

**Nepad's "Science & Technology" Forum  
African Research Centers of Excellence on Water  
Nairobi workshop (9-12 May 2005)**

**Scientific and Technical Training  
and NEPAD centres of excellence in water sciences and technology**

**Background paper on challenges in education and research for the African Water Sector**

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Increasing the economical return from water was lately the main motivation: water supply, irrigation, hydro-power, navigation, flood prevention etc... Recently, the increasing scale of such projects involved an important interaction between the hydrological parameters and the development of societies at the global scale. Moreover, the number of local and regional water management failures is increasing despite an apparently higher level of engineering solutions (Berndtsson *et al*, 2005).

Water problem has become a great concern to many African countries. At the Addis-Ababa Conference, (4-6 November 2004) focussing on the specific issues of the African States in shaping Water for Food and Ecosystems, it appeared that, Africa, one of the world's driest continents, is facing a water crisis affecting 300 million people. The diminishing availability of usable water in the face of rising demand creates the potential for conflicts over water resources, both within and between countries. Recurring cycles of long droughts, sometimes followed by floods, accentuate water scarcity and imbalances across the continent.

This paper aims to examine the challenges which African education system needs to meet in order to train technicians, engineers and scientists able of responding to contemporary and future water problems for a sustainable development in Africa. It endeavours to find how the New Partnership for Africa's Development (NEPAD) - with its emphasis on regional cooperation and integration – can reinforce higher education institutions in Africa.

### **Present state of education in water sciences and water engineering**

During undergraduate studies, water sciences are often taught in the curricula of various courses in civil and agricultural engineering, forestry, fluid mechanics, meteorology, geography and geology. In some courses, water sciences are treated as a subject of secondary (or marginal) interest, in others as a source of data for application within a major discipline as agriculture. In geography or in geology they are taught as a component topic where the water cycle is usually presented in a rather descriptive and non-quantitative manner (Nash *et al*, 1991). Water is a large subject involving a wide range of disciplines and interests from hydraulic engineering to social mobilisation, from environmental and public health issues to business management.

Post graduates studies are more often conditioned by the nature of the primary training of the participant. Civil engineers with interest in water sciences became hydrologist engineers. Some geologists similarly became hydrologists. Very few post graduate studies are completely devoted to water. Browsing the list of 2227 higher education institutions in 59 African countries and neighbouring islands available on the website <http://www.chem.ru.ac.za/afuniv.html> we would find that only 9 public or private tertiary educational institutions in Africa include the word "water" in their title.

Another fact is the diversity of organisations and diploma dedicated to higher education in water sector. Education and training takes many forms from Universities offering under- and post-graduate degrees to Institutes offering diploma courses and training. It is often very difficult for an undergraduate student to pursue in another university. For Africa which needs to do economies of scale, the lack of dotted lines between the education institutions is significantly hampering.

### **Water related problems to be taken into account by the next generation in Africa**

Increasing water consumption induced by recent development, including irrigation, has raised the stakes on water sharing, collective use and environmental protection of this natural resource. Water and land use planning should not only focus on the mobilization of the resource in order to make it available according to the needs, they should also take in account many others goals such as (Falkenmark, 1998, Lundqvist *et al.*, 2003):

- Water supply security: development and maintenance of water / sanitation infrastructure for both urban and rural areas. The World Water Forum<sup>1</sup> estimates that, about 2 billion people globally will have difficulties in find-

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<sup>1</sup> <http://www.worldwaterforum.org>

ing safe water sources in the coming decade. In Africa alone, 19 nations are listed by the UN Environment Program as being the most water stressed countries in the world.

- Conflict prevention: water sharing based on water ethics including human rights, poverty eradication, democratisation and gender issues...Ample opportunities exist for advanced cooperation on water in Africa. Africa has some 80-transboundary river and lake basins, and the catchments areas of the 17 largest exceed 100,000 square kilometers each. Large transboundary rivers flow through many countries. For instance, the Nile has 10 riparian countries; the Congo (which holds almost 30% of Africa's freshwater resources) has 9, the Niger 9, the Zambezi 8, the Volta 6, and Lake Chad 5. Moreover, several international rivers cross many countries - 12 rivers cross Guinea
- Crop security: simple drought proofing technology based on rainwater harvesting, crop testing and breeding for tolerance to drought or to salt can save a big amount of water dedicated to irrigation.
- Water-related land fertility degradation prevention: water erosion, salination, nutriment management...
- Risk estimation and flood prevention.
- Pollution prevention: waste management, agricultural chemicals etc...

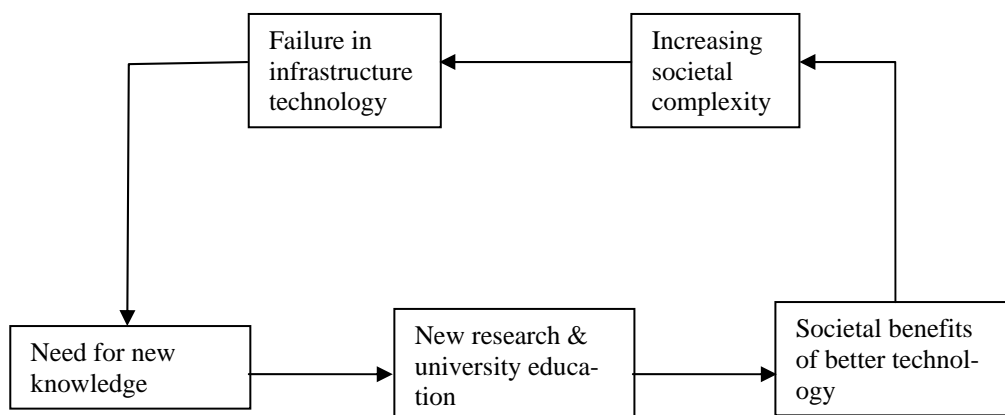
Water engineers will play a quite crucial role in promoting quality of life, particularly in dry climate countries with rapid population growth. By adopting the Millennium Development Goals, countries of the world pledged to solve the important existing problems of development by rethinking water management.

Water management has to deal with a multi-faced, multidisciplinary problem; it should have a human dimension and should be placed in its proper social context. The ecosystem approach is far- removed from the full multidisciplinary of complex water problems. Alternatively, the human dimension needs to be introduced for relevant problem-based instead of discipline-based solutions. Consequently, university curricula should try to establish strong links and new cooperative initiatives with socio-economic and human sciences.

Moreover the technical aspects, new infrastructure, such as dams, long water lines or deep drillings, contain an indisputable ethical dimension and responsibility that the engineer must accept and be able to handle. The public must be always well-informed, about potential advances, imminent risks, long-term effects and potential dangers of planned and/or implemented water projects. The education of water engineers should include techniques to evaluate and provide information about the risks and uncertainties in the short and long terms for water projects. Water engineers need to explain to stakeholders, stakes of each hydraulic installation and management rules. They need to popularize the general rules of water management and water-savings to the general public. University education needs to include trainings in communication skills, on the ways to approach and inform the interest groups, on the capacities to meet oppositions and the ability to negotiate.

### Why education and research need to be close and linked?

The rapid development and increasing complexity of water problems in Africa call for new way to fowl the mark of land and water planning. "Education is linked to research in the way that new ideas and thinking, are to great extent, examined and tested in research and implemented in education. At the same time, society's urge to develop new science and engineering knowledge is often driven by the wish to resolve failures in infrastructure technology (fig.1)" (Berndtsson *et al*, 2005).



**Fig. 1** "Simplified scheme on how failure in infrastructure technology may be seen as society's need to develop new thinking and new knowledge to resolve these problems, thus increasing needs for new education and research" (Berndtsson *et al*, 2005).

Currently, the knowledge in water sciences is generated within the academy; scientific problems are set and solved by scientists who decide of priorities autonomously and collegially. These scientists gather in international associations which are used to do the state of the art of the discipline and to decide on the next challenges. One of the most important international association for water sciences is IAHS for “International Association for Hydrological Sciences” which belongs to the International Union of Geodesy and Geophysics (IUGG); its objectives are:

- To promote the study of Hydrology as an aspect of the earth sciences and of water resources.
- To provide a firm scientific basis for the optimal utilization of water resources systems, including the transfer of knowledge on planning, engineering, management and economic aspects of applied hydrology.
- To provide for discussion, comparison, and publication of research results.
- To initiate, facilitate, and coordinate research into, and investigation of, those hydrological problems which require international cooperation.

Other organizations are also involved in the development of sciences in the water sector of among which one can quote:

- IHP UNESCO, the International Hydrological Programme (IHP), UNESCO's intergovernmental scientific co-operative programme in water resources, is a vehicle through which Member States can upgrade their knowledge of the water cycle and thereby increase their capacity to better manage and develop their water resources. It aims at the improvement of the scientific and technological basis for the development of methods for the rational management of water resources, including the protection of the environment.
- IWRA, the International Water Resources Association goal is to improve water management worldwide through dialogue, education, and research.
- WWC, the World Water Council is the International Water Policy Think Tank dedicated to strengthening the world water movement for an improved management of the world's water resources and water services.
- GWP, the Global Water Partnership support integrated water resources management programmes by collaboration, at their request, with governments and existing networks and by forging new collaborative arrangements.
- ...

Africa takes a very small part in the works of these associations, apart from South Africa, Nigeria and in a minor way Morocco and Algeria. One objective of NEPAD centres of excellence in water sciences and technology must be to be present in these instances and to share the relevant knowledge of the future needs.

### **Networking, exchanges of students and scientists, equivalent diplomas**

NEPAD centres of excellence in water sciences and technology shall contribute to the development of quality education in water sciences and water engineering by encouraging co-operation between African States and networking with the institutes of research and higher education of non African States. If necessary, they shall support and supplement the action of African education institutes in the water sector, while fully respecting the responsibility of the States for the organization of education systems and their cultural and linguistic diversity. They shall encourage cooperation for a common basic content of teaching.

NEPAD centers of excellence shall be aimed at:

- Developing the African dimension in education in water sciences and water engineering, particularly through teaching and dissemination of African climatology, African hydrology and African water needs and water uses;
- Encouraging mobility of students and teachers, by promoting the academic recognition of diplomas and periods of study;
- Promoting cooperation between educational establishments;
- Developing exchanges of information and experience on issues common to the education systems of the African States.

In Europe, 40 countries are now involved in the Bologna process (Bologna Declaration, 1999). Its aim is to make the higher education systems in Europe converge towards a more transparent system. The different national systems would use a common framework based on three steps - Degree/Bachelor, Master and Doctorate. They are very close of North American educational structures. Many African States which have strong links and networking experiences with European education system are adopting also the Bologna process principles:

- A system of academic grades which are easy to decipher and compare, including the introduction of the diploma supplement (designed to improve international "transparency" and facilitate academic and professional recognition of qualifications);
- A system essentially based on 2 cycles for graduate studies : a first cycle geared to the employment market and lasting at least three years and a second cycle (Master) conditional upon the completion of the first cycle;
- In addition, the doctorate cycle will henceforth be covered by the Bologna reforms, thus promoting closer links between the higher education area and research area;
- A system of accumulation and transfer of credits mobility of students, teachers and researchers;
- Cooperation with regard to quality assurance.

NEPAD centres could not be unaware of the Bologna process and should encourage the African Institutes which conform to it.

The appendix shows Institutions which are taking in account the principles of Bologna Process through The African and Malagasy Council for the higher education (CAMES) in West Africa.

### **Private sector in water education and water research**

All major companies in the water sectors: Vivendi Veolia, Suez, SAGEP in France, German energy conglomerate RWE... have an important action in education and research. The researchers of these major companies have created a network of R&D units all over the world to gather scientific intelligence. Ambitious programmes are carried out to improve existing technologies and prepare for customers' future environmental requirements.

For example Veolia research unit has a budget of €140 million and focuses development work on innovation and cost-effective performance. The R&D unit relies on feedback, a vision of future environmental requirements and scientific exchange of information with customers. It contributes to the more basic research which is carried out at Veolia Water's research center, Anjou Recherche, as well as to many international programs.

The Company of Paris' Water Management, SAGEP, takes part in the information and the sensitizing of the public to the questions of water. It is for this reason that it chose since 1989, to engage specific actions towards the children. In 1991, the first Parisian water class was born. The water classes of Paris have the role to initiate the participants in water, its cycle, its circuit, its treatment, and to sensitize the public with citizens behaviors for a better use of the resource and its safeguarding.

### **Few recommendations**

After this review of the education system in water sector, it is possible to suggest few recommendations in this workshop.

Regionally, it exists, as we have seen for West Africa (Annex), a range of offers going from technician school in agricultural engineering (ETSHER of Ouagadougou) to PHD (doctorate cycle of Cheikh Anta Diop University in Dakar).

Excellences centres of Nepad must have federator actions to facilitate networking between different formation's institutes.

They must also promote links and exchanges with Universities and Research Institutes in Europe and North America.

Traditional instruments of these exchanges are:

- Grants for students who want to follow a die which will bring them from a country to another, maybe in Europe or America for specialities not available in Africa yet.
- Stay grants for teachers and researchers who would like to follow a formation in Northern Countries.
- Visitor Professors in African Institutes to teach or to share research program in Africa.

In these initiatives, technician schools have to be in the foreground. Actually, technologies are quickly exceeded and a renewal in technical formation must follow those in informatics and electronics.

Let us take for example flow measurement of rivers. Nowadays, measures by ADCP method become the rule in hydrology while technician schools like AGRHYMET or ETSHER use only measure with current meters.

Data loggers and data transmission in hydrology, as well as in climatology are more and more sophisticated, electronics evolved quickly. Training for technician, initial training but also professional training has to be encouraged.

At a higher level, doctorate cycle and research institutes a convergence with international research centres must be a priority. Actions are recommended for:

- A better access to the scientific production,
- Subscription to specialized magazines and to online scientific papers,
- Participation to conferences and seminary...
- Participation to scientific associations like "IAHS", "IHP/UNESCO", "IWRA", "World Water Council", "Global Water Partnership".

## **APPENDIX**

### **Few examples of African education institutions in the water sector which can interest NEPAD Centres**

These examples have been chosen among French speaking Institutes, only because they have relationships with the AUF (Agency of French speaking Universities) which I am very familiar with. All these education institutions practice a regional and international networking. They belong to the The African and Malagasy Council for the higher education

(CAMES). They are committed in reforms which must bring them closer to the European establishments taking part in the Bologna process.

### ***ETSHER – EIER in Ouagadougou (Burkina Faso) (ETSHER –EIER, 2005)***

The Group of Schools EIER-ETSHER was created in 1972. Each year fifty students coming from Member States receive a bachelor degree and about forty a Master degree in (i) civil engineering, (ii) agricultural hydraulics, (iii) environmental engineering, (iv) water management, (v) energy or (vi) data processing.

To contribute more effectively to the economic development of the Member States in the fields of water, energy, environment and infrastructures, EIER-ETSHER Group is increasing its offer of formation and research by improving its adaptation to the needs for the private sector. It engaged an important reform to harmonize its educational system with the international system (Bachelor, Master and Doctorate). It gives greater importance to new technologies of information and communication (NTIC); allowing students to get easy and flexible access to internationally recognized high level formations. This reform should permit an increase in manpower, a diversification on profiles. This reform on the programs was accompanied by a deep administrative reform

The group is centred on its activities of academic training and research, by outsourcing all other activities on the basis of a cost analysis. A complete recasting of the schools financing system was adopted to ensure their survival in case of an interruption or a reduction in the subsidies given by the backers. The mechanism of States contribution was re-examined and simplified to improve the transparency and covering. Mechanisms have been set to allow the Member States and the backers to follow and control effectively the budget as well as the use of public resources.

The Member States are engaged to prepare a completely renewed legal structure to answer the new administrative needs.

The partners are:

- School of civil and environmental engineering : ENGEES of Strasbourg (France)
- Federal Polytechnic School of Lausanne (Switzerland),
- National School of Agricultural, Water and Forestry Engineering : ENGREF (France)
- Universities based in Ouagadougou (Burkina Faso), Niamey (Niger), Dakar (Senegal), Lomé (Togo), Cotonou (Benin) and Yaoundé (Cameroon)

The financial partners are the Member States, France, Denmark, Switzerland, Germany, Agency of French Speaking Universities (AUF), West Africa Economic and Monetary Union (UEMOA)

### ***Master and Doctorate cycles on “Environment and Water” at UCAD in Dakar (Senegal)***

In the framework of “Bachelor, Master and Doctorate” reform, UCAD (Cheikh Anta Diop University in Dakar) is aiming to establish a Masters and a doctoral school in the fields of Water and Environment which would combine all its faculties: Literature, biology, geography, mathematics, physics, medicine...

The purpose of this new vocational education is to provide a multidisciplinary teaching covering the main water issues preparing the students to a professional career as researchers or specialists of a high educational level.

The program includes the following subjects:

- generation and renewal of water resources
- water quality preservation and water rational management
- relations between “water-human society and wildlife”
- impacts of climate change and human activities on water resources

Its major fields of intervention are:

- Hydrology which is currently taught at FLSH ( Literature and Humanities Faculty) by the Geography department endowed with a renown research laboratory (especially in French-speaking countries). Almost all the researchers of this lab. have obtained their doctorate in the framework of programs mediated by IRD (French Institute for Research for Development) scientists and researchers.
- Hydrology, hydraulics and chemistry at the faculty of sciences. This faculty has a Master degree (DEA) in hydrology in which BRGM (French Geology Office) and IRD have partaken.
- Biology, environmental sciences and physics of the atmosphere at the Faculty of Sciences and Techniques.
- Parasitology, ecotoxicology at the Faculty of Medicine and Ppharmacy.

This discipline is based on the UCAD networks, whether they are local: centre of ecological monitoring, OMVS, OMVG, or international such as IRD, BRGM, European and North American universities.

Through CAMES and AUF, this teaching program endeavours to become regional and to federate other academic initiatives of higher education.

## ***AGRHYMET in Niamey (Niger)***

The AGRHYMET (AGRONomy, Hydrology, METeorology) Regional Centre (ARC) is a specialized institute of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). It is an interstate public institute with a legal status and financial autonomy. It has an international status and is based in Niamey, Niger (Chevallier *et al*, 1998). Its objectives are:

- To contribute to achieving food security and increased agricultural production in the CILSS member States.
- To improve natural resource management in the Sahelian region by providing training and information for the development of stakeholders and partners in agroecology taken as a whole: agroclimatology, hydrology, crop protection....

Over the years, the AGRHYMET Regional Centre has asserted itself as a regional Centre of Excellence in:

- training officers from Sahelian countries and elsewhere;
- regional agrometeorological and hydrological monitoring ;
- agricultural statistics and crop monitoring;
- regional databases;
- management and dissemination of information on natural resource monitoring across the Sahel;
- documentation on agrometeorology, crop protection, environmental monitoring, desertification, natural resource management, etc;
- maintenance of meteorological instruments and electronic equipment;
- Strengthening interstate co-operation by sharing methodologies and technologies.

Accordingly, the expertise of officers of the Centre is increasingly sought-after by bilateral and multilateral organizations (USAID, FAO, WHO, IRD, CIRAD, etc...). The AGRHYMET Regional Centre also takes part, in conjunction with the CILSS system, in international meetings on food security, sustainable development, natural resource management and desertification control.

## ***CRESA Network***

CRESA or the regional educational centres specialized in agriculture, offer academic career oriented education in southern countries.

They aim at training managers capable of taking part in the rural and agronomic development of the countries of the region. The recruitment is done by university students or recent graduate students or by professionals and managers that have a similar educational background and a new work experience.

Five CRESA covering specific sectors are currently working in different establishments in the following countries:

- Economy and rural sociology at the Research Center of Economy and Social Sciences at Abidjan University (Ivory Coast).
- Civil engineering and hydraulic equipment at the inter-states School of engineers (EIER) at OUGADOU-GOU in Burkina Faso.
- Agronomy and crop production at the agronomic Faculty of Science of Niamey in Niger.
- Water management and irrigation at the Agronomic and Veterinary Institute Hassan II of Rabat in Morocco.
- Forest and wood engineering at the Faculty of Agronomy of the Dschang University in Cameroon.

Two CRESA are planned in Indian Ocean:

- "Rice and rice growing" at the agronomy School of Antananarivo (Madagascar)
- "Sugarcane growing and sugar industries" at Reduit Faculty of Agriculture (Mauritius).

## **References**

- Berndtsson, R., Falkenmark, M., Gunnar, L., Bahri, A., Jinno, K. (2005). Educating the passionate water engineer - a remedy to avoid future water management failures? *Hydrol. Sc. J.*, **50(1)**, 7-16
- Chevallier, P., J.P. Goutorbe, and F. Maraux (1998), Evaluation de la Participation de la Coopération Française au Programme AGRHYMET. Secrétariat d'Etat à la Coopération et à la Francophonie. Fond d'Aide et de Coopération - Projet Régional 162/CD/93, pp. 85, ORSTOM, CIRAD, Météo-France, Montpellier, 1998.
- EIER - ETSHER (2005) Document d'orientation stratégique – Horizon 2005-2010. Le groupe EIER- ETSHER : Une nouvelle ambition au service des Etats. 27p. + An.
- Falkenmark M., (1998). Meeting water requirements of an expanding world population. *In Science, Technology, and Society, University Leadership Today and for the Twenty first century*; ed. By Ingmar Grenthe. Symp. For the Dean of the Royal Institute of Technology, Janne Carlsson, 2 June 1998, KTH, Stockholm Papers in Library and Information Science, Stockholm
- Lundqvist J., Appasamy, P. & Nellyyat, P. (2003). Dimension and approaches for third world city water security. *Phil. Trans. Roy. Soc. Lond. B Biol. Sci.* **358**, 1985-1996

Nash, J.E., Eagleson, P.S. Phillip, J.R., van der Molen, W.H. (1990). The education of hydrologist. (Report of the AAHS-UNESCO Panel). *Hydrol. Sc. J.*, **35**, 597-607

The Bologna Declaration on The European space for higher education. (1999)

<http://europa.eu.int/comm/education/policies/educ/bologna/bologna.pdf>