Guidelines for development and management of groundwater resources in arid and semi-arid regions

A. General:

1. vital and irreplaceable resource;
2. water scarcity in arid and semi-arid regions;
3. population.

B. Supply management:

1. non-renewable (fossil) water management;
2. water conservation and artificial recharge;
3. conjunctive use of groundwater and surface water;
4. reuse of treated wastewater;
5. rational use of available water resources.

C. Demand management:

1. integration of supply and demand;
2. efficiency of water use in all sectors;
3. water pricing;
4. implementation of legal instruments.

D. Methods of analysis:

1. data management and monitoring;
2. use of appropriate models;
3. application of available investigation techniques;
4. elaboration of positive as well as negative environmental impacts;
5. economic costs and benefits.

E. Planning process:

1. planning as a continuous process;
2. incorporation of environmental and other natural resource issues from the beginning;
3. integration of disciplines;
4. sectoral coordination;
5. involvement of users at an early stage;
6. presentation of the plans.

F. Specific issues:

1. international cooperation;
2. human resources development;
3. management of wetlands.

G. Future cooperation:

1. continuation of international exchange of experiences within the region.

A. General

1. Vital and irreplaceable resource

Water is a vital and irreplaceable resource for further socio-economic development of arid and semi-arid countries. For most of these countries, availability of water and fertile land is the main constraint to development. Unlike different forms of energy and raw materials, which could be substituted for one another, there is no substitute for water. Availability of an adequate quantity of water of appropriate quality is thus an essential prerequisite for future development.

2. Water scarcity in arid and semi-arid regions

Water resources are a scarce commodity in (semi-) arid regions. In the past it was believed that the resource groundwater is usually available even in arid regions, and that plans should make it available to the user at the right time, in the right place and of the proper quantity and quality. In recent years awareness has risen of the scarcity phenomena and hence the limited groundwater resources should be the starting point to develop inventive solutions for justified exploitation.

3. Population

In the (semi-)arid regions of the Middle East and Africa the population growth rate is 2−4% per year. With an increasing per capita water demand due to increasing affluence, the total water requirements of these countries are expected to increase rapidly. These factors need to be carefully considered during preparation of future groundwater management plans.

The ever-increasing demands may constitute a severe threat for over-exploitation of our existing

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fresh groundwater reserves and through that for the deterioration of our natural environment.

B. Supply management

1. Non-renewable groundwater management

Non-renewable (fossil) groundwater reserves in major aquifer systems constitute the most important fresh water reserves in arid regions. In many cases those major aquifers extend across the borders of two or more countries and hence development and exploitation of those aquifers require bilateral consultations.

Exploitation of reserves without any or with a very low recharge refers to *mining* and can only be continued for a limited time period. Nevertheless for some countries groundwater mining could be a feasible solution to solve the urgent problems created by water scarcity, provided appropriate social, economic and environmental conditions are carefully considered during the planning process. If groundwater is to be used for agriculture, emphasis should be put on small-scale development rather than on large-scale projects. It is recommended to pay great attention to management of mining in the coming years.

2. Water conservation and artificial recharge

Countries with limited water resources cannot afford to lose or abuse their resources. Therefore, control measures should be taken to conserve water resources in arid regions. Such measures essentially include rationalization of water use, minimizing losses, quality protection, and improving the potentiality of aquifer systems through natural and artificial recharge and water harvesting techniques.

Extension services and public awareness are needed to achieve successful application of such measures.

3. Conjunctive use of groundwater and surface water

Rational use of scarce water resources could be accomplished through the conjunctive use of groundwater and other available sources (surface water, treated wastewater or water imported from other areas).

Conjunctive use can be achieved in various ways, based on local and regional hydrogeological conditions, soils and crops. Groundwater could either be evenly pumped into the system or supply part of the system totally. Groundwater pumpages could also be achieved on the basis of inter-annual or intra-annual regulation.

4. Reuse of treated wastewater

Wastewater generally forms a burden on the community. Its disposal and transfer to remote areas may form quite an expensive and inconvenient procedure. Industrial and domestic wastewater are either disposed into a common sewerage system or in two different systems. Treatment of the water depends on its sources. The degree of treatment depends on many factors, including health and environmental conditions, and potential use of the treated wastewater.

5. Rational use of available water resources

The ever-increasing demands for water require an efficient use of the resources available. Water of a specific quality should be used for appropriate purposes. As a general rule fresh groundwater of good quality should not be used for purposes where lower quality water would be appropriate, ie brackish groundwater and treated wastewater may substitute the abstraction of fresh groundwater for agricultural use. In such cases, good quality groundwater should be reserved for domestic water supply, for both present and future generations.

C. Demand management

1. Integration of supply and demand

Generally water is not considered an economic commodity, but rather a free good. Demand management, which refers to a set of incentives to promote a justified use of water, should play an important role in future planning.

The demands for water and the possibilities to reduce them should be analysed in detail during the early phases of the planning process and compared with the consequences of additional abstraction of groundwater for adequate economic returns and environmental protection.

2. Efficiency of water use in all sectors

Considerable potential exists to improve the efficiency of water use in all sectors. As the agricultural sector is the main consumer of water in arid countries, the greatest savings can be made in this area. A steady improvement in water use efficiency will generate several immediate benefits:

- water saved could be used to irrigate more areas and/or used for other purposes;
- additional water can be provided at lower cost than from new projects;
- adverse environmental impacts can be reduced.

Several country papers presented during the Round Table Meeting indicated that 50% or more savings can be obtained by making domestic and industrial water sectors more efficient.

3. Water pricing

A major reason for inefficient water use is that farmers seldom have to pay for irrigation water and thus have no incentive to practise water conservation. Similarly, the flat rates usually charged in the domestic sector do not contribute to water conservation.

Water pricing is likely to have a beneficial effect on water consumption in all sectors and could also generate additional funds for better operation and maintenance of the water systems. While in principle water pricing is a desirable option, the associated legal, social and political aspects should be carefully considered before its introduction.

4. Legal instruments

Legal instruments such as licences for groundwater abstraction and effluent charges for wastewater are powerful mechanisms for controlling water use. In most countries, regulations often exist on water rights and priorities for water use. Legal instruments available should be reviewed in their totality to ensure their effectiveness for rational groundwater planning and management.

Regulations are not in themselves enough for sustainable groundwater management. They must be properly implemented. Often for social, economic and political reasons such regulations are not implemented and such constraints must be overcome effectively.

D. Methods of analysis

1. Data management and monitoring

Information should be collected, stored and processed throughout the planning and management processes and be accessible and easily retrievable to the users as and when necessary. Computerized databases are powerful tools to store and process data and to provide input to hydrogeological maps and vulnerability maps.

Monitoring of the predicted effects of groundwater development (water-tables, water quality, environmental impacts) is of utmost importance and provides the necessary feedback for adjustment of plans.

2. Use of appropriate models

Models are powerful tools for groundwater planning. Selection and application of models should be in accordance with the tasks to be performed and amount of available data. Sophisticated models are only effective when large amounts of reliable data are available.

3. Application of available investigation techniques

Particularly in arid regions, the use of remote sensing techniques for the assessment of the groundwater resources may be very useful. Satellite images can provide a wealth of information on land use, soils, vegetation and hydrology.

Moreover, in arid areas other reconnaissance techniques, such as hydrochemical and isotopic analysis, and geophysical surveys reveal important information about the occurrence of the groundwater in the subsurface, eg extent of aquifers, and their hydraulic properties, groundwater flow, origin, age and quality of groundwater.

4. Elaboration of positive as well as negative environmental impacts

Environmental impact analysis (EIA) should be integrated in an early stage of the planning process. For rational groundwater planning the assessment should involve balanced attention to positive as well as negative environmental impacts. Attempts should then be made to maximize positive environmental impacts and to minimize negative impacts. The EIA procedural framework should be incorporated during the initial phase of the groundwater planning process.

5. Economic costs and benefits

Economic evaluation of costs and benefits provides a sound base for comparing different alternative plans for groundwater development, including the zero option (no development scenario).

Benefits and disbenefits (damages) that cannot easily be translated into economic terms (public health, many environmental effects, socio-cultural aspects, etc) should be expressed at least in qualitative terms. The decision makers can then make the final decisions on the basis of both quantitative data and qualitative information available.

E. Planning process

1. Planning as a continuous process

Planning and decision making are continuous, dynamic processes due to changing conditions and circumstances. Inputs to the water resources system (natural, infrastructural and administrative aspects) vary with time and space.

This is also valid for the demand considerations (population growth rate or economic development,

land use, etc), for the resources (quantity and quality changes due to natural processes and human interferences), and for social and political preferences.

2. Incorporation of environmental and other natural resource issues

Issues related to the environment and other natural resources should be incorporated in the planning of groundwater development from the beginning instead of their consideration at a later stage primarily to ameliorate some adverse effects.

3. Integration of disciplines

Multidisciplinary expertise should be available to incorporate all aspects in the groundwater development plan. Economists, geologists, environmentalists, sociologists and lawyers should work with engineers in all stages of the planning cycle (data management, policy formulation, planning, programming and implementation).

4. Sectoral coordination

Planning for groundwater resources has to deal with many related fields of activity, such as agricultural and industrial development, health, energy, land reclamation, etc.

Considerable effort must be devoted to adjust groundwater plans to the planning of related sectors, although their components (such as time horizon, administrative boundaries and estimated developments) are rarely identical.

5. Involvement of users at an early stage

Water users play a dual role in water resources planning: they are the ultimate beneficiaries and managers, whose behaviour plays a dominant role. Users' participation is required to get people motivated and willing to take necessary – and sometimes unpleasant – decisions about water use and distribution. Users' involvement is desirable from the early stage of plan preparation.

6. Presentation of the plans

National and regional plans have to be presented in an appropriate level of detail to the different users as well as to the general public. Water resources planners should promote sustainable development and inform the public on the positive and negative consequences of future developments, as compared to the zero-option alternative.

Planners should make an objective and balanced presentation of the plans to the decision makers and the general public. Full advantage should be taken of the media to disseminate objective information to the people concerned.

F. Specific issues

1. International cooperation

Many of the aquifers in the arid and semi-arid regions are shared by two or more countries. Because of their international character, their development and management are more complex when compared with aquifers which are totally contained within one country.

Planning the development of the international aquifers requires good cooperation between the countries concerned. While many of the issues could be political in nature, much can be done at the technical level in terms of:

- joint research projects to better understand the hydrogeological characteristics of the aquifers, including preparation of reliable hydrogeological maps;
- free exchange of data between the countries concerned; and
- joint planning to optimize water use, including fair allocation between countries.

2. Human resources development

Sound planning for groundwater development can only be implemented effectively if planning agencies are provided with adequate manpower and institutional capacity. Human resources development and institutional strengthening should be provided to bring the organization and manpower of planning agencies in line with their respective responsibilities. A particular task is reserved for central government agencies to train lower administrative levels.

3. Management of wetlands

Wetlands in arid and semi-arid regions are internationally important and ecologically sensitive areas. The short- and long-term effects of interventions in the groundwater regime may affect the vulnerable hydro(geo)logical equilibrium. This impact should be incorporated in the planning process and requires careful evaluation with the agencies responsible for protection of wetland areas.

G. Future cooperation

1. Continuation of international exchange of experiences within the region

The guidelines formulated at the Round Table

Meeting are the output of the presentations and discussions. The meeting expressed the need to hold similar meetings in the future and to establish a permanent exchange of experiences between the participating countries in the field of groundwater planning. Topics for future meetings are the mining of fossil groundwater reservoirs and environmental impacts of groundwater management.