WATER TECHNOLOGY TRANSFER TOOLS

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Keywords: Technology, technology transfer, education, training, formal education, continuing education, research and development, software transfer, networking, professional bodies, publications, intellectual rights

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Summary

Water resources technology transfer, for it to be effective must be accompanied by appropriate transfer tools which take into cognizance the socio-economic and cultural conditions of the recipient country. The complex of transfer tools must be seen within the framework of creating also a solid foundation of human and institutional capacities necessary for the analysis and the choice of technologies. The main tools for technology transfer, including software, are discussed under education and training (both formal and informal), research and development, software transfer pool systems, professional bodies, scientific and technical publications and networking of water sector institutions,

which put together also constitute the main means for achieving capacity building. Technology transfer and capacity building must be seen as a process of developing the necessary regional and local infrastructure base necessary for adapting and assimilating the most needed technologies, knowledge and information bases, indispensable for the development of the water resources of developing countries in order address the urgent questions of food security, access to clean and adequate water and sanitation facilities, while conserving the environment.

1. Introduction

From a historical perspective, water technology transfer from one area to the other was enhanced through conquests of new territories and the exigency to replicate the socio-economic structures existing in the conquerors' environments. Examples are the Roman aqueducts found in various parts of Europe and North Africa. Another is the extensive irrigation systems the Aryans introduced into India and present day Sri Lanka. The exploration and subsequent colonisation of vast areas of the world accelerated the transfer of technology, especially in water supply systems to many countries. To a lesser extent, there was also the technology transfer for irrigation and hydropower development. The process of assimilation of technology during this period by the local population was through the experience acquired in the construction and management of such water resources projects, mostly through on the job training and apprenticeship. The low levels of development and exploitation of water resources in developing countries in contrast to the growing demand for water in response to population growth and socio-economic development, necessitate urgent infusion of much needed technologies into water resources development and management. The aim of any technological use or transfer is to effect a given action either for water use development or for water resources assessment and management.

Hardware technologies are normally commercially acquired or acquired through aid and cooperation projects. The main tools for technology transfer, in the case of software are formal and non formal education, applied and joint research, networking of water institutions, etc which together also constitute the means to achieving capacity building. Research and development activities not only substantially contribute to technology transfer but also create the necessary conditions for adaptation and assimilation of new technologies by building up the human and institutional capacities necessary for integrated water resources management.

2. Education and Training

2.1. Formal Education

The first mechanism of technology transfer is mostly through the process of acquisition of knowledge through the formal educational system at vocational and university levels. At each level the students are introduced to the state of the art of the hydrological sciences and water resources systems and also the basic technological and infrastructure needs. Vocational training for technicians is normally carried out in technical institutions at various levels, such as general technical education and for specialised higher levels within public works, civil engineering and agricultural schools.

Technicians need the knowledge necessary for the installation of new technologies and maintenance of existing technologies. Water professionals are normally drawn from different disciplines of university education like civil, agricultural or mining engineering and other fields of physical sciences like geology, geography, physics, etc. First degree courses in hydrology, hydro-meteorology, and water resources engineering are available only in large countries with enhanced water resources activities whereas most countries depend more on post-graduate training course to prepare professionals in hydrology and water resources. With respect to postgraduate studies and with special reference to the UNESCO-sponsored training courses, an attempt is made at this stage to filter out background biases towards creating professional hydrologists, water resources engineers and managers. It is also at this level that attempts are made to convey hydrological and water resources concepts and more specifically the advances in the science and technology of the sector. Nevertheless, the general nature of the various curricula, developed first and foremost on the basis of the experiences of the host country and may not amply reflect the regional and national specific needs in hydrology and water resources of the recipient participants At all these educational levels the students are introduced to available hardware and software technologies and are encouraged to carry out comparative analysis of methodologies and techniques through course projects and case studies in order to adapt them to their specific problems.

Some of the pertinent issues on which postgraduate training needs could be focussed can be summarised as follows:

- non-uniformity of university curricula
- diversities of professional backgrounds
- different course emphasis at various training institutions
- diverse physico-climatic environments require specific top-up knowledge

2.2. Continuing Education Programmes

Continuing education, as a system of direct and indirect instruction, must in essence serve to reduce the lag time between the professional activity and the advances in science and technology in the field of hydrology and water resources. Continuing education must also provide the necessary link between the dynamics of changes in the hydrological and water cycles and the ability to perceive and manage them. In a world in which the physico-climatic ecosystems are continuously changing under human impacts, and advances in science and technology are moving at an ever increasing pace, training needs are dynamic rather than static. This situation poses a challenge to the formulation of such needs that can stand the test of time, including contemporary ideas of natural disaster reduction and the effects of impending climate change. Moreover, training needs would differ from country to country depending on the socio-economic level of development. This complex matrix of physico-climatic and socio-economic environments within which diverse professionals operate, requires a transversal format which could serve as a guide to national bodies for employers and employees alike.

The role of continuing education in technology transfer is to contribute to human and institutional capacity through a continuous process of updating knowledge in order to adapt and assimilate technologies developed in different environmental set-ups to the

exigencies of the receiving environment. This necessity stems from the fact that the progress of science and technology, increasing demands for development, and also the ecological-environmental challenge of our age, are calling for a larger number of highly trained water experts. The training needs for capacity building necessary for effective integrated environmental and water resources management call for a continuing education framework which blends together the multidisciplinary and multi-objective characteristics inherent in modern water resources development for sustainable development. In order to bridge the gap between professional practice and the advances in the science and technology for water resources development and management, a system of continuing education has become necessary through various forms like apprenticeship, short courses, distant learning facilities, correspondence courses, seminars, workshops, etc.

3. Research and Development

The role of research in technology transfer is fundamental since it creates the necessary tools and basis for updating and adapting a given technology to the new environment. Research can be basic or applied and more often than not are intertwined. Basic research deals with the increase in knowledge, creating new methodologies and techniques whereas applied research is more concerned with adapting available methodologies to specific objectives and local conditions and hence facilitating their application by users, in our case by water resources institutions. Research efforts contribute substantially to the development of both software and hardware technologies for assessment and management of water resources and also for the design of water projects. Even though research needs vary from country to country depending on the climatic, geographical and land use conditions, the socio-economic level of development also impacts the research needs in water resources. The dissemination and transfer of research results is considered an effective medium in the process of technology transfer between various researchers and most importantly from the developed countries to the developing ones, particularly if coupled with joint research efforts. Described below are two examples of partnerships in applied research that facilitate the transfer of methodologies and techniques of proven validity in one environment to a new one through actual testing and validation using physical and socio-economic data of the receiving environment.

3.1. The International Water Management Institute (IWMI)

The IWMI is a non-profit scientific research organization which is engaged in knowledge base development through applied research and the subsequent transformation of the results into tools for effective management of water and land resources in agriculture and other uses in developing countries. IWMI's research is coordinated through regional offices located in Sri Lanka, India, Pakistan, South Africa, and Thailand. The Institute has resident offices in China, Nepal, Ghana, Senegal, Kenya and Uzbekistan and operates in a non-resident mode in some 20 countries, across Asia and Africa. The research activities are centred around five thematic areas which address the following crucial issues in the water sector of developing countries:

- Integrated Water Management for Agriculture

- Sustainable Smallholder Land and Water Management Systems
- Sustainable Groundwater Management
- Water Resources Institutions and Policies
- Water, Health and Environment

The professional team, comprising economists, agronomists, hydrologists, engineers, sociologists, management specialists and health researchers, guarantees a multidisciplinary approach to water management research. The specific objectives of IWMI are as follows:

- Identify the larger issues related to water management and food security that need to be understood and addressed by governments and policymakers.
- Develop, test and promote management practices and tools that can be used by governments and institutions to manage water and land resources more effectively, and address water scarcity issues.
- Clarify the link between poverty and access to water and to help governments and the research community better understand the specific water-related problems of poor people.
- Help developing countries build their research capacities to deal with water scarcity and related food security issues.

Another activity worth mentioning is what the IWMI considers as its laboratory; that is identification of Benchmark River Basins in which the acquired water management tools and concepts are tested within a multidisciplinary framework, whilst at the same time updating the tools with continuous incoming data. This innovative strategy adopted by IWMI recently is to address issues relating to the water sector from a river basin perspective. A river provides a natural hydrological focal point for examining, analysing, and managing multiple and often competing uses for water by identifying the potential for water savings, increasing the productivity of water, and meeting the various social and environmental challenges. The Benchmark Basin initiative is an approach to understand and beneficially influence water resource development in selected basins in a variety of agro-ecological zones and committing resources to develop and maintain long-term research activities and data sets in these basins. In making a long-term commitment to benchmark basins, IWMI plans to conduct a significant amount of its own research in these basins.

Apart from the research activities, the institute also actively engages in knowledge and information dissemination by organising seminars and supporting regional and continental meetings dedicated to capacity building for integrated water resources management. Taking cognisance of the general lack of expertise and cadres for IWRM, the institute has also initiated a programme for young scientists from developing countries to carry out post-doctoral research work at various centres of the institute.

Finally, the IWMI is a practical example of pooling together human and financial resources from the North and channelling them to address the endemic problem of poverty in the South, and to ensure food security through a more effective management of their water and land resources.

3.2. The GLOWA Research Cooperation Programme

The aim of GLOWA is to develop strategies for sustainable and future-oriented water management at a regional level, taking into account global environmental changes and socio-economic conditions.

The Research programmes focus on case studies on large river basins where simultaneous research is carried out in a collaborative framework on interrelationships between changes in the hydrological cycle and:

- the large-scale climate and precipitation variability,
- changes in the biosphere (in particular caused by land use changes), and
- the effects on water availability and related conflicts of use.

The initiative was launched by the Federal Ministry of Education and Research (BMBF) of Germany which is also the main funding institution. A GLOWA project combines up to some 15 natural and socio-economic disciplines and ensures both a multi- and an inter-disciplinary framework, necessary for the development of research scenarios and tools. The initial GLOWA programmes launched in 2000 include:

- **Glowa Impetus**: Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa – case studies in the catchment areas of the river Dràa (Morocco) and Ouémé (Benin).
- **Glowa Volta**: Sustainable management of Water Resources: intensive land use, precipitation variability and water need in the Volta basin – case study in Ghana and Burkina Faso.
- **Glowa Elbe**: Integrated Analysis of the Impact of Global Change on Environment and Society in the Elbe Area.
- **Glowa Danube**: Integrative Techniques; Scenarios and Strategies concerning Global Change of the Hydrological Cycle of the Catchment Area of the Upper Danube.

Capacity Building Content of GLOWA: The programmes are formulated within the concept of a learning process in which the vital elements of knowledge and information exchange and technology development and transfer are given special emphasis. Specifically, students from both European countries and the project areas are offered the opportunity to carry out Masters and Doctoral studies using the methodological tools and techniques of these projects as part of their thesis. The partner institutions also benefit in the use of modern technological inputs of the projects and are the final users of the decision support systems being developed.

4. Software Transfer Pool Systems

Generally, hydrological and water resources soft wares have been developed in temperate climatic and in more advanced socio-economic conditions. Their transfer to the tropical climatic areas where most of the developing countries are found necessitate knowledge and skills capable of updating and adapting them to the physical and socio-economic conditions prevalent in such environments. Towards this goal a lot of efforts

have been put into the creation of technology transfer systems by various organisations and institutions in the form of pools or toolkits.

4.1. WMO Hydrological Operational Multipurpose System

The most notable and extensive of these is the **Hydrological Operational Multipurpose System** (HOMS), established by the World Meteorological Organization for the transfer of technology in operational hydrology. This is a pool of technologies which have been made available for inclusion in the system by the Hydrological Services of member countries of WMO based on techniques which they themselves use in their normal operations. This is an important aspect of the HOMS philosophy in that it ensures that the technology transferred is not only ready for use but also works reliably. They are usually in the form of descriptions of hydrological instruments, technical manuals or computer programs. An important aspect worth mentioning is that the request and transfer of the technology are carried out through bilateral contacts and therefore promotes feedbacks on the performance of the technology in the new environment. The technology available through HOMS is provided as separate HOMS components which, for easy reference, are classified into sections according to their subject matter as follows:

A. Policy, Planning and Organisation
B. Network Design
C. Instruments and Equipment
D. Remote Sensing
E. Methods of Observation
F. Data Transmission
G. Data Storage Retrieval and Dissemination
H. Primary Data Processing
I. Secondary Data Processing
J. Hydrological Forecasting Methods
K. Hydrological Analysis for the Planning and Design of Engineering Structures and Water Resources Systems
L. Groundwater
M. Mathematical and Statistical Computations
N. Training Aids in Operational Hydrology

Even making allowances for the diverse environmental and institutional situations encountered around the globe, it is evident that National Hydrological Services face the same basic challenges the world over. Thus, the probability is high that, when a Service is addressing an issue for the first time, the technology needed has already been developed and tested somewhere else.

In this context, WMO has the responsibility to foster the organized transfer of technologies of proven efficiency to the national hydrological communities, in particular those of developing countries, to avoid unnecessary waste of human and economic resources. Accordingly, since 1981, WMO has operated the Hydrological Operational Multipurpose System (HOMS) to achieve precisely this goal.

In addition, WMO has key a role in providing technical guidance in the fields of operational hydrology and water resources management, based on the consensus of international experts. To this end, WMO publishes, and regularly updates, both a Guide to Hydrological Practices and a series of Technical Regulations. Specific issues are covered through technical publications and reports, which often constitute the main, and sometimes the only, source of technical advice accessible to the National Services of developing countries.

4.2. Global Water Partnership Toolbox

The purpose of the **IWRM ToolBox** developed by the Global Water Partnership on Integrated Water Resources Management, is to make available to water management professionals the rich store of experience acquired by water practitioners, specialists and decision-makers worldwide.

The ToolBox builds on this experience and seeks to provide a forum for sharing knowledge and experience. The ToolBox has therefore been designed by the Global Water Partnership to support the development of Integrated Water Resources Management (IWRM) worldwide

Its aim is to support water professionals and policy makers by offering easy access to practical, non-prescriptive advice and, information on how to establish integrated water resources management in the real world. It provides a range of tools which users can select and modify according to their needs and each set of tools includes references, organisations, resource persons and relevant websites.

The IWRM ToolBox is primarily addressed to water resource management professionals such as water resource planners, policy makes, river basin managers and political advisors. Other users will include local government staff, non-government organisations and the general public with water related interests. It provides a range of tools which users can select or modify according to their needs and local circumstances and will be regularly updated with feedback from users. The structure for the Tools in the ToolBox is based on three fundamental elements of IWRM:

1. The enabling environment or rules of the game created through legislation, policy and financing structures.
2. Institutional roles of resource managers, service providers, irrigation agencies, utilities, river basin authorities, regulators and other water sector stakeholders. Capacity building supports for the functions required in the various roles.
3. Management instruments: water resources assessment, demand management, public information and education, conflict resolution, regulatory devices, economic measures and information and communications.

The concept of creating a thematic toolbox for various sectors of water resources development and management is fast catching up with many international and non-governmental institutions, mostly in the developed countries and directed at facilitating technology transfer and knowledge dissemination to the developing countries.

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Global Water Partnership: IWRM Toolbox Community [The IWRM ToolBox draws together a wealth of experience and expertise in IWRM. It aims to support water professionals and policy makers by offering practical information and non-prescriptive advice on how to implement IWRM in practice. The GWP document on 'The Policy Guidance and Operational Tools on IWRM' was downloaded and contributed extensively in formulating various chapters of Water Resources Transfer Tools, including education and training, networking of water sector institutions]

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WMO: Official HWRP Home Page: http://www.wmo.ch/web/homs/hwrpframes.html [Describes the contribution of WMO in water resources technology transfer with special reference to HOMS]

Biographical sketch

Dr. Kodwo Andah was born in 1947 in Ghana. He is the Scientific Co-ordinator of the Water Resources Research and Documentation Centre, WARREDOC, of the University for Foreigners of Perugia, Italy. Dr. Andah obtained his M.Sc. in Civil Engineering with specialisation in Hydraulic Structures at the Patrice Lumumba Friendship University in Moscow in 1978. He later obtained his PhD in 1983 at the Hydrology and Water Resources department of the same University. He was invited by the Hydraulic Institute of the University of Genoa to carry out a research programme in Quantitative Geomorphological Approaches to River Basin Analysis and Response in 1984. He moved to Perugia in 1986 to coordinate the activities of the then newly founded Centre. WARREDOC's main activities are centred on organising an International Advanced Course on Water Resources Management for developing countries. He lectures on *Hydroemeteorological Data Collection Techniques and Network Design*, and also on *Quantitative Geomorphology of River Drainage Networks*. He also supervises case studies on real world hydrological and water resources problems brought in by the participants from Africa and Asia in particular.

His research interests cover Geomorphological Characterisation of River Networks and Hydrological Response, Analysis of Extreme Hydrological Events, Analysis of Water Resources Systems, Modelling of Agricultural Droughts, Capacity Building in Water Resources Management.

Dr. Andah has participated and continues to participate in various capacity building initiatives sponsored by the European Commission, specifically in EUWATERMAN, the European Union SOCRATES/ERASMUS Project co-ordinated by Budapest University of Technology and Economics on the development of water management policies in Europe, and he has been a member of the Management Committee of the TEMPUS Joint European Project on *Decision Making for Flood Protection* within a process of continuing education and institutional capacity building for Public Administrators in the Czech Republic. He has had a number of special service agreement consultancies with WMO. He has extensive experience in organising and coordinating international scientific meetings and summer schools not only on water resources but also on hydrogeological disaster prevention. He is presently engaged in the organisation of a 6-month postgraduate training course on Integrated Water Resources Management for water professionals from sub Sahara African countries. Dr. Andah has been nominated as a member of the Peer Review Committee for the publication of the African Water Development Report (AWDR). He is an author and co-author of more than 60 scientific and technical papers and has edited a number of proceedings.