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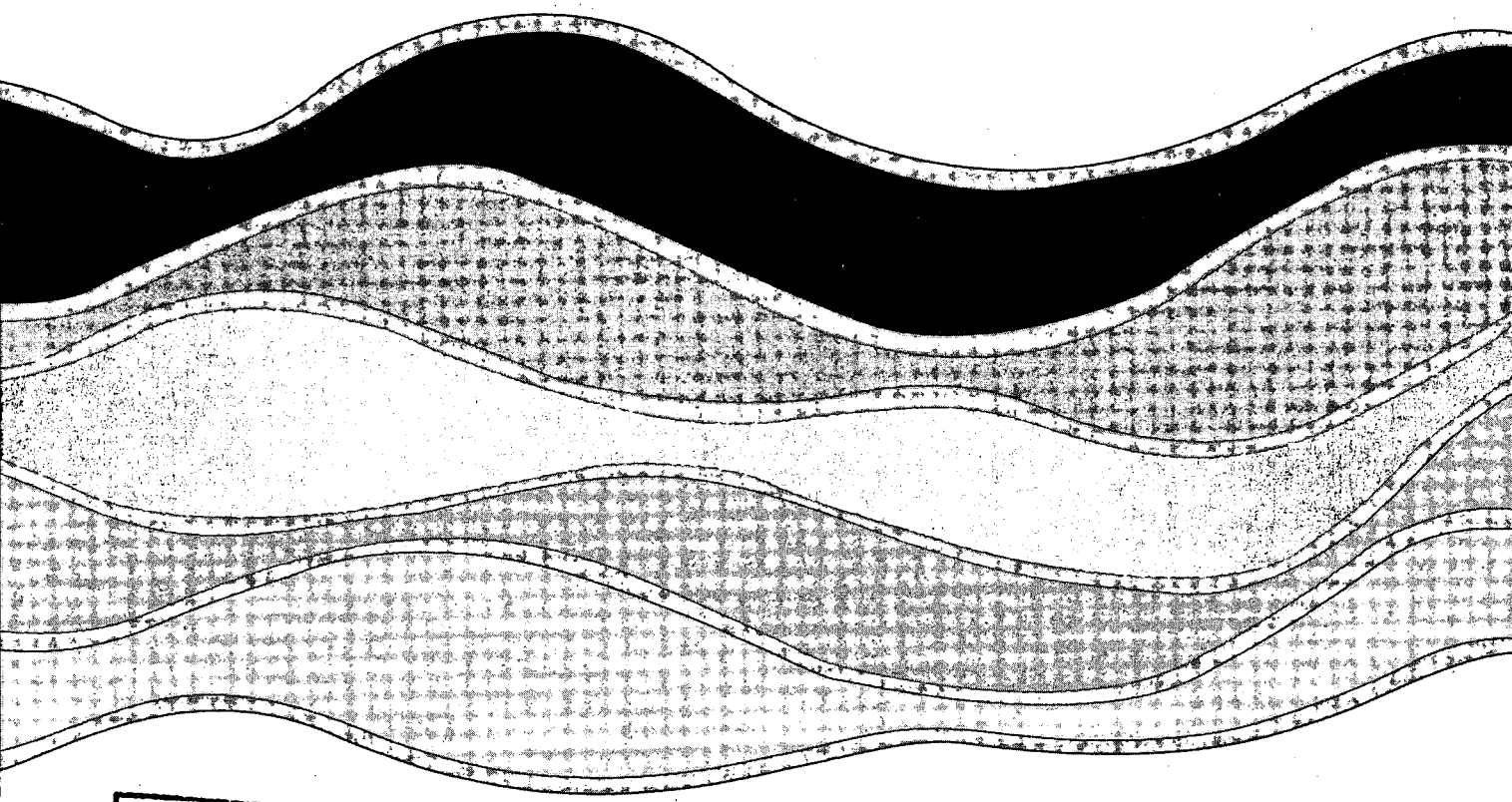

ECOSYSTEM APPROACH TO WATER MANAGEMENT IN URBAN AREAS: GOALS AND SELECTED CASE STUDIES FROM DEVELOPING COUNTRIES

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NWRI CONTRIBUTION NO. 94-89

MANAGEMENT PERSPECTIVE

The ecosystem approach to water management has been adopted by industrialized countries as a preferred approach to the management of water resources. In this connection, it is of interest to examine the water management approaches currently used in developing countries. For this purpose, case studies presented at a recent UNESCO workshop on this subject were examined. As demonstrated in some of these studies, the ecosystem approach may be the only feasible and affordable alternative in specific conditions of developing countries.

SOMMAIRE À L'INTENTION DE LA DIRECTION

Les pays industrialisés ont adopté l'approche écosystémique pour gérer leurs ressources hydriques. À ce sujet, il est intéressant d'examiner les approches de gestion de l'eau qu'utilisent les pays en développement. À cette fin, on a examiné des études de cas présentées lors d'un atelier de l'UNESCO qui a eu lieu récemment. Comme le démontrent certaines études, l'approche écosystémique pourrait être la seule solution de rechange applicable et abordable dans certaines conditions des pays en développement.

ABSTRACT

Increasing competition for water resources calls for fundamental changes in water management. Among the various management approaches, the ecosystem approach, attributing equal importance to social, economic and environmental interests in managing human uses of natural resources, is preferred. Goals and objectives of this approach are presented for specific conditions of urban areas. Finally, the use of the ecosystem approach and sustainability principles in developing countries is examined for five case studies presented at a recent UNESCO workshop. Even though comprehensive applications of this approach are still uncommon, these case studies indicate a clear trend towards adopting the features of the ecosystem approach and sustainability principles in developing countries.

RÉSUMÉ

La concurrence de plus en plus grande en matière de ressources hydriques exige des changements majeurs dans le mode de gestion de ces ressources. Parmi les différentes approches de gestion, on privilégie l'approche écosystémique, qui tient compte également des intérêts sociaux, économiques et environnementaux lors de la gestion des utilisations humaines des ressources naturelles. Les buts et objectifs de cette approche sont présentés pour des zones urbaines particulières. Enfin, on examine le recours à l'approche écosystémique et aux principes de durabilité dans les pays en développement à l'aide de cinq études de cas présentées récemment dans un atelier organisé par l'UNESCO. Même si les applications globales de cette approche ne sont pas encore courantes, ces études de cas indiquent clairement une tendance dans les pays en développement à opter pour les caractéristiques de l'approche écosystémique et les principes de durabilité.

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BACKGROUND

As part of the UNESCO International Hydrological Programme (IHP), a project on Integrated Water Resources Management in Urban and Surrounding Areas has been initiated by the National Committee of the Federal Republic of Germany (FRG) for the IHP and the Operational Hydrology Programme of WMO, and the National Committee of the Netherlands for the IHP. In this project, a draft report on the project theme has been prepared, and further discussed and supplemented by some case studies presented at the International Workshop on the same topic, chaired by Prof.Dr.-Ing.W.F. Geiger of the University of Essen, FRG, and held in Gelsenkirchen, FRG, from May 29 to June 2, 1994. In the following, the goals of integrated water management in urban areas are briefly discussed and this discussion is supplemented by descriptions of several case studies which were presented at the Gelsenkirchen Workshop.

INTRODUCTION

As urban water resources become depleted or overexploited and their quality deteriorates, the need for their comprehensive management increases (Marsalek, 1990). Without such management, further development of the society is impeded and its general well-being is threatened. Although various forms of single or multipurpose water management have been practised in many areas, a comprehensive approach to water management, referred to as the integrated or ecosystem-based water management, is still relatively uncommon. In the ecosystem approach to water management, the social, economic and environmental interests are equally important in managing human uses of natural resources (Lindh, 1986). The fundamental qualities of the ecosystem approach are its holistic nature, which recognizes the system complexity and interconnectivity of its elements, demonstrated by exchange of information, energy and matter, and the style of planning actions. Other characteristics of the ecosystem approach include focus on integrated knowledge; a perspective that relates systems at various levels of integration; and, actions that are ecological (taking into account integrated knowledge and perspective), anticipatory (preventing outcomes that would be detrimental; Tjallingii, 1990) and ethical (showing respect for other natural systems; Christie et al., 1986).

GOALS AND OBJECTIVES OF INTEGRATED WATER MANAGEMENT

The general goal of integrated water management, expressed in a wider context of resource management, can be stated as sustainable utilization of water resources respecting the social, economic and environmental interests. Considering the close interrelationship between the society and economy, the first two groups are usually aggregated into socio-economic goals, and should be defined according to the level of economic development and the social structure. Socio-economic goals express the needs and goals of various interest groups in urban areas. Usually these goals are highly interrelated and partly contradictory, or competitive. In defining socio-economic goals one has to consider the complexity of the system, including the cultural, geographical, economic and political conditions.

Environmental and Ecological Goals

In general, environmental protection goals could be listed as follows (UNESCO, 1994):

- Stop pollution at the source
- Prevent accumulation of non-degradable toxic substances
- Practice reuse of water and other materials
- Prevent transport of contaminants
- Prevent exhaustion of natural resources
- Sustain or enhance the existing surface and ground water uses
- Manage energy use
- Develop and use non-polluting energy sources
- Minimize land desertification
- Prevent water-related diseases (malaria, typhoid fever)

Most of the above goals relate to achieving the sustainable resource management and managing cycles of various types of matter or materials (Niemczynowicz, 1993).

The most important ecological goal is the protection, maintenance and enhancement of ecological integrity. The ecosystem characteristics that are critical for system maintenance have been defined by Herricks and Schaeffer (1987) and are listed in Table 1. These characteristics can be used as a basis for identification of critical ecosystem integrity attributes, which include elemental dynamics, energy dynamics (physical), food web (trophic dynamics), biodiversity, critical species, genetic diversity, dispersal and migration, natural disturbance, and ecosystem development (successional processes; NRC, 1981).

Table 1. Factors necessary to maintain a healthy, self-sustaining ecosystem (UNESCO, 1994)

1.	Habitat for desired diversity and reproduction of organisms.
2.	Phenotypic and genotypic diversity among the organisms.
3.	A robust food chain supporting the desired biota.
4.	An adequate nutrient pool for desired organisms.
5.	Adequate nutrient cycling to perpetuate the ecosystem.
6.	Adequate energy flux for maintaining the trophic structure.
7.	Feedback mechanisms for damping undesirable oscillations.
8.	The capacity to temper toxic effects, including the capacity to decompose, transfer, chelate or bind anthropogenic inputs to a degree that they are no longer toxic within the system.

Water Management Objectives in Urban Areas

Technical objectives are developed for a given water body, or better a river basin, by a stakeholder group broadly representing social, economic and environmental interests within the affected area. This group also includes members (ecologists in general) representing the "interests" of the living organism in the ecosystem. Stakeholders define criteria for evaluating the fulfilment of objectives and set up priorities and time schedules. In urban areas, this process has special characteristics arising from high population demands on water resources, high fluxes of matter and energy resulting in environmental impacts on the surrounding and remote areas, and limited space for implementation of problem solutions.

The objectives of water management are often expressed in terms of unimpeded or enhanced water uses. In the context of urban water resources, the most pertinent water uses include water supply (safe, reliable and equitable), drainage and flood protection (affordable), sanitation with maximum reuse, recreation (protecting public health), aesthetic and cultural values, and ecosystem health. In typical situations, water management plans combine many of these objectives, and strive to provide protection of receiving waters by minimizing environmental impacts. It should be also emphasized that the above objectives do not receive the same priorities in various societies at different stages of development (Niemczynowicz, 1994).

Safe, reliable and equitable water supply is one of the most important objectives of urban water management. In providing such supply, it is important to recognize the demands of various sectors and the need to take a conservation approach by managing such demands. Solutions, involving water import from distant areas are no longer acceptable, because of great environmental costs incurred in the area of water harvesting and along the transport route. Similarly, processes involving high energy consumption, such as desalination operated with energy from thermal plants, should be avoided because of adverse environmental impacts. Thus, in the ecosystemic approach, it is important to manage demands, use local water resources, reuse water, and allocate equitably water supplies withdrawn with low energy consumption.

The protection of population and material property against harmful effects of water comprises a number of specific objectives - prevention of human life losses during flooding, prevention of damages of material property by flooding or ground water inundation and/or wave forces, and prevention of disruption of economic activities and accompanying losses by inundation (both on the surface and underground). In urban areas, the concentrations of population, properties and economic business activities are particulary high and the potential losses caused by flooding or inundation are extremely high. Consequently, the objectives of protection against harmful water effects, and particulary against the loss of human life, receive the highest priority.

Sanitation and protection of surface water quality are very important objectives not only from the point of view of environmental protection, but also from the public health point of view. In selection of control measures, emphasis must be placed on appropriate technologies matching the local conditions in terms of local climate, resources (funds and human skills), and cultural traditions. It is of interest to note that various biotechnological measures, used for many centuries by indigenous people, may represent low cost, low energy demand solutions providing local employment and a very effective environmental protection.

Water based recreation is widely practised in industrial and post-industrial societies. To protect public health, various guidelines for quality of recreational waters have been promulgated and particularly important are those for microbiological water quality, typically based on permissible concentrations of indicator bacteria (e.g. faecal coliform, or Escherichia coli), implying faecal pollution and the presence of pathogens.

Aesthetic and cultural values of water can be effectively incorporated into the modern urban design. Specific features include open discharge of rainwater, runoff conveyance in cascading open channels, treatment in ornamental ponds, and recharge of ground water aquifers by surface water of relatively good quality. Incorporation of water into the urban design brings about economic benefits in the form of higher property values and general attractiveness for modern industries, particularly when dealing with redevelopment of environmentally damaged ares. Successful designs require an early incorporation of water aspects into the planning process, retaining a multi-disciplinary team in planning, and well organized public information/ involvement programs.

It should be noted that there are opportunities to include ecological objectives in practically all projects dealing with urban water. One example is the rehabilitation of sewer systems - rehabilitation programs offer excellent opportunities to incorporate ecological objectives into the older system, which were generally built during an era of environmental neglect and abuse.

CASE STUDIES

Calcutta Wetlands. In the environs of the City of Calcutta, indigenous traditional practice, involving discharge of sewage into fish ponds and wetlands, is used to treat wastewater from the city. The objectives of this operation include (1) Preservation of natural processes of wastewater

purification and resource recovery, (2) Recovery of the optimum amount of energy, material and nutrients through pragmatic and appropriate choice of technology and reuse, and (3) Protect the living conditions, employment and entrepreneurial interests of local people. Resource recovery, through agriculture and fishery, brings cash income and is important for sustaining these systems. While no health problems are recognized at this time, a further assessment of health risks is recommended. To protect these wetlands, it is required to regulate land use within this conservation area, control development, and prevent land fills. Institutional measures are important - Calcutta wetlands were declared as a wetland area of national importance and a Conservation Authority should be established. This is probably the first case of preserving wetlands as an urban treatment facility (Ghosh, 1994).

Integrated Water Management in Yogyakarta City. The Yogyakarta City is a capital city of about 600,000 inhabitants covering an area of about 90 km ^{2}. Further rapid growth is expected in this decade. To keep this area supplied with potable water and to increase the number of households supplied with piped water is a major challenge. Besides the urban population, intensive agriculture (rice paddies), practised in the surrounding area, places also heavy demands on water supply. To resolve these problems, an integrated system approach is taken and is based on a system of models dealing with water supply for the whole area, considering demands of urban and rural population and agriculture, and various water resources - surface as well as ground waters. It will be required to establish a basin agency which would resolve conflicts caused by land use and other resources development. Since agriculture is the largest user, conservation of water should be practised by increasing irrigation efficiency and switching to crops demanding less water. A new system of water use rights and institutions enforcing these rights will be established. Such institutions should allow further municipal and industrial development and sustained agriculture (Susanto, 1994).

Comprehensive Planning of Water Resources Utilization and Protection in Changli County, China). Changli county is an agricultural county with poor industrial base. To improve this status, a proposal has been made to develop tourist industry in this county. While this should bring prosperity to the county, it will also increase stress on the environment and a good pollution prevention plan is needed. Such a plan has been proposed and is based on the following principles: (1) Reuse of marginally polluted water for agricultural irrigation, fishery, improved landscaping, and afforestation, (2) Optimization of sewage treatment by introducing new technology, (3) Search for sewage reuse opportunities, and (4) Staged implementation. Specific proposed measures include reduction in sewage production by reuse of process waters, conservation of water by improved industrial technology, sewage treatment by on-land disposal, building a system of oxidation ponds to improve riverine water quality, and enhancing river self-purification capacity. To achieve sustainability, industry will be regulated, by focusing on non-polluting industries and compensating for loss of income by developing the tourist industry. A sustainable rate of development will be established (Tianwen and Haisheng, 1994).

Use of Madras Temple Tanks for Integrated Water Use. Temple tanks in the City of Madras have been traditionally used for bathing, washing cloth, and religious and social rites (e.g. festivals), and performed water management functions, such as storing water for periods of low

rainfall, recharging the surrounding aquifer, and serving for flood protection. Progressing urbanization often disrupts the operation of these tanks - by clogging inlets, overutilization of groundwater, and reducing aquifer recharge by increasing the area imperviousness. In recent years, some of these tanks became dry and remedial measures are needed. It was noted that the Mylapore tank, after removal of bottom silt, would not hold water and would require a bottom liner made of one of the three materials - concrete, clay, or alluvial soil. The clay floor was found too impervious for aquifer recharge; an alluvial soil would provide better solution in terms of water percolation and its quality. It is apparent that temple tanks fulfil a number of useful functions, by integrating traditional functions, including rain harvesting, aesthetical enjoyment and limited-exposure use by the public, and all temple tanks should be brought into fully operational conditions (Ganesan et al., 1994).

Holistic View of Madras Urban Water System Prospects for 2000 AD. A comprehensive program for mitigating water shortages in the City of Madras has been proposed. Additional water will be brought from a neighbouring state and a remote lake, storage in river reservoirs will be increased, and six well fields will be developed. A newly started program addresses the treatment and reuse of industrial sewage, and restrictions on industrial water use in times of crisis. However, even these measures cannot cope with the projected demands of growing population and industry. Hence the solution lies not only in developing new major water supplies, but also renovating and restoring small reservoirs (including temple tanks), nearby lakes, and promoting rain harvesting from roofs of all new houses and apartment buildings. The quality of piped water should be improved and the quality of well water could be improved by controlling disposal of solid waste in streets. Concerted measures sensitizing the elected officials, managers and public are needed to find solutions and resolve these problems (Somasundaram and Pundarikanthan, 1994).

CONCLUSIONS

While the advantages of an ecosystem approach to water management in urban areas are generally recognized and accepted, the number of planning applications or implemented projects is still rather small. It is hoped that some improvement will be brought about by the UNESCO project on Integrated Water Resources Management in Urban and Surrounding Areas. This project will produce (in early 1995) a manual for such management. The case studies presented at an adjunct UNESCO workshop and highlighted in this paper showed a tendency toward a comprehensive water management respecting social, economic and environmental interests.

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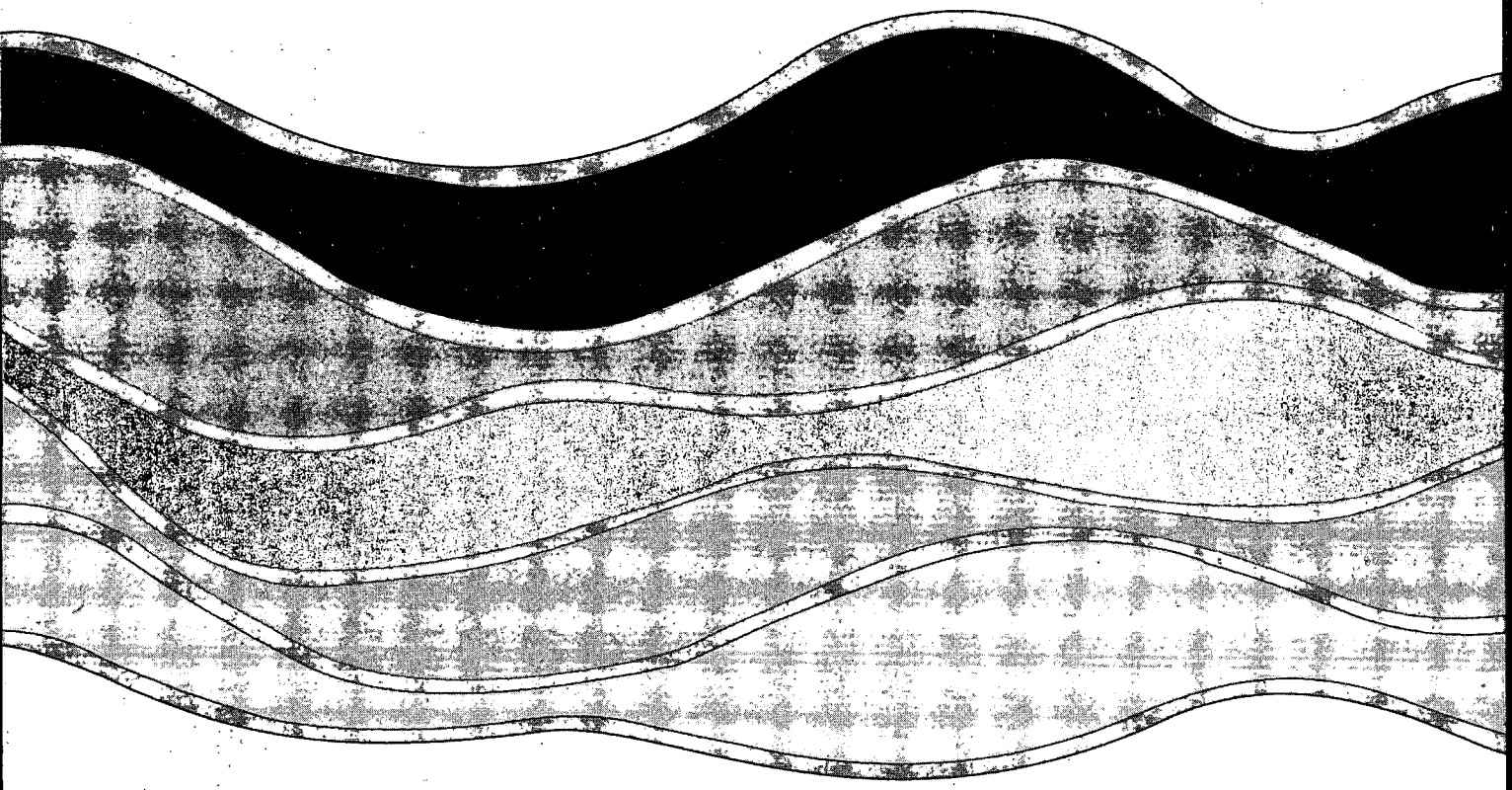

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