UNESCO

Regional Office for Science and Technology
for the Arab States (ROSTAS)

# TRAINING IN WATER RESOURCES EXPLORATION, DEVELOPMENT AND MANAGEMENT

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## I. Introduction:

We are witnessing an unprecedented accelerating scientific development. Man's power over nature has reached a level unparalleled in all his history. The rapid development of science, and with it of the new technology, makes it possible, for the first time in history, to satisfy all the material and spiritual requirements of every inhabitant of the Earth.

The physical pattern of the world of the future may change very considerably. We are limited at the present moment, far more limited than we like to be or need be, by the great variation of climatic conditions over different parts of the world. For instance, as the welfare and advancement of any people in the world can be affected and interfered with by mere fluctuations in the weather, droughts and excessive rain, leading to famines and floods, an elementary stage of conquest of the environment has not been achieved. Yet with the resources at present available in the world it could be achieved, only these are too unevenly distributed.

Training is not now a function of a certain number of years, but of something which extends throughout the whole of our life. It is clear that we have to train people to respond to a rapidly changing environment and to change their response to it at any period in life.

In training engineers and technicians, special attention should be paid to their high qualification both in basic general scientific subjects and in the theory of applied sciences. It is equally important that they should be able to carry out experiments, using high-quality modern measuring instruments.

A good theoretical training of specialists must be closely liked with the acquisition of practical skills by work at different plants, factories, design offices and research institutions, employed mainly as skilled workers or as technicians, laboratory assistants, computer operators, etc.

Economic factors play an important part in solving scientific and engineering problems. The technique of work organizations is also of great significance. This is achieved by the study of the fundamentals of economics and special aspects of economics.

A good knowledge of foreign languages is of great importance to the successful activity of the engineer or technician, as it enables him/her to master the achievements of world science, without which no progress in science of technology is possible. This must be followed during the period of training. Methods of training have improved and these improvements have made possible the great technical innovations of which we are so proud.

Adequately trained personnel are necessary for the rapid and continuous development of ROSTAS countries in the area of water resources management. Various disciplines at different levels are required including:

* water resources engineers,
* civil engineers,
* agricultural engineers,
* hydrologists,

* geologists,
* economists and administrators, and
* technicians and skilled workers.

The need for technicians is often crucial. Shortage of drilling foremen can be a major constraint in, for example, a rural water supply project. Even more important is access to engineers on the academic level who can by their initiatives and competence be essential for promoting development.

Correct water-resources assessment can only be achieved with adequate manpower - adequate both quantitatively and qualitatively at all necessary levels and for all specializations.

Efficient manpower can be formed in-service or hired. It needs sufficient incentive to stay in the water resources assessment service long enough to be able to contribute satisfactorily. In the majority of developing countries there is a shortage of water resources manpower at all levels and in particular at the middle and lower levels.

Manpower surveys should cover all educational levels, i.e., training of technicians, etc., undergraduate and post-graduate courses and continuing education. They should be based on criteria such as the actual and potential water resources problems in an area, the available manpower qualified to deal with these problems, and existing educational and training facilities. Conclusions should be drawn on the types and sizes of institutions required, on appropriate curricula and syllabi, on the numbers of teachers and their special skills, and on the physical facilities, including teaching aids, that will be needed. All available information points to the fact that at this stage the most crucial deficiency in the majority of developing countries is the absence or insufficiency of training facilities and in-service training programmes at the middle-level technicians level.

Unlike progressional hydrologists and water resources engineers whose tasks and educational requirements are more or less similar in most countries, working and educational requirements for technicians may differ greatly from one region or country to another. Therefore, the problem of training such technicians may occasionally be more difficult than that of training professional hydrologists and water resources engineers.

## II. Major Fields of Training:

The water resources sector possesses a great responsibility in the fulfillment of several goals, considering not only the very important task of providing safe water supply and sanitation systems, but also the role of water to stimulate economic growth mainly through expansion of irrigation, hydro-power production and providing water for industrial purposes.

Some of the important fields of training are given in the following:

2.1 Water supplies for domestic use in both urban and rural areas;
2.2 Water for agricultural use;
2.3 Water for industrial use;

2.4 Flood and drought alleviation;
2.5 Hydropower generation;
2.6 Sewage treatment and disposal;
2.7 Water pollution control, and
2.8 Improving environmental quality;

When analysts speak of the "demand" for water, they typically refer to water's use as a commodity as a factor of production in agriculture, industry, or household activities. No society can draw on all its available supplies and hope to maintain the benefits water freely offers when left undisturbed. The need to protect these natural functions is thus a critical backdrop to considering society's pattern of water use.

Each of these aforementioned fields of training could be handled in brief in the following lines.

2.1 The approach of water demand - supply for domestic use involves a number of steps which are:

* A water availability inventory. This is based on the activity of hydrometeorological and hydrological guaging and surveying and areal assessment done using physiographic data and

applying the satellite rainfall estimation methods (METEOSAT) as well as the Landsat imagery and thematic Mapper sensing system.

* A survey of the committed water resources, i.e. water already consumptively used within the study area of water to be released at the study area's boundary.

* An inventory of water available for use is then prepared on the basis of the previous 2 steps and technical-economic indexes and other data relative to each water source and type of use.

* A review of demographic, social, economic and political conditions and trends and/or the policies, objectives and targets formulated by the political institutions of the relevant jurisdictions.

* An inventory of potential natural resources is usually required as a base for the general economic planning.

* An inventory of current development is then required both to identify the committed resources and the starting point for further development.

2.2 In regions where agriculture predominates, an adequate supply of water must be made available at appropriate periods in order to ensure maximum agricultural production. The largest single agricultural use of water is usually for irrigation, which is often the largest consumptive use. Other uses are for raising livestock and poultry, for processing farm products, and for other general purposes.

2.3 Most industries require water for their operation. The quantity and quality of water required for each industry vary. In most instances, it is neither economical nor practical for industrial establishments to provide their own water supply. Industries will usually locate in communities where ample water supplies of suitable quality are readily available and where sewerage system already exists for the proper disposal of their wastes.

2.4 For large basins in arid regions there is a little prospect of producing reliable flood estimates from rainfall estimates. The flood might result from high - intensity convective rainfall over part of the catchment area, or from relatively uniform, low-intensity rainfall over the whole area, or from any combination of circumstances between these extremes. For this reason, statistical methods coupled with geomorphological and flood level evidence are generally preferred to rainfall-runoff models. However, the latter may be useful in setting a physical upper limit on flood values estimated from a frequency distribution.

Runoff control methods may be generally classified as follows:-

* terracing on side-long slopes to intercept dispersed runoff, with one or more contoured walls of stone behind which downwashed sediments gradually accumulate to form narrow strip fields, cross-terracing in small hillside drainage channels, where a series of fields are formed from sediment retained behind the terrace walls, primitive provision for spill being provided at the lower end of each field.

* groups of terraced fields located in small valley bottoms, and watered by long catch-water channels which intercept the runoff on the surrounding hills and conduct it to the cultivated areas.

* water-spreading on terminal deltas by either "wild flooding" or using ad hoc measures for guiding the waters, such as semi-permanent checks, bunds or spurs to give some initial direction to the floods.

* primary spate irrigation systems, whereby terraced field complexes of tens or hundred of hectares which flank the main channels or valley bottoms, alluvial plains or deltas are watered by diverting flood flows into them.

* storage dams, sometimes with canals constructed in rock now mainly defunct.

In addition to using runoff for agriculture, the traditional dwellers in these lands also divert it to cisterns to meet both domestic and stock watering needs. An excellent example of ancient practices for runoff management typical of most of the Middle East and North Africa could be adopted.

Measurements associated with flood include:

. River stages in excess of bank full storages;

. Areal extent of flooding;

. The extent of industrial, residential, and agricultural development, and potential and observed financial losses; and

. Estimates of loss of trafficability and workability of fields or roads due to wet ground or the unuseability of fords (corssing sites).

Drought can occur anywhere and is a constant problem in semiarid areas especially those bordering on deserts. Drought is often expressed by meteorologists in terms of days without rain or the number of millimeters or inches of rainfall below long-term normals. In arid and semiarid areas, farmers generally lack the water to irrigate all the land that could be cultivated. Measurements related to the extent and severity of drought include:

- Precipitation in terms of annual seasonal, and monthly amounts;

- Deviations of precipitation from normal, that is, mm below means of quantities described in the above item;

- Evaporation;

- Temperature, humidity, and the dew point depression (difference between the mean air temperature and the mean dew point temperature);

- Deficits in the soil moisture such as required amount of rain to reach saturation, or adequate levels of available moisture in the soil;

- Groundwater conditions determined from groundwater discharge into streams, the drying up of ponds, or the lowering of or drying up of wells; and

- The number of significant days without rain or, in some areas, the estimated percentage below normal of mountain snowpacks.

2.5 Where rainfall is abundant and the terrain is favorable, hydroelectric power development is an undertaking of great economic importance. Hydroelectric power is often least expensive, and practically all water supply utilized for such purpose can be recovered for other uses. Furthermore, the quality of water is hardly of any significance, provided that large suspended matter is not present. Inexpensive sources of energy are most essential to the development of industry, transportation, public utility and communications.

2.6 Sewage Treatment and Disposal: There are three possible directions for disposal of liquid wastes, namely: disposal onto land, disposal into large and natural bodies of water, and disposal into the atmosphere. To a certain limited extent waste disposal onto land has long been practiced in sewage irrigation, in sub-surface leaching systems for septic tanks, and in the percolation (no matter how insignificant) of sewage in oxidation ponds or sewage lagoons. The bulk of disposal of treated or untreated wastes has been traditionally a discharge to large natural bodies of water such as rivers, lakes, or the ocean.

Despite the wealth of published knowledge on secondary waste treatment by biological means, we are a little disappointed to know that no new and innovative biological treatment method is being investigated outside of the three old reliables: (a) trickling filters, (b) activated sludge, (c) oxidation ponds and their various modifications.

Works for the sewerage system include major sewers, lateral sewers, intermediate pumping stations, a main pumping station, sewage treatment lagoons and an outfall sewer.

2.7 Water Pollution Control: Each liter of polluted water discharged untreated contaminates many additional liters of freshwater in the receiving stream. The disposal of synthetic chemicals and heavy metals, which pose dangers in extremely low concentrations, is an especially grave threat to the quality of water supplies. Without adequate treatment, the growing volume and toxicity of wastes could render as much as a fourth of the world's reliable supply unsafe for use by the year 2000. Many industrial countries now require that wastewaters meet specified standards of quality before they are discharged. Yet in most Third World Countries, pollution controls are either nonexistent or unable to keep pace with urbanization and industrialization.

There are wide numbers of activities that are associated with man's introduction of foreign chemical and biological material in the subsurface environment. The first of these is agriculture, which is responsible for 5 major sources of materials. Industry serves as another originator of chemicals for groundwater pollution. More often, pollution occurs due to leaks from evaporation ponds, holding or oxidation ponds, varied wastes, landfills, or deep well waste disposal activities.

In discussing the uses of modern technology in groundwater quality management, it is easiest to consider two broad categories. The first is the use of technology to prevent groundwater contamination by controlling the quality of the water which recharges the aquifer. The second involves the use of technology to manipulate the groundwater flows to reduce other spread of contaminated or potentially contaminated groundwater, or to clean it up.

Using the indications of the source of pollution located on the remote sensing image, a ground survey can often further identify the type and cause of pollution which can then be corrected by a mix of legal and engineering remedies.

## 2.8 Improving environmental quality:

Developing countries water resources are very rarely monitored for their quality, and water quality surveillance programmes are only operational in some countries. No routine data on organic micropollutants exist for most of the world's freshwater bodies or groundwater. Many aquifers are monitored locally but little integrated information on groundwater quality exists on a regional scale. There are many difficulties in the sampling, preparation, analysis and interpretation of heavy metals and persistent organic micropollutants in the water phase. Suspended particulate matter and sediments should thus be used for reconnaissance surveys and routine monitoring of these pollutants.

In most developing countries neither the necessary laboratory instrumentation nor the highly specialized personnel are available to monitor micropollutants accurately.

The reliability of the analysis of water is another important step in the global assessment of water quality. Better understanding of the basic biogeochemical processes and interactions between particulate and dissolved forms of pollutants, biota and sediment is required to assess the fate and pathways of pollutant in the quatic environment.

## III. Manpower Policies Influencing Present Status:

The simplest way of attracting staff to certain disciplines is the salary structure and the most difficult is influencing the social status, although the two are often linked. It may be of interest to evaluate these policies with respect to water resources staff and their implications for training and education if in the majority of countries, the situation with respect to manpower for water resources assessment is unsatisfactory. But there is a large variety of causes throughout the world. In some countries this is due to too low a number of secondary school graduates. In other countries there is a discrepancy between the number of people who choose an engineering profession and those who choose administrative or a "soft" scientific one. Again, in other countries water resources specialists may resign their jobs to accept a position in construction engineering attracted by higher salaries. In a few countries, where the number of water resources engineering graduates is large, they may leave the country temporarily or for good because of higher salaries elsewhere or because there are not sufficient water resources projects going on in the country to enable them to gain practical experience.

Some measures which could be taken by governments to remedy the situation are:

3.1 Give a somewhat higher salary to government staff working in engineering professions than to those in non-engineering professions. This is done successfully in several countries. It has the additional advantage of raising the status of the staff as the government shows its interest by such measures.

3.2 Provide special allowances for government employees working in the field outside the capital cities or at least see that the staff working in the field do not lose out financially. If this is not done, field work will be regarded as a punishment even if the staff are enthusiastic about increasing their practical experience.

3.3 Improve the status of basic water resources personnel through public information campaigns concerning the role they play in the development of the country.

The brain-drain is regarded in many countries as a serious threat to indigenous development. The case where water resources specialists go abroad because there is not enough work in their own countries can be regarded as beneficial to both the sending and receiving end. The number of developing countries in this situation can, however, be counted on one hand. The most serious situation is in those countries where water resources engineers and technicians leave the country when they are already in short supply in their own country. This situation happens in quite a number of countries that are temporarily going through difficult economic periods in comparison with other countries.

## IV. Evaluation of Manpower Status and Future Needs:

It would be impractical to take all possible factors into recount when evaluating the manpower situation. The object of the evaluation is to identify problems so that remedial measures can be taken. It is thus not necessary to mention manpower aspects for which no difficulties exist or are unlikely to occur in the future. For example, water resources assessment activities require transport by car, if car maintenance and repairs do not pose any problem it is not necessary to evaluate the manpower status in the car mechanics field.

The evaluation is carried out separately for the main fields of water resources, namely:

4.1 Institutional framework.

4.2 Data collection, processing and retrieval.

4.3 Areal assessment of water resources planning.

4.4 Data requirements for water resources planning.

4.5 Research and development.

The manpower problems which exist or are likely to occur in the above 5 fields should be indicated. For instance, if there are manpower problems in the field of areal assessment of water balance components, a table mentioning surface water mapping, surface water modelling, groundwater mapping and modelling should be made. The procedure is then continued until the necessary personal specialization is reached. When manpower problem has been identified, the reasons for the deficiency should be monitored. There could be, for instance, the absence of trained personnel, lack of interest in the jobs offered, insufficient funds to employ personnel.

It is difficult to evaluate manpower quality aspects objectively. The evaluation should not only cover the quantity aspect but also the quality aspect.

In the quality evaluation the following are the most important: has the person sufficient knowledge, does he know how to apply this knowledge, in his working environment and does he have sufficient self-confidence to effectively execute the tasks assigned to him?

Also if work in the field poses problems, the reasons should be indicated.

## V. Formal Education and Training Levels:

In evaluating the training programmes for water resources, a summary of the educational facilities directly or indirectly related to it should be prepared. The following formal educational and training levels can be identified:

### 5.1 Primary and Secondary General Education:

It is important as preparation or further training.

### 5.2 Lower Technician Training:

In the great majority of countries, no special school or institutes for training in the field of water resources exist. In practically all countries it would not be advisable to create them on a permanent basis. Training is executed on an in-service basis.

### 5.3 Middle Level Technician Training:

In countries with a population of less than 4 million inhabitants, it appears that specialized institutes for training in water sciences education within larger entities such as public works and agricultural departments. There is, in general, a great need for improvement in the methodology for training in water resources subjects at this level.

## 5.4 University Training:

Specialized training in water resources subjects normally takes place as a specialization within public works, civil engineering, agricultural hydraulic engineering, mining engineering and their fields. This training is very important but methodologies are, in general, well known.

It is important to emphasize that the UNESCO Regional Office for Science and Technology for the Arab States (ROSTAS), sponsored valuable post-graduate courses, one was held at the National School of engineers in Tunis (6-18 February, 1989) on "Simulation in Hydrology", while the other, an annual post-graduate course (May - June) was held at Ain Shams University in Cairo on "Environmental Hydrology for Arid and Semi-Arid Regions". The annual course started in 1980.

The Center for Applied Geology (established in 1970 in cooperation between the Ministry of Petroleum and Mineral Resources and the United Nations Development Programme/UNESCO), is located in Jeddah, Saudi Arabia. In addition to the Master's degree program, the Center for Applied Geology has a 2-year Geology Technician training program leading to a diploma. Comprehensive courses in hydro-geochemistry, geophysics, geohydrology, hydrology, groundwater geology and field training were given at this center together with other subjects. Since the establishment of King Abdel Aziz Al Saud University in Jeddah, this center became to be an affiliation of the university.

5.5 Decision-Makers:

Who need to be made aware of the nature of the problems of water sciences application in their own particular circumstances and aware of the necessity to apply the principles of environmental water management. In general they need to be informed about: the generalities of the hydrologic cycle, the methods involved in water resources exploration, development and environmental monitoring of the resource (surface water and groundwater), the consequences of misuse of the resource, the potential of modern remote-sensing and other data acquisition techniques, precaution measures against the resource pollution and the need for a high level of integration in planning and decision making to demonstrate that these situations are usually not amenable to solution by technical or sectoral inputs alone.

5.6 Field-Level Staff:

Here the emphasis needs to be not only on new technical advances such as human and animal powered water lifting devices, hydropowered water lifting devices, wind powered water lifting devices, solar powered water lifting devices, electric and fossil fuel engines, water management, and the socioeconomic factors of the community, but in methods of rapid rural assessment. Thus the extension worker will become less the traditional "bringer of good news" and instead will become a point of contact between the local community and the planning level. The extension worker will, therefore, often require a much broader training and retraining than is commonly available or practiced at present.

In some countries hydrology candidates have a basic civil engineering training, in others they are recruited from among physicists, geographers, hydraulic engineers, geologists or mining engineers. Each country has its preferences and therefore the description of the educational system should be based on the traditions of the country itself.

Important descriptive items are entry requirements, curricula, numbers of students over the last 5 years, capacity of the institution to increase the number of students, profile of the teachers, ratio of hours of practical work versus classroom education, administrative aspects such as availability of fellowships, etc. job opportunities and the kind of job the respective graduates are going into and the eventual social profile of entrants in this kind of education.

## VI. In-Service Training and Other Training Activities:

Several levels can be distinguished, between which are the following:

### 6.1 Lower Technician Level:

In most countries, in-service training is most appropriate and practical. In-service training means all training organized by the service or ministry in which the trainee is working. The lower technician is probably best trained by his supervisors. The problem in this case, however, is that often these supervisors are not trained to teach. Therefore, in some countries, the first step to be taken is to train supervisors in the pedagogical field.

### 6.2 Higher Technician and Middle Level Engineering:

There is a great need for increasing the number and improving the quality of middle level technicians in the majority of countries and, in particular, in developing countries. Even for countries which now have middle level formal education institutes, post-school training is particularly needed for those appointed to supervisory posts when formal education and/or in-service training had not yet been established.

### 6.3 Post-University Level:

In general, post-university training is available and, in most instances, it is of a high level. This type of training lends itself greatly to international participation and, in face, a large number of such courses accept non-nationals. All UNESCO-sponsored post-graduate courses are designed for international access, particularly from developing countries, and about 200 trainees benefit from these courses annually.

In-service training and other post-school or post-university training may be needed in the circumstances to:

* Adapt the general knowledge acquired at school to the specific requirements of the job to be done. The effort to be made, in duration and intensity, depends on the discrepancy between school-acquired knowledge and job requirements. This is most apparent when no specialized training institutions exist within the formal educational system.

* To acquire new knowledge as it becomes available or because the equipment, circumstances, or job requirements change; because in the course of development of the country new kinds of specialization are required.

* To keep the quality of personnel at the required level. Those who do not keep up with recent developments will gradually become less qualified to carry out their functions and loss of self-confidence will ensue.

Middle level engineers and higher technicians have usually received a theoretical background at their formal training institutions, but this is usually not sufficient to facilitate adaptation to new technologies and methods without assistance from higher trained personnel. Continuous training is therefore necessary.

In-service training activities have both a technical and social functions and are of the greatest importance for keeping the work force competent and aware of their social and economic role.

In some countries it may be very difficult to organize this kind of training due to either the very small number of people involved, the size of the country, lack of funds, management capabilities or other reasons. In such circumstances the situation will not be adequate from this viewpoint. However, criteria for adequacy cannot be quantified internationally; it would even be difficult, in many cases, to quantify them nationally. Therefore, the evaluator will be required to apply his best judgement in indicating the extent to which such lack of in-service training contributes to the inadequacy of the basic water resources assessment programme.

## VII. UNESCO's Achievements in International Hhdrosciences Education and Training Programmes:

The International Hydrological Programme (IHP), as an integral part of the efforts made by United Nations system as a whole to promote a rational policy for the development and management of water resources around the world.

The realization of the significance of a scientific basis of hydrology, in the development of water resources began in the years following the Second World War. In 1950, UNESCO launched a programme of research on the world's and zones in which hydrology formed an important role, followed in 1964 by the launching of the International Hydrological Decade (IHD) which made a significance contribution to the understanding of the processes occurring in the water cycle, the assessment of surface and groundwater resources, and the adoption of a more rational attitude towards water use.

As a result, in 1974, the General Conference of UNESCO launched the long-term International Hydrological Programme (IHP), with the aim of finding solutions to the specific problems of different geographical conditions and different levels of technological and economic development: The main purpose established for the IHP, which is the major Component of UNESCO's water resources programme, was to develop a scientific and technological basis for the rational management of water resources both as regards quality and quantity. Its objectives were:

* To improve the assessment of water resources managements;

* To improve the evaluation of the influence of human activities on the water cycle;

* To promote education and training in the field of water resources; and

* To increase the capacity of Member States to develop and manage their water resources.

The first phase of the IHP was executed from 1975 to 1980. It included studies of scientific and practical value such as those on:

- Hydrological parameters for water projects;

- Hydrological aspects of draught;

- Changes in the hydrological regime due to various human activities;

- Hydrological problems related to energy development;
- The dispersion of pollutants in aquatic media;
- Socioeconomic aspects of urban hydrology;
- Aquifer contamination and protection; and
- Land subsidence due to groundwater abstraction.

By 1980, numerous symposia and workshops in the field of hydrology had been held and some 1500 specialists in hydrology had been trained in UNESCO - sponsored or UNESCO - organized courses, twice as many as had been trained during the IHD decade from 1964 to 1974. The following table shows the number of participants of UNESCO course of English speaking countries of Africa, ordered after their home country:

| COUNTRY | COURSE AND YEARS | | |
|---|---|---|---|
| | HERARE 1984 | LUSAKA 1982 | LUSAKA 1974 |
| 1. Botswana | 1 | 2 | 2 |
| 2. Ethiopia | 1 | 2 | 3 |
| 3. Gambia | - | 1 | - |
| 4. Ghana | 2 | 1 | 3 |
| 5. Kenya | 4 | 2 | - |
| 6. Lesotho | 3 | - | 2 |
| 7. Liberia | 2 | 2 | - |
| 8. Malawi | - | 2 | - |
| 9. Mauritius | - | - | 2 |
| 10. Seychelles | 1 | 1 | - |
| 11. Sierra Leone | 1 | 1 | 1 |
| 12. Tanzania | 5 | 3 | 2 |
| 13. Uganda | 1 | 1 | 2 |
| 14. Zambia | 2 | 10 | 3 |
| 15. Zimbabwe | 5 | - | - |
| TOTAL | 28 | 28 | 20 |

The second phase of IHP was of a three year duration, lasting from 1981 to 1983. It accentuated the problem-solving aspect that IHP-I had begun to assume considering multi-purpose uses of water resources and with the protection of those resources, with emphasis on ecology, economic and social factors. Among the emphasis given were:

- Regional activities and national initiatives parallel to the International activities of IHP;

- Particular hydrological aspects of different climatic and morphological regions and areas, such as arid and semi-arid zones, humid tropical zones, flatlands, zones of perennial snow and ice;

- Creating an awareness by planners and decision-makers and the general public of the importance of water resources planning an management in socioeconomic development and the role IHP is to play in helping to solve water problems in the future;

- Education and training activities in the field of hydrological and water resources; and

- The role of infrastructures in the field of water resources, and the development of scientific and technical information systems for water.

These were reflected in the work of about twenty symposia and workshops convened by UNESCO or organized with its support.

To alleviate what were perceived to be some difficulties, a number of actions were undertaken specifically in water resources education and training:

* The number of courses was greatly increased; this increase enabling a greater coverage of geographic regions, languages subjects;

* A greater regional emphasis on training activities was begun - with emphasis on Central America, Africa, Asia and Latin America - as well as on transfer of educational activities from developed regions to developing regions; and

* Appropriate guidance material for technical training courses organized by UNESCO was developed.

Among other achievements of IHP-II were:

- The reinforcement of regional and sub-regional co-operation in IHP activities through the implementation of three major regional projects on the rational utilization and conservation of water resources in rural areas in Africa, the Arab States and Latin America and the Caribbean; and

- Close co-operation with international organizations such as the World Meteorological Organization (WMO), United Nations Environment Programme (UNEP), International Atomic Energy Agency (IAEA), the International Association and Hydrological Sciences (IAHS), the International Association of Hydrogeologists (IAH), the ICSU, Committee on Space Research (COSPAR) and the International Commission on Irrigation and Drainage (ICID).

With the results of IHP-II as a background, the programme and plan of IHP-III was developed at the Paris meeting of the Intergovernmental Council of the IHP in 1981 to be executed over the period 1984 - 1989.

IHP-III aimed at taking information to the user through regional seminars, workshops and symposia with supporting pilot demonstration projects wherever possible. On-the-job training was also included for those who would later apply the processes. Emphasis was given to technician level training in addition to traditional technical studies and regular education components of earlier phases of the IHP. The development of technical documents also continued. The IHP-III was essentially keyed to targets contained in the United Nations Water Conference (1977) Action Plan with the ultimate goal of solving the crucial hydrologic water management and water - related socioeconomic development problems as could be foreseen from 1981 onwards. In spite of its 18 themes, the plan developed, essentially maintained the two main lines of emphasis as in previous phases:

* A scientific programme devoted to the consolidation and advancement of knowledge; and

* An education programme comprising the transfer of knowledge, techniques and skills.

As already indicated above, the plan consists of 18 themes, divided into 4 sections:

1. Hydrological processes and parameters for water projects (themes 1-5);

2. Influence of man on the hydrological cycle (themes 6-8);

3. Rational water resources assessment and management (themes 9-12); and

4. Education and training, public information and scientific information systems (themes 13-18).

Education and training activities cover all aspects of water sciences and are directed at all levels from middle-level technicians through undergraduate to postgraduate. Two main programmes will be followed :

- Hydrology education for the training of specialized personnel (middle-level and postgraduate); and

- General water resources education with emphasis on the integrated aspects of water resources management at all levels from technicians through graduate engineers to decision-makers.

IHP-IV (1990-1995) is a continuation and an enhancement of almost a quarter of a century of hydrologic and water resources activities under previous phases of the IHD and IHP.

Worth-mentioning, UNESCO published a technical document by V. Maniak in 1989 on "Model Curriculum For Short-Term Courses For Senior Hydrology Technicians", as an IHP-III Project.

The model was designed to provide the structure for the teaching of basic hydrological subjects, field work and special optional supplements. It includes advice on how to prepare, organize and execute courses.

An IHP-IV project was covered by the first meeting of the IHP working group on curricula and syllabic for hydrology in university education. It was held in Vallendar (Federal Republic of Germany) during 17-19 October, 1990. The meeting was tabled the following material:

* Curricula and syllabi in hydrology (UNESCO, 1983);

* Integration of environmental aspects in water resources engineering education (UNEP/UNESCO, 1983);

* Evaluation of the UNESCO - sponsors post-graduate courses in Hydrology and Water Resources, UNESCO 1988;

* Questionnaires prepared within IHP-III project; and

* Material provided by the participants.

## VIII. ROSTAS ACTIVITIES:

In cooperation with the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), the following activities held in Damascus, Syria:

a. Training course on Management of Water Resources In Expanding Urban Areas In the Arab World (17-22 October, 1987).

b. Training course in Water Resources Technology and its Application for Developing Rural Areas in the Arab World "Special Workshop on Rain Water Harvesting" (15-21 October, 1988).

c. Appropriate Technology for Water Resources Assessment and Development in Arid and Semi-Arid Zones [Course I: Survey and Assessment of Groundwater Resources] (19 August - 9 September, 1989).

d. Workshop on Water Resources Development Strategy Under Drought Conditions (25-27 October, 1989).

In addition to the above-mentioned joined activities with ACSAD, UNESCO/ROSTAS, under the auspices of the International Hydrological Programme (IHP), sponsored/organized the following activities:

8.1 The UNESCO Regional Office for Science and Technology for the Arab States (UNESCO/ROSTAS), the Tunisian National Committee for IHP and the Directorate of Water Resources, Ministry of Agriculture in Tunis organized a regional seminar on "Integrated Water Resources Management in Arid and Semi-Arid zones in the Arab region" in Tunis (March 5-10, 1990).

Twenty-three specialists participated in the meeting: Algeria (1), Bahrain (1), Egypt (1), Jordan (1), Syria (1) and Tunisia (10).

Two consultants from United States and Poland, representatives from UNESCO Headquarters and ROSTAS, ALECSO, World Bank and UN/ESCWA participated in this meeting.

The purpose of the meeting was to discuss and elaborate on the main report entitled: " Approaches to Integrated Water Resources Management in Humid Tropical and Arid and Semi-arid Zones in Developing Countries", by: Maynard M. Hufschmidt (USA) and Janusz kindler (Poland), to present country reports and to join a one day field trip in Tunisia.

The basic purpose of the main report mentioned above, is to contribute to the development and adoption of much-needed integrated approaches, which can accommodate the climatic and physical differences as well as commonalities between the arid and semi-arid and the humid tropical. Specifically, the report is aimed at helping water resources users, managers, analysts, planners, educators, administrators and policy-makers make better decisions on the effective use of water resources in achieving national, regional and local goals.

To this end, the review and analysis of existing approaches and the presentation of a suggested approach focus on actual management situations that exist in developing countries. Emphasis is placed on approaches that will be relevant to water resources management problems likely to be encountered over the next two decades. No attempt is made to present a complete systems analytic model that deals with all complexities of the hydrological and human regimes. Rather, the treatment pf the topic is selective, concentrating on those aspects of water resources management which experience has shown to be most problematic. Four such aspects have been identified for emphasis:

(1) Handling the environmental, social, and cultural consequences of water resources projects, by incorporating studies of such consequences and measures for their alleviation at early stages of project planning, rather than considering them only after major decisions have been made.

(2) Effective integration of watershed land management with water resource development, of streams, lakes and ground water, in order to deal effectively with important land-water linkages in the river basin such as erosion, sedimentation, pollution, flooding and water yield.

(3) Rational allocation of water among competing uses in the context of efficiency, equity, and other objectives. This includes emphasis on the "demand" side in water resources management, including the use of water pricing along with technical measures to help allocate water resources properly, attain more efficient use, and thus to balance demand for and supply of water.

(4) Attaining effective implementation of project plans through use of economic and other incentives, decentralization of project management including involvement of local people in planning and implementation, and making necessary changes in organizations and institutions, including laws, regulations and informal arrangements.

The realities of the water resources situation in arid, semi-arid and humid-tropical countries present a serious challenge to water resources management well into the next century. In spite of the problems associated with water development, pressing needs for food, energy and domestic and industrial water supplies require that surface and groundwater resources be used much more effectively than at present. The challenge for water users, planners, managers, and policymakers is how best to achieve such development to contribute effectively to meeting social and economic goals, while maintaining the water resources on a sustained yield, yield, high quality basis, and avoiding serious degradation of the physical environment and unacceptable social disruption.

The following papers were presented and discussed:

* Salinity Control and Reclamation Project - A Case Study.

* Methods de Replacement pour la Planification et la Gestion Integree des Ressources en Eau en Regions Arides et Semi-Arides.

* Experience of Jordan in Planning and Managing Water Resources.

* Water Resources in Algeria.

* The Tunisian Experience in Ground Water Artificial Recharge by Treated Wastewater.

* High Aswan Dam: A Follow up of the Major Effects and their Impact.

* Water Resources Management Projects in Egypt and their Impact on the Environment and Economical and Social Aspects.

* Report from Syria

* Report from Oman.

During the course of the meeting, participants discussed in details the following issues:

1. Water is limited, thus there is a need for a "General Public Awareness Programme".

2. Water needs a strong authority.

3. Water uses: municipal, industry, agriculture, hydro-power, inland navigation, fisheries, recreation, etc.

4. Demand management and effective use of water resources [ the need of sewage water treatment, industrial water recycling, crop pattern to maximize value of production per cubic meter of water, water quality control, restrict pollution (reducing leakage), make use of short intensive rainfall events, conserve water in small dams, make use of any groundwater available (conjunctive surface - groundwater use) ].

5. Training (technicians and young engineers) and research, better facilities needed.

6. Make use of saline (brackish water) in agriculture.

7. Management of upstream watersheds (above storage reservoirs).

8. Operation and maintenance of water systems (minimize seepage and evaporation losses).

9. Strategic future options of using seawater, economic and social justification of using sea and brackish water.

10. Enforcement of water resources legislation at the national level (water police).

11. Agreements in shared basins.

12. Low-cost supported technologies (pumps, appropriate sanitation facilities, drip irrigation).

13. Water pricing, demand control.

14. Desertification prevention and control.

15. Evaporation control.

16. Cloud seeding.

17. Cooperation among hydrological institutions (data collection, environmental impact, water pollution control).

18. Public participation and involvement (top-down, bottom-up), effective use of crisis: flood, pollution, etc.

8.2 UNESCO/ROSTAS sponsored a regional seminar on "The Application of Remote Sensing to Hydrology and Water Resources" in Damascus, Syria (12-18 March, 1990) in cooperation with the Arab School of Science and technology.

The seven day intensive seminar was attended by sixty-six professors, scientists and researchers involved in the field of Hydrology and Remote Sensing in the Arab region.

Seminar participants came from: Algeria (1), China (1), Democratic Yemen (1), Egypt (2), Oman (1) Palestine (1), Qatar (1), Saudi Arabia (2), Sudan (1) Syrian Arab Republic (49), The Netherlands (1), Tunis (2), United Arab Emirates (4), the United States: three lecturers and a scientific consultant (4) and Yemen Arab Republic (1).

In addition to regular lectures concerning a comprehensive review of the latest developments and the most important problems related to remote sensing applications in the Arab region, fourteen short papers were presented from ACSAD, China, Egypt, Palestine, Qatar, SSRC, Tunis and the International Association of Hydrologists (IAH).

The regional seminar included also country reports from Yemen Arab Republic, United Arab Emirates, Sudan and Saudi Arabia and a regional report from UNESCO/ROSTAS.

Regular lectures dealt with the following areas:

1. The nature and practice of environmental remote sensing.

2. Hydrology and remote sensing:

   - Need for remote sensing.
   - Remote sensing techniques.
   - Computer based remote sensing.

3. Remote sensing applications in hydrology:

   - Hydrometeorology.
   - Surface water hydrology.
   - Hydrogeology and ground water.
   - Snow cover mapping and monitoring.
   - Remote sensing and Arid land management.

4. Practical considerations for the use of remote sensing in hydrology:

   - Analysis and transfer of data.
   - Geographic information systems.
   - Digital Terrain maps.
   - Others.

5. Future needs and prospects.

During the seminar, some films and videotapes relevant to remote sensing technology and applications were shown.

UNESCO/ROSTAS made available to the participants copies of the hydrogeological map, "IMPACT on Science and Technology number 62 on remote sensing", ROSTAS Bulletin, UNESCO/ROSTAS study on: "the Effective Application of Remote Sensing Techniques to Water Resources Development and Management in the Arab region" and ACSAD/ROSTAS/IHE-Delft study on: "Water Resources Assessment in the Arab Region".

Participants discussed ROSTAS study on remote sensing and emphasized the impact of groundwater rise on the ancient monuments in the Arab region and recommended UNESCO to save such valuable and important treasures (forming about 80% of the monuments of the world) in the ROSTAS region.

8.3 UNESCO/ROSTAS in consultation and cooperation with UN/ESCWA held an Expert Group meeting on "Water Resources Atlas in the Arab region" in Baghdad, Iraq (3-5 April, 1990).

Representative from UN/ESCWA, UNESCO/ROSTAS, UNESCO Headquarters, ALECSO and ACSAD participated in the Expert Group Meeting.

The Expert Group Meeting acting as a starting point to investigate the possibilities and to set up modalities for the publication of "Water Resources Atlas(s)", decided to establish a steering committee and appointed ROSTAS to follow-up matters related to the organization of next meeting, preparation of project document and an informative booklet and to contact other regional organizations concerned, such as: ALECSO, AFESD, ISESCO, ABEGS and IDB.

Part of the discussion centered on the possibility of utilizing remote sensing techniques and the possibility that the proposed project include the publication of three types of Atlases. The proposed three types of Atlases will tend to satisfy the special needs of:

(a) Technicians, (b) Academicians, and (c) The General Public at large.

During the course of the Expert Group Meeting, participants:

a. Assessed and evaluated previous ACSAD and UNESCO/ROSTAS cooperative work accomplished and in particular the hydrogeological map of the Arab region (scale: 1/5,000,000).

b. Set up the purpose and aims of the project.

c. Decided to use the Regional Geohydrological Information System (REGIS) to store and retrieve needed information.

d. Expected that the project may take about four to five years for preparation of the Atlases and about two years for printing.

8.4 In cooperation with the Egyptian National Committee for IHP, Ain Shams University, the Ministry of Public Works and Water Resources, Egyptian Ministry of Foreign Affairs, Egyptian Society for Irrigation Engineers, UNESCO/ROSTAS sponsored a post graduate training course on "Environmental Hydrology for Arid and Semi-Arid Regions".

The course has been designed to offer advanced education and training in the principles of environmental hydrology and to equip the trainees with sufficient competence in the collection, analysis and use of meteorological and hydrological data for integrated and natural planning of water resources development.

The two-month post graduate course (May-June, 1990), was held at Ain Shams University, Cairo, Egypt.

UNESCO/ROSTAS awarded six grants to six hydrologists from: Bahrain, Democratic Yemen, Jordan, Iraq, Saudi Arabia and Sudan.

8.5 At the initiative of UNESCO Regional Office for Science and Technology for the Arab States (UNESCO/ROSTAS) and as a follow-up to the recommendations of the Expert Group Meeting held in Baghdad, IRAQ (3-5 April, 1990), representatives from the United Nations Economic Commission for Africa (UN/ECA), the United Nations Economic and Social Commission for Western Asia (UN/ESCWA), Arab League Education, Culture and Scientific Organization (ALECSO), the Arab Center for the Studies of Arid Zones and Dry Land (ACSAD), UNESCO/ROSTAS and Dr. Kamal Hifni, Director of the Egyptian Research Institute for Ground Water, Egypt met in Cairo, Egypt (27-28 June, 1990).

It was decided that an Advisory Council will follow-up the implementation of this project. Full Members of this Council will be the representatives of the concerned regional and international organizations and three focal points representing concerned research institutions in the Arab region possibly one representative from the Maghreb, one from Egypt and one from the Gulf Area. The council can invite experts, consultants, representative of Non Governmental Organizations (NGO's) and others as observers.

The meeting recommended that the proposed project document presented by ACSAD was accepted as a phase one of the project and called upon UNESCO/ROSTAS and ACSAD to draft a comprehensive project where the second phase of such project will include the generation of about 10 to 14 other maps at different scales (1/200,000 - 1/500,000), concerning certain countries and shared water basins in the Arab region. These basins and countries will be designated at a later stage.

The participants emphasized that the proposed revised project document should include detail description of objectives, purpose, methodology and manpower requirement and should be written in English and to be translated -if possible- into Arabic and French languages.

8.6 The following documents which was contracted with various research institutions in the Arab region, were disseminated to concerned hydrologists and institutions in the ROSTAS region:

a. Lecture notes of the training course on "Management of Water Resources in Expanding Urban Areas in the Arab Countries" organized by ACSAD in co-operation with UNESCO/ROSTAS in Damascus, Syria, during October, 1987.

b. Lecture notes of the training course in "Water Resources Technology for Developing Rural Areas in the Arab World - Special Workshop on Rainwater Harvesting", organized by ACSAD in co-operation with UNESCO/ROSTAS and held in Damascus, Syria (15-21 October, 1988).

c. Lecture notes of the training course in "Appropriate Technology for Water Resources Assessment and Development in Arid and Semi-Arid Zones: Course I: Survey and Assessment of Groundwater Resources", organized by ACSAD in co-operation with UNESCO/ROSTAS and the Federal Institute for Geosciences and Natural Resources (BGR) in Damascus, Syria (19 August - 9 September, 1989).

d. Lecture notes of the workshop on "Water Resources Development Under Drought Conditions", organized by ACSAD in co-operation with UNESCO/ROSTAS and held in Damascus, Syria (25-27 October, 1989).

e. "AFLAJ, the Traditional Groundwater Development System in the Arab Gulf States," by ACSAD in co-operation with UNESCO/ROSTAS.

f. "Al-Sakia, the Traditional Water Extraction System Used for Irrigation in Egypt," published by the Water Research Center, Ministry of Irrigation, Cairo, Egypt in co-operation with UNESCO/ROSTAS.

g. "Al-Faqarah, the Traditional Water Extraction System Used for Irrigation in Syria," expected to be published by the Syrian Ministry of Irrigation in co-operation with UNESCO/ROSTAS.

h. UNESCO/ROSTAS recent publication entitled, "the Effective Application of Remote Sensing Techniques to Water Resources Development and Management in the Arab region".

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