MODEL PROJECT INFORMATION SHEET

ISOTOPES GROUNDWATER RESOURCES DEVELOPMENT

REGIONAL AFRICA - RAF/8/022

SUMMARY

The scarcity of water in many countries in arid and semi-arid zones of Africa is of great national, regional and international concern. Water resources development therefore has a high priority in the region. This model project aims to apply indispensable isotope hydrology techniques, in combination with other investigations, to practical problems for the development and optimum management of groundwater resources in nine African countries. Areas have been identified in each country by end users where reliable assessment of scarce water resources is vitally needed for water supply to large population centres or development activities. The project is expected to yield important hydrological data which is essential, from the socioeconomic standpoint, for water and development authorities in order to plan medium and long term sustainable development based on rational management of water resources. The project also aims to strengthen regional and local capabilities in the integration of isotope hydrology projects within water resources assessment and development programmes, which is essential for sustainability. The project will be implemented in two phases.

Project duration: 4 years. Total budget: US $1,776,000.

INTRODUCTION

Water resources are essential for the achievement of sustainable development. When a country has fewer than 1000 m^3 per capita of renewable fresh water available annually, chronic water scarcity becomes one of the main limiting factors to economic development, human health and wellbeing. Among the countries currently facing water shortages are, particularly, those in arid and semi-arid zones of Africa. Recognizing the vital role of adequate water resources for sustainable development and the potential of

isotope hydrology techniques in water resources management, the Board of Governors discussed in June 1994 the subject of Utilizing Isotope Hydrology for Ground Water Management in Arid and Semi-arid Zones of Africa (GAVEENOUGH/73 8).

The combination of several factors, the most important of which are adverse climatic conditions, recurrent droughts and a continuously growing population, has put intense pressure on the use of groundwater resources. Furthermore, there is still insufficient information on the aquifers and, consequently, water resources, some of which are of a fossile nature or very poorly renewed, are being over-exploited. Detailed knowledge of flow patterns, natural and modified by withdrawal, is necessary for the rational development of groundwater resources, especially in the case of deep confined aquifer systems. In the case of shallow unconfined aquifers like wadi underflows, it is of primary importance to assess the average renewal rate of the system and to investigate whether recharge occurs on an annual basis or if it is due to exceptional rainfall.

The determination of the area of recharge is, of course, a major requirement for the evaluation of pollution risk by irrigation returns and overflows around the wells and the boreholes. For all types of aquifers in zones of internal drainage where the only discharge process is by evapo-transpiration, it is important to evaluate such diffuse discharge, which produces soil salination.

The scarcity of groundwater in areas located on low permeable geological terrain implies the utilization of surface waters through artificial reservoirs. However, soil erosion and related sediment transport controlled by present hydroclimatic conditions often induces a sedimentation rate which reduces the capacity of the surface reservoir. Furthermore, under high evaporation, water from dams and reservoirs easily becomes saline and, when sodium enriched, cannot be used indefinitely, especially for irrigation purposes. This emphasizes the need for careful evaluation of groundwater resources in alluvial beds and the importance of studies for artificial recharge.

Isotope techniques play a significant role in understanding the nature of many of these problems. To address problems related to water resources development and management, using isotope techniques, and in order to determine end users' practical needs in countries in arid and semi-arid zones of Africa, a regional planning meeting was held in Rabat, Morocco, in September 1993. The meeting was attended by 13 participants from Algeria, Egypt, Ethiopia, Libya, Mali, Morocco, Niger, Senegal and Sudan. They came from various disciplines in isotope and water science and engineering, and represented direct beneficiary institutes and end user organizations. At the meeting, the outline of a model regional project was prepared, general objectives were formulated and specific objectives of various countries were determined to serve end users of the water sector. The nine countries that participated in the Rabat meeting will co-operate in this model project.

Subsequent missions by outside experts were undertaken to the countries concerned (a) to assess the feasibility of the activities proposed by the countries and their integration into ongoing programmes within the water sector, (b) to assess the relevance of the planned activities to practical solutions of water management problems

in the countries, and (c) to determine the local inputs required for the successful implementation of the planned activities.

The project will be implemented in two phases. The activities to be carried out under Phase I (1995-96) will start in Egypt, Ethiopia, Morocco and Senegal. Activities under Phase II (1997-98) are expected to be carried out in Algeria, Libya, Mali, Niger and Sudan.

POTENTIAL OF ISOTOPE TECHNIQUES IN ARID ZONE HYDROLOGY

Given the nature of hydrological problems that need to be addressed in arid and semi-arid regions, isotope hydrology techniques are increasingly recognized as indispensable tools for the assessment and development of water resources in these regions, when adequately integrated with other hydrological methods. Although not able to detect and delineate groundwater resources, isotope techniques can provide unique information relevant to assessing the dynamics and balance of aquifers, including recharge conditions and vulnerability to pollution and over-exploitation. For example, conventional hydrological methods often fail to identify and evaluate recent groundwater replenishment if the replenishment rates are smaller than some tens of mm of water per year. However, under arid and semi-arid climatic conditions, recent recharge is often much smaller. Analysis of the environmental isotope composition of rainfall, surface and groundwater is then the only tool which allows evaluation of present and/or past groundwater replenishment - a basis for estimating the renewable source of water available for sustainable exploitation.

Under the present climatic conditions, some of the main aquifers used as a source of water may not be replenished at all, and their exploitation would represent simply a mining operation of the existing stored volume of water in the system. In such cases, mapping of palaeowaters and estimation of available reserves are essential for proper planning of development strategies. It should be emphasized that environmental isotopes constitute the only tool capable of identifying palaeowater through groundwater dating (radioactive isotope carbon-14) and/or use of climatic imprints on the water reflected by its isotopic composition (deuterium, oxygen-18). Problems in assessing, developing and proper managing of water resources where the use of isotope techniques is indispensable include identification of origin and dynamics of groundwater (palaeowater resources); evaluation of recharge and discharge of aquifers; evaluation of mixing between surface (river, lake) and groundwater; definition of aquifer vulnerability to pollution and over-exploitation; determination of water balance of reservoirs; evaluation of possible enhancement of local groundwater resources.

The Agency's activities in isotope hydrology in Africa started in the early 1980s in the Sahelian countries and were later extended to East Africa. The activities comprised national and regional co-operation projects which were instrumental in developing and strengthening manpower and infrastructure for isotope hydrology, particularly in Mali, Niger and Senegal. The regional projects implemented in the Sahelian countries and the Nile Valley were directed to studies of water resources and aimed at promoting exchange of information and co-operation between various countries. Hydrological and hydrogeological studies in West Africa by isotope

techniques were implemented from 1978 to 1990, while a study on water resources in the Nile Valley was implemented from 1988 to 1992 in Egypt and Sudan.

This model project, based on the experience acquired and the established infrastructure in isotope hydrology in some African countries, will expand and enhance the utilization of isotope techniques in arid and semi-arid zone hydrology in Africa. This will further strengthen regional capabilities and foster regional co-operation. An important feature of this project is the strong emphasis on end user involvement and application of the results in optimum management of groundwater resources.

OBJECTIVES

The overall objectives are:

To apply isotope hydrology in combination with other investigations to practical problems for the further development and management of water resources in various countries in arid and semi-arid zones of Africa. In particular, the model project will aim at solving problems where the use of isotope techniques is indispensable. These problems include: identification of the origin and dynamics of groundwater (palaeowater resources); evaluation of recharge and discharge of aquifers; evaluation of mixing between surface (river, lake) and adjacent groundwater; definition of aquifer vulnerability to pollution and over-exploitation; determining water balance of reservoirs; and evaluation of possible enhancement of local groundwater resources.

To strengthen regional capacities, foster regional co-operation and reinforce the regional infrastructure in isotope hydrology. This will help to promote the practical use of isotope hydrology techniques in water resources development projects and activities in Africa.

The specific objectives of Phase I are as follows:

EGYPT:

Assessment of the recharge rate from the Nile aquifer to the Western Desert fringes and study of agricultural pollution. The determination of induced recharge is essential for development and reclamation of about 120,000 feddans[1] at Wadi El-Farigh, west of the Delta, and Simulate, Ensna and Qena, west of the Nile Valley. Study of the origin of agricultural pollution affecting 10,000 feddans at El-Fashn will be undertaken, and the result will be used by the Water Research Institute of the Ministry of Public Works and Water Resources (the end user) to establish a water management programme.

[1/] One feddan = 42 m^2

ETHIOPIA:

Assessment of replenishment of water resources in the Moyale region and vicinity (population about three million), which suffers recurrent drought. The results are essential for a water management programme by the Ethiopian Water Works Construction Authority (the end user).

MOROCCO:

Assessment of balance of terms of some South Atlasic aquifers for optimum management of water resources. These aquifers, at Tafilafel, Guelmim and Afendul Lahajar, supply drinking water for several population centres (of about half a million people) as well as water for irrigation needs. The studies are expected to yield information on the estimated evapo-transpiration, infiltration rate, origin of salinity, mixing ratio between aquifers, and the determination of most suitable recharge sites. The results will be utilized jointly by several end users: the Drinking Water National Board, the Water Resources Regional Directorates (for the exploitation of the aquifers), the Agriculture Provincial Directorates and the Land Utilization Boards (for the agricultural development of the regions under study).

SENEGAL:

Re-assessment of water resources to upgrade the water supply for Dakar and vicinity. It is planned to determine the balance terms characterizing aquifers at Thiaroye, Sebikotane, Pont-Mbour and North Seaboard as well as the infrabasaltic aquifer. The results will be used to update existing mathematical models and enable rational management of resources by the Ministry of Water Resources (the end user).

The specific objectives of Phase II are as follows:

ALGERIA:

Assessment of underground water resources in the Hoggar and Tassilis by isotope and hydrochemical studies. The expected results will complement the available data obtained by conventional hydrogeological studies and will be utilized in the elaboration of different simulation models at different horizons. This will enable long term planning for the exploitation of the resources to be undertaken.

LIBYA:

An isotopic approach to groundwater recharge of the Kufra aquifers in south-eastern Libya. This will involve a solution of the recharge problem (palaeo-recharge and/or recent recharge). The results are expected to enable estimates to be made of groundwater resources and protection zones to be delineated, which are basic prerequisites for the implementation of national activities such as agricultural projects.

MALI:

Assessment of the recharge and evaporation rates of unconfined aquifers within the Gondo Plain. This will involve determination of recharge and evaporation of the Gondo aquifers. The results will enable rational management of the groundwater resources to be established.

NIGER:

Determination of the contribution of isotope geochemistry to study the dynamics of underground water in the alluvial valley of Dallol Maowi for water resources management, hydro-agricultural development and land utilization. This will involve obtaining detailed information of recharge rate, discharge by evapo-transpiration and lateral flows, mixing of old and recent groundwater, relation between surface and groundwater, and radiometric groundwater dating. The results will enable planning of hydraulic structures to be established, and will also benefit the exploitation of water resources for domestic use, hydro-agricultural development and land reclamation.

SUDAN:

The Northern State Adjacent Nile aquifers study project on the use of isotopes in groundwater development and of proper water management in the Northern State Adjacent Nile aquifer. The project is expected to help the survival of two-and-a-half million people who were displaced by the recent drought from a long distance towards the Nile banks.

PROJECT IMPLEMENTATION AND MONITORING

The project is planned to be implemented over a period of four years. In Phase I (1995-96), activities will begin in Egypt, Ethiopia, Morocco and Senegal. Activities in other countries will be carried out in Phase II (1997-98). In parallel, efforts will be devoted to setting up two central laboratories in the region to render analytical services to various end users during implementation of the project and after its completion. Intercomparison for quality assurance of analytical services will also be undertaken.

The project will be implemented mainly by participating countries. Agency support is vital for provision of analytical services (at least in Phase I) and guidelines on field work and interpretation of data. Local and regional training on specific field measurements, sampling techniques, data handling and interpretation and modelling will also be organized in various workshops. It is essential to appoint a technical expert in the region to undertake co-ordination, monitoring of the activities and dissemination of information.

Monitoring implementation and progress of the project will be undertaken at meetings to be held annually at an appropriate venue for project participants from recipient and end user organizations and Agency representatives. The meetings will discuss an annual progress report to be submitted to the Agency in advance by project participants, problems of implementation and detailed plans for the coming year. The progress report should include the main achievements, the impact, the problems and follow-up actions needed for further progress. Upon completion of the first phase, a seminar will be held at an appropriate venue to evaluate the project activities and the main results achieved, to make a quantitative assessment of the project's socioeconomic impact and its role in supporting sustainable development, and to make recommendations for the future. A model project final report will be prepared by the Agency on the basis of the seminar papers.

REGIONAL AND NATIONAL COMMITMENT

The countries concerned are committed to active participation in the project. This commitment was expressed at the Rabat planning meeting and to the experts who visited the countries where Phase I will start, as well as through formal notification to the Agency. These countries will make available scientific and support staff, analytical laboratory facilities (if available), drilling and sampling equipment, and will host workshops and training activities.

THE AGENCY'S INPUT

The Agency will provide expert and consultancy services for the planning, co-ordination, implementation and evaluation of project activities; equipment for the regional laboratories; consumables and supplies; laboratory and specific analytical services as necessary; training through the organization of regional scientific seminars and workshops and the exchange of scientists and qualified technicians.

IMPACT

In the short term, the data obtained from hydrological studies will be used in estimating recharge rates and water budgets in the countries concerned, which would lead to the development of guidelines for water policy and optimum management of the existing resources. Accordingly, the water authorities and other end users who participated in the project from the start can undertake regional plans for agricultural development and provision of water needs for large population centres. In Phase I, water assessment and reassessment activities will have a significant socioeconomic impact since they will contribute to the provision of an adequate water supply to over three million people in the Moyale region (Ethiopia), more than one-and-a-half million people in the Dakar region (Senegal) and about half a million people in the South Atlasic region (Morocco). Furthermore, the expected results are essential to the reclamation of more than 120,000 feddans west of the Nile Valley (Egypt) and maintaining 15,000 hectares south of the Atlasic region (Morocco). The project will create a long term impact by strengthening regional capabilities and facilities as well as increasing experience in the integration of isotope hydrology within water resource assessment and development programmes in the region. There has been close co-operation between direct beneficiaries (research institutes) and water authorities of the participating countries in designing this project. Strengthening regional co-operation is essential for better understanding of regional water resources since there are common hydro-climatic conditions in the region. Further development and optimum management of water resources as well as determination of aquifer vulnerability to pollution and over-exploitation will support sustainable development in the participating Member States.

FINANCES

The budget allocation for the project is US $1,776,000, distributed as follows:

Year	Experts		Equipment	Fellowships		Scientific Visits		Grp trg.	Sub-contr.	Misc. Comp	Total
	M/D	US $	US $	M/D	US $	M/D	US $	US $	US $	US $	US $
1995	14/0	159,600	80.000	-	-	-	-	35.000	90.000	-	364,600
1996	14/0	168,000	80,000	-	-	-	-	40,000	120,000	-	408,000
1997	6/0	75,600	550,000	-	-	-	-	30,000	90,000	-	745,600
1998	4/0	52,800	175,000	-	-	-	-	-	30,000	-	257,800
Total	38/0	456,000	885,000	-	-	-	-	105,000	330,000	-	1,776,000

Source of funding: TACF