soils; inundation of adjacent territories; reduced volume of river flow and changes in hydrological and quality conditions; blocking of fish migration routes by hydraulic works and loss of young fish from water bodies through water-intake structures; changing of habitat conditions and reduction of wildlife habitat areas.

44. As a result of adverse impacts on ecosystems, various problems may occur. These may be important in scale and call for urgent measures to avert or eliminate them. Problem situations may arise by: wrong or imbalanced use of natural resources; resource deficits; shortcomings in production organization; resource-intensive types of production and technology; lack of co-ordination between authorities responsible for natural-resource utilization and those responsible for nature conservation; adverse transformations of the natural environment, among other factors.

45. Most ECE countries have assessed the impacts of different water-development projects on aquatic ecosystems and the environment as a whole. For instance, in the submission of Turkey, an example was cited of effective action taken as a result of EIAs done on two recent water resources projects. Their unmitigated implementation could have led to the drying out of swamps serving as vital habitats for certain bird species during migration.

46. Environmental impact assessment should become an integral part of all water management activities at all stages (planning, design, construction, operation and maintenance). EIA should also be applied on an international scale, in particular with regard to activities with a potential impact on transboundary waters. For this purpose, the methodological base should be improved and standardized. It will also be necessary to set relevant standards, regulations, etc. A regional framework agreement currently under elaboration within ECE on environmental impact assessment in a transboundary context, can serve as a forceful instrument in this regard.

47. Actions taken to rehabilitate degraded ecosystems will help various lakes and rivers. These actions may close the gap between current practice and predetermined ecological goals, e.g. the return of fish species. For example, the envisaged return of salmon in the Rhine River has become the symbol of a general ecological recovery brought about by planned reductions in emissions and removal of obstructions to fish migration routes. Experience with the restoration of eutrophicated lakes is also accumulating. These actions are normally analysed in procedures similar to that used for assessing environmental impacts.

F. Technical and economic measures

48. One of the most important factors in the water-management process is planning. It must become more comprehensive and anticipatory than that achieved heretofore in the conventional pattern. The ecosystems approach to water management should pre-determine the system of optimal composition of

measures and managerial tools. Greater withdrawals of water from water bodies reduce their assimilative capacity. Increased drawdown, therefore, leads to greater vulnerability of aquatic ecosystems in the face of pollution exposure. That is why economic and technical measures should be undertaken aimed at reducing withdrawals from natural water sources. This aspect is covered in relevant provisions contained in the ECE Declaration of Policy on Rational Use of Water. Water-saving measures should be complemented by water-protection measures. These may be:

(a) Preventive, aimed at halting and reducing ecologically negative effects; such measures should span all stages of water management activities;

(b) Distributative, so as to balance anthropogenous loads on water bodies by distributing them over time and space, taking into account the assimilative capacity of various parts of the ecosystem; and

(c) Compensatory, intended to eliminate (mitigate) negative consequences.

49. Economic assessment of relevant measures is especially important. Application of the ecosystem approach makes this problem more complicated at first glance, as the data analysis involves not only direct socio-economic benefits (losses) but also interconnections between ecosystem components as stipulated by allocations of the resources base. Ecosystem-oriented water management may call for the economic assessment of all the components of the ecosystem, in particular water as the resource base for other basin ecosystem components.

50. The following approaches may be used to this end: (a) monetary, (b) non-monetary and (c) alternative "futures" (large-scale scenarios). The question of the value of water, and the pricing of water, as a first step, therefore takes on great importance.

G. Ecosystem evaluation

51. It is necessary to identify an ecosystems spatially distributed and cumulative responses resulting from its component interactions both in ambient conditions and in those induced by water management. Attention should be given to water resources available for use, taking into account the effect of, and requirements imposed by, other components of the ecosystem that are also intended for use. This proposition stems from the general formulation of the problem of provision of co-evolution conditions and constitutes a standard analysis within the framework of the systems approach to water management at all stages (e.g. planning, design, construction, operation). Quantitative and qualitative analysis methods will have to be combined.

52. In order to evaluate the components of a basin ecosystem, it would appear practicable to use, inter alia, the following methods:

(a) Expert method, based on qualitative evaluations;

(b) Balance method, based on evaluation of the natural resources' potential within the basin boundaries; appraising the state of water/natural-resource utilization; evaluation of distribution in time and space of anticipated anthropogenic loads on the ecosystem, and the effect of these loans on the state of its components;

(c) Cartographic method, providing for production of maps describing the state of a river basin ecosystem by its components;

(d) Natural analogy method, applying controls observed in a particular basin to a basin under evaluation; transfer of data to the prototype is made on the basis of selected similar criteria.

(e) Stress evaluation method.

53. Irrespective of the type of project, analysis should incorporate an evaluation of all components of an ecosystem so as to trace a clear line between implicit links and impacts. There are many examples in ECE countries where the pollution situation and pollution development in water ecosystems have been described using carefully selected biological parameters or indicators. For instance, in Canada and the United States of America, biological indicators have been developed to assess water quality in the Great Lakes. Examples include the use of herring gull eggs as an indicator of the presence of toxic pollutants, algal blooms as indicators of accelerated eutrophication, and changes in species composition of aquatic communities as an indicator of habitat deterioration. A work group on indicators of ecosystem quality, established in 1982, has developed specific objectives and criteria for maintaining Lake Superior as a balanced and stable oligotrophic ecosystem. The mesotrophic indicators work group was established in 1986 in order to develop ecosystem parameters for mesotrophic waters of the other Great Lakes where trout (used as the Lake Superior indicator) were unsuitable. This work will be continued for the other lakes in the system. These additional parameters are not designed to replace but rather to complement the existing chemical indicators.

54. Biological assessment of river water pollution in Hungary rests on a saprobic system using the presence of characteristic species of saprobic organisms. A research project is under way in Finland to study the possibility of using bottom fauna as indicators of river-water quality. The

results of this research have not, however, yet been applied on a wider scale. The most commonly used biological parameters for assessing impacts are those depicting bottom fauna, sediment, zooplankton, phytoplankton, periphyton, and aquatic plants.

H. Monitoring

55. Environmental monitoring is one of the most effective tools applied in the ECE region for ecosystems evaluation. Monitoring as a multi-purpose system is widely used in water and environmental management. Monitoring systems are established in the ECE region for resolving specific problem situations. They differ from one another somewhat in scale, objectives, methods and criteria.

56. Impact monitoring is generally used to pinpoint and avert local problems. Surface- and ground-water monitoring systems may serve as a vivid example in this regard. The assessment of water quality is based on such criteria as permissible concentration limits or quality standards, for example.

57. Areal monitoring comprises more sophisticated processes. It may embrace vast areas (for example, entire river basins). In areal monitoring, the variety of individual impacts tends to be muted; conversely, vast specific features of an ecosystem can be scanned. The breadth and scale may make the evaluation process more difficult, especially if the area in question includes several countries, as for instance in the case of transboundary basins.

58. Background monitoring is designed to help assess and predict the state of the environment. Monitoring programmes of this type are subdivided into two separate but interrelated elements: (a) monitoring of background conditions of ecosystem elements, including biotic components; and (b) monitoring of environmental consequences. Background monitoring allows a database to be established and ecosystem parameters (and their components) to be determined. It also helps in defining the flows of pollutants and the paths of their migration in ecosystems.

59. Integrated monitoring programmes are gaining ground as among the most promising for ecosystems' evaluation. Programmes of this type are designed to monitor climatic, atmospheric, aquatic, terrestrial, and biotic variables in the same area. For example, integrated monitoring of small catchment areas has recently started in the Nordic countries. Chemical variables and the movements of elements into and out of the catchment areas, as well as internal dynamics within the catchment area are under study. This includes, for example, throughfall, litter fall, nutritional status of soil and trees, tree

damage, biological variables of lakes and running water. The work is expected to allow for an integrated evaluation more capable of determining cause and effect relations than other less-comprehensive monitoring programmes currently under way.

I. Ecosystems zoning and mapping

60. Zoning may be applied for the purpose of evaluating ecosystem components. Zoning allows for the identification of utterly unfavourable (critical), unfavourable, partially favourable or favourable areas, in terms of ecosystem conditions.

61. It is important that natural and socio-economic conditions of the region be fully taken into consideration in such zoning, from the viewpoint of balancing anthropogenic influences with ecosystem stability. Equilibrium could be assured by creating particular "natural frames" (structures) comprising vital ecosystem components. Such a natural frame should include the following elements:

(a) Areal elements (national parks, preserves and other nature conservation areas);

(b) Linear elements, supporting the integrity of the ecosystem, i.e. rivers and their flood plains, watersheds (especially watershed forests), boundary sections of biotopes, green corridors of transport and technical infrastructure, protective forest belts (land-protection belts, forest strips along rivers and water bodies, trees planted along railways and highways, etc.), special bio-technical corridors, etc.;

(c) Point elements, i.e. green urban zones, upper marshes, cultural monuments with adjacent protection zones, etc.

62. Zoning of ecosystems should be closely integrated into water-management zoning and be based on a system of ecological mapping. Ecological maps reflect the conditions of all basin ecosystem components. Ecological conditions are most completely reflected in landscape or landscape-indication maps. Use of remote sensing and space imagery in mapping is a promising tool in this regard. Integrated ecological cartography acquires special significance when enlarged to encompass transboundary water issues.

63. Maps outlining water-quality situations as well as existing and potential uses of basin ecosystems are being developed in many ECE countries. In Austria, Bulgaria, France, Hungary, Netherlands, Poland, Switzerland, USSR and some other countries, water-resource classification systems are used on a regular basis in order to map the current water-quality situation. Such maps

are revised regularly. Maps showing current and/or potential water use are less frequently produced on a regular basis. These maps are often produced on an ad hoc basis as needed for specific sectoral and regional planning activities.

64. For instance, at five-year intervals, a map covering all of Finland is made illustrating the qualitative usability of water bodies in five categories. In future, regional maps will also be published illustrating the suitability of water bodies for water supply and recreational use. A national map on the scale of 1:1,000,000 has been published on water resources. It also contains information on water use showing, for instance, discharge sites of industrial effluents, hydroelectric power plants, fresh water sources for water supply and aquifers.

65. In the USSR, water maps have been developed for hydrological and hydrogeological purposes. They are used for the preparation of the State water cadastre which incorporates elements on water use. In this part, water mapping is applied to water-management (water-use) subregionalization of river basins. The scale of maps ranges from 1:100,000 up to 1:1,000,000.

J. Water classification

66. An ecologically founded system to classify water quality and water use is important for the ecosystems approach. It can be of help in communicating information and evaluating water problems as well as possibilities of water use. Numerous systems of water classification abound in the ECE region. Most of them rely on chemical and physical parameters. There is a trend, however, to put more emphasis on biological parameters. Various plant and animal species (for example, freshwater fish and aquatic plants) as well as other ecological indicators figure in such water-quality classification systems.

67. Development is under way in Austria of new methods for an ecologically based classification system that takes into account the ecological functioning capacity of watercourses. One ecological indicator which might be used in this context is the ecological variation range, reflecting the degree of variety in terms of morphology of flora and fauna of the riverbed and its embankment zones.

68. In the USSR, according to biological indices (saprobity index, biota index, bacteria population index, etc.), one of six distinctive classes of water quality could be relevant to a water body in question. In addition, standard criteria for water quality, elaborated within CMEA in 1982, are

widely applied in the USSR. The criteria and classification of surface-water quality are subdivided by flowing and stagnant water bodies. Two types of classification have been proposed: water quality with an ecological component and water quality for use.

K. Ecological forecasting, simulations and modelling

69. At present, water-management activities often take into account only the closest direct consequences. However, alterations in ecosystems usually do not occur suddenly but undergo a long-term evolution. In this context, ecological forecasting should be viewed as an elementary part of water-management activities at each stage.

70. Integrated ecological forecasting should precede implementation of water project design and planning studies, and should serve as a basis for identifying acceptable use of a given ecosystem. As its integrity is one of the main features of an ecosystem, it may be asserted that any forecast which ignores a single ecosystem component would not present a complete picture. Ecological forecasting must be based on regular, systematic and highly reliable observation data of basin ecosystem components.

71. The use of ecological models is becoming an important tool in water management and decision-making. Complex ecological models are used in research and in more profound studies. In daily management and decision-making, however, there is a need for simple overview models which capture the essence of complex systems. The models should be easy to operate and require very little input data.

72. In the ECE countries, hydrological models are well-developed and have a long tradition of application in water management. Nevertheless, in order to apply an ecosystems approach, water-quality and biological aspects should be combined with hydrological models. Such models have been developed in a research setting; there are few examples of the use of complex models in daily water-management and decision-making activities.

73. Some simulation models describing water-management systems include, in addition to water parameters, anthropogenic factors and ecosystem components. The simulation of processes defining the conditions of habitats and living organisms in aquatic ecosystems, including hydrophysical, hydrochemical and hydrobiological factors, has recently gained wide recognition in the ECE region.

74. In Finland, for example, rather advanced models are used in practice. Ecological models have been used primarily in the planning of water protection projects. Two sophisticated models have been developed recently in Finland. FINNECO, a simulation model developed in the United States of America for lakes and reservoirs, was adapted to Finnish conditions and then applied. Another model is the two- and three-dimensional VENLA model that takes into consideration flows in a watercourse. VENLA can be used to forecast regional concentrations of different water-quality parameters at different periods of time. The model also contains parameters describing the degree of eutrophication.

75. In the USSR, the following mathematical models are used in water ecology and forecasting studies:

- Models of hydrodynamics and thermodynamics as well as those of water bodies, as a hydrophysical basis for studying ecological phenomena;
- Models of water salt content in reservoirs and those of secondary pollution from bottom sediment;
- Models, describing hydrophysical processes, dynamics of bacteria, phytoplankton and zooplankton, biogenic substances, organic matter and metals;
- Balance models of water exchange for the assessment of "genetic" composition of water in water bodies and reservoirs;
- Water balance models reflecting water quality; and
- Models of biogenic and organic matter balance.

L. Research and development

76. ECE Governments are aware of the need to broaden existing knowledge and understanding of the complex relationships between human activity and environmental quality. Environmental research and development are considered to be indispensable as a basis for the formulation and implementation of viable environmental policies and strategies. Research and development are intended to contribute to the improvement of an ecosystems approach by broadening the latitude for protection measures and creating scientific substantiation for sound environmental and water policies. This R & D work is expected to clarify the close interlinkages of ecological factors, as well as establish cause-and-effect relationships.

77. Sound ecological management of water resources requires adequate ecological information and tools for analysing the effects of measures and actions. Scientific data and methods have an important place - not for their

own sake, but for their potential to improve decision-making. The objective is not to get bogged down in matters of science or technique but to keep the actual goals clearly in view.

78. The stage of development of a particular aquatic ecosystem has to be considered as well. The scope for a full-fledged application of an ecosystems approach is obviously much greater in a relatively pristine system than in one that is heavily developed or substantially man-made. However, for the former, obtaining the necessary data and resources for study and research may often be more difficult, because the area may be remote or not seem to warrant urgent attention such as that focused on more crisis-ridden areas. A full application of the wide range of uses and their context will enable all ECE member countries to benefit from comparisons of their experiences with this approach and to support each other in their common endeavours.

79. The long-term Canada-USA programme to clean up the Great Lakes is an interesting example of a specific pollution control programme ("Protection of the Waters of the Great Lakes"). Started in 1972, it had evolved by 1978 into a programme calling for restoring and maintaining "the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem". This particular programme can offer considerable practical insight into what can be accomplished in a decade or so using the ecosystems approach and how this issue has been dealt with scientifically.

M. Public participation and education

80. The ecosystems approach represents both a challenge and an opportunity. On the one hand, it requires a new level of awareness on the part of the whole population, and therefore represents a significant challenge for environmental education and information. On the other hand, the ecology perspective is also a focus for many types of environment-development issues and attention paid to it can contribute greatly to clarifying such concerns - if one succeeds in the difficult process of simplifying and expressing them in terms easily understood by everyone.

81. In fact, the "translation" of ever more complex relationships into policies and decisions understood by the public might well be impossible without the ecology frame of reference. Public (and therefore policy) debate absolutely requires "manageable" facts and, to the extent possible, clear cause-effect relationships. This is of course also true in professional circles, where there is growing uncertainty about the real meaning of large

masses of data or certain highly refined measurements of infinitesimally small concentrations. The ecosystems approach probably presents a safeguard against dangerous over-simplification, since it does not permit a problem to be simply "explained away".

82. It is to be noted that a state of equilibrium between economic activity and the pressure on the environment in general and on water in particular will only be reached with the full comprehension and the active participation of all interested actors, including consumers. This equilibrium should reflect a broad consensus in order to avoid, inter alia, any type of distortion in economic competitivity.

83. Education in ecological and ecosystems' thinking as well as citizen participation in environmental affairs are crucial for the development of an ecosystems approach. Without active participation by the general public and shared knowledge of the policy needed, efforts to apply an ecosystems approach will flounder.

84. Public participation in planning and decision-making processes is important both for collecting information on people's views and priorities, and for engaging the local population effectively in water-related environmental activities. The degree of public participation, and where and when the public can participate, varies among ECE countries. The general trend is that the growth of citizen participation in environmental matters has paralleled the growth in environmental awareness over the past few years. Active citizen participation in the decision-making process with regard to environmental protection measures is becoming a general procedure. Today, it is established practice in most government agencies. More public officials are now formally participating in citizens groups, some as members of these organizations.

85. In many cases, citizen participation is now set in specific acts of legislation. For instance, most environmental impact assessment statutes in ECE countries establish regulations or procedures on ways in which interested individuals and organizations can participate or articulate their views with regard to major water projects. EIA legislation in the Netherlands, for example, prescribes obligatory public consultation. Ecosystems considerations are of major importance in the public's view, so they are taken carefully into account. In Hungary, discussion of EIA studies for important water projects can be initiated by non-governmental organizations involving public participation. In Bulgaria, public committees for environment protection and

restoration, established on national, regional and local levels, actively influence decision-making in water-related activities. In Canada and the United States of America, the Great Lakes Basin project has contributed to the growth of public awareness of water issues, and led to the public organizing itself in highly effective ways on both sides of the border as well as across the border.

86. More and more people are becoming members of one or more of the growing number of voluntary organizations concerned with a widening range of environmental issues ranging from the "built environment" to the conservation of wildlife and their habitats and the combating of environmental pollution. There are, however, few voluntary organizations or competent interest groups with a focus aimed at protecting and improving water ecosystems as such. Here again there is a need for broadening the scope of public awareness and systems-oriented thinking.

87. Ultimately, public acceptance of an ecosystems approach to water management requires that both the authorities and the general public know how an ecosystem functions as well as its reactions to stress and change. Many ECE member countries have had particular success in developing teaching materials and other aids for environmental education as well as in incorporating environmental subjects into curricula. In teacher training, environmental education has matured in recent years. At present, in many ECE member countries all students in this field are being informed about ecology and environmental protection issues.

88. Across the ECE region, lessons in environmental problems have become part of public education and in some countries this subject is even mandatory in primary and secondary schools. The advantage of this broad appeal is that it places emphasis on the interrelationship between nature and society, which is the all-important perspective for an ecosystems approach.

89. Non-institutional, informal education is of equal significance in this respect. It is carried out through lectures, seminars, symposia, scientific conferences, the press and regular specialized radio and television programmes. Voluntary organizations also play an active role throughout the region in informal environmental education, particularly through adult education programmes. For example, in Finland, the system of adult education promoting environmental affairs consists of about 350 institutes and a great number of study groups and leisure-time associations.

90. A good variety of public information on environmental and ecological topics is produced in Canada by both authorities and non-governmental groups. It includes wide dissemination of printed and audio-visual materials. The federal Department of the Environment in Canada has a substantial publication programme of its own, but it also co-operates with Canadian provincial governments and the United States Federal Government in joint efforts. For example, the description of the ecosystems approach in the early drafts of this report was adapted from and frequently quotes a lavishly produced Canada-United States "Great Lakes Environmental Atlas and Resource Book".

IV. CONCLUSIONS

91. At present, the need for an ecosystems approach to water management is recognized all over the ECE region. This fact alone is encouraging and worth recording. Given the wide interpretation of what could be meant by the concept, it is not surprising that the words are sometimes used in contexts that are still quite limited and not "systemic". Conversely, there are also cases where no claims are made to a comprehensive ecosystems approach and yet the approach may be quite far advanced towards taking into account entire ecosystems.

92. The ecosystems approach does not depend on any one programme or course of action. Rather the approach assumes a more comprehensive and interdisciplinary attitude. Certain basic characteristics, however, mark this approach. First, it takes a broad, systemic view of the interaction among physical, chemical and biological components in a river basin or other ecological unit. The interdependence of life in water bodies and the chemical/physical characteristics of water are reflected in the biological indicators used to monitor water quality and changes in ecosystems. Secondly, the ecosystems approach is geographically comprehensive. It covers the entire system comprising land, air, water and wildlife. New emphasis on the importance of atmospheric inputs of pollutants and the effects of land use on water quality are evidence of the broad scope of management and planning required in an ecosystems approach.

93. Finally, the ecosystems approach includes humans as a central factor in the well-being of the system. This implies recognition of social, economic, technical and political variables that affect the ways in which human beings use nature. All these elements must be considered in an ecosystems approach because of their ultimate effect on the integrity of the ecosystem.

94. To sum up, the ecosystems approach is a departure from the earlier focus on localized pollution, neglect of ecosystems or, at best, management of separate components of the ecosystem in isolation, not to mention planning which often ignores the profound influences of land use on water quality. The ecosystem forms a framework for decision-making that compels managers and planners to co-operate in devising integrated strategies for research and action so as to restore and protect the integrity of water for the future. Anticipation and prevention are fundamental to the concept. For all its complexity, the ecosystems approach represents an effective manner of water-resource problem-solving, planning and management.
