PROCEEDINGS OF THE CONFERENCE ON EXCHANGE OF EXPERIENCES IN WATER RESOURCES MANAGEMENT BETWEEN AFRICA, CHINA, LATIN AMERICA AND EUROPE

Ispra (Varese)
October 15-18, 2012
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Joint Research Centre – Ispra, Italy
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FOREWORD

Water is one of the most important of the natural resources upon which all life on Earth depends; however a number of factors, both environmental factors and those resulting from anthropic pressure, are threatening its availability. Despite the efforts made towards achieving the millennium development goals during the last decade, access to improved water supply or basic sanitation is still not available for millions of people across the world. Presently, 783 million people still lack access to clean water and more than 3.4 million people die each year from water, sanitation and hygiene-related diseases. May 2013, the UN stated that the Millennium Development Goal target for safe drinking water was reached while the World is unlikely to meet the sanitation target. Although the UN estimates that by 2015, 92% of the global population will have access to improved drinking water, behind these average global figures, strong disparities appear across regions and between urban and rural areas all over the world. It is foreseen that only 67% of the world will have improved sanitation access by 2015, far from the 75% expected by the Millennium Development Goals (MDGs).

In certain geographical areas, such as in sub-Saharan Africa, the situation remains critical and progress is largely insufficient. More has to be done in taking up the growing challenge of protecting and managing our water resources in a more sustainable and equitable way in order to address the needs.

With a common approach and a global understanding of the different threats that our water resources are suffering from, we can hope to find common solutions and guarantee protection to this vital resource. The conference “Exchange of experiences in water resources management between Africa, China, Latin America and Europe” held in Ispra, Italy on October 2012, marks an important step towards supporting this premise.

This conference was funded by the European Commission (EC) and organized by the Institute for Environment and Sustainability of the Joint Research Centre (JRC) of the European Commission (EC), in the framework of the EC support project to the African Union/NEPAD Networks of Water Centres of Excellence, managed by DG Development and Cooperation - EUROPAID. This scientific network provides the opportunity for its members to collaborate in building capacity and stimulating innovative research towards the development of the water sector in the African continent.

The objectives of the workshop were to exchange experiences and lessons learned on the application of innovative technologies, to disseminate results of successful projects, identify challenges in achieving sound science-based policies, and to reinforce international thematic partnerships.

The conference welcomed the JRC international water partnerships for water and development, including the NEPAD Networks of Water Centres of Excellence as main contribution of the event, the RALCEA-Latin American Network of Knowledge Centres in
the water sector, the China-Europe Water Platform Institutions and, finally, foremost European basin authorities with a long experience on the implementation of the EU Water Framework Directive. Consequently this workshop was characterized by a geographical, cultural and scientific heterogeneous representation of sector professionals.

By illustrating successful projects, research results and various countries’ science based policy, the participants exposed their respective challenges in managing water resources. These challenges were influenced by various factors such as climate variability, level of economic development and growth, level of urbanization, availability of water resources, institutional set up and sector policies. The conference highlighted the situation that China’s water problems are highly influenced by its fast growing economy while at the same time water quality and availability issues can limit this fast development. Africa’s water issues, on the other hand, focused more on the lack of targeted and effective water policies, limited economic development and partial availability of environmental data. Europe’s water challenges concentrated on the harmonization of water standards and norms as well as implementing the ambitious European directives on water management. Finally, Latin America’s focus was on protecting its water resources while at the same time sustaining a rapid economic growth.

Involving water experts from four different continents contributed to making the conference original in the mix of content and enriching in the exchanges. It proved to be a rare opportunity for professionals and researchers of numerous countries not only to present research activities, but also to exchange lessons learned and to identify solutions and innovative ways to address issues in water resources management. This work demonstrates the EC commitment through the activities being implemented by its services to developing sound cooperation and scientific research to improve the sustainable development of the water sector in its partner countries.

In conclusion, these proceedings represent the exchange and dissemination of good practices across four different regions, shedding some light on issues and proposing common possible solutions towards the sustainable management of our water resources.

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Abbreviations

AfWA African Water Association
AMCOW African Ministers Council on Water
AMCOST African Ministers Council on Science and Technology
ANN Artificial Neural Networks
ASUFOR User Associations of Rural Boreholes
AU African Union

BADEA Arab Bank for Economic Development in Africa
BQE Biological Quality Element

CAZALAC Centro del Agua para Zonas Aridas y Semiaridas de America Latina y el Caribe
CDC Centre for Disease Control
CEWP China-Europe Water Platform
CSIR Council for Scientific and Industrial Research – South Africa

DEM Equipment and Maintenance Division
DFID Department for International Development
DGPRE Water Resources Management and Planning Directorate
DHR Rural Hydraulic Directorate
DHU Urban Hydraulic Directorate

EC European Commission
EFD EU Floods Directive
EIB European Investment Bank
ENSO El Nino Southern Oscillation
EQR Ecological Quality Ratio
EU European Union

FCH Fundacion Chile
FET Further Education and Training
FICH Facultad de Ingeniería y Ciencias Hídricas de la Universidad Nacional del Litoral, Santa Fe

GIG Geographical Intercalibration Group
GLMs Generalised Linear Models
GoS Government of Senegal

HJKYB Hadejia Jaamare Komadugu Yobe Basin

ICPDR International Commission for the Protection of the Danube River
IDB/BID Inter-American Development Bank
IHP-UNESCO International Hydrological Program
IWA International Water Association
IWRM Integrated Water Resources Management

JRC Joint Research Centre

LWMS local water management schemes

MDGs Millennium Development Goals

NEPAD New Partnership for Africa's Development
NESREA National Environmental standards and Regulation Enforcement Agency
NDDC Niger Delta Development Commission
NGO Non-Governmental Organization
NWRI National Water Resources Institute - Nigeria

OMVG Gambia River Basin Organisation
OMVS Senegal River Basin Development Authority

PEPAM Programme Eau Potable et Assainissement (Senegal)

RALCEA – Latin American network of knowledge centres in the water sector
RFA-LM Regional Analysis Frequency with L-Moments
R&D Research and Development

SADC (Southern Africa Development Community)
SANWATCE Southern Africa Water Centres of Excellence network
SEEAW Social Economic Environmental Accounting for Water
SNA System of National Accounts- China
SWRM Strictest Water Resources Management Policy

UNESCO United Nations Educational, Scientific and Cultural Organization
UN–HABITAT United Nations Human Settlements Programme
UNICEF United Nations Children's Fund
USAID United States Agency for International Development

WAEMU/UMOA West African Economic and Monetary Union
WFD Water Framework Directive
WfGD Water for Growth and Development
WRDMAP Water Resources Demand Management Assistance Project
WRM Water Resources Management
WRMS Water Resource Management System
WSF Water Sustainability Flagship – South Africa
WSDP Water Sector Development Project
WHO World Health Organization
WFD EU Water Framework Directive
BACKGROUND OF THE CONFERENCE

1. Introduction

Environmental stresses imposed by population growth, urbanisation, industrialisation and climate change have become a prominent theme of international concern, especially since the 1992 Earth Summit held in Rio de Janeiro. One of the most affected of the natural resources is that of freshwater. Demands upon the world’s supply of freshwater resources are increasing which in turn brings greater threats and risks to both the quantity and quality of this natural resource which is essential to human life, health, and social and economic activities. The risks to water resources have raised attention at the political level which has in turn been translated into political commitment, within and between countries, for the protection of this vital resource.

In 2000, the European Union took a ground-breaking step when it adopted the Water Framework Directive, establishing a legal obligation by the EU to protect and restore the quality of waters across the European Union. Two years later it played an equally fundamental role in promoting and fostering the development of the water sectors in partner countries. By adopting in 2002 the Communication on water management in developing countries, which set out the EU priorities for development cooperation on water, the European Commission recognized the crucial role of water resources management for sustainable development. The EC not only recognized politically the importance of water but also concretely, during the period 2007-2012, committed expenditure of more than 2.2 billion Euros in developing countries on objectives ranging from providing access to water and basic sanitation to the poor to improving water resources management, governance and policies. The European Union development policy presently considers the management of water resources to be a crucial prerequisite for development as is laid down in the Millennium development Goals (MDG).
2. The conference - an international experience

Over the past 25 years the EU has been actively developing international scientific cooperation to address the needs and opportunities of an interconnected world, and to contribute to peace and prosperity for Europeans and its partner countries’ citizens.

Research is seen as an essential contribution to the solution of specific problems faced by different countries through equitable partnerships. The EU supports networking in science as a fundamental tool to increase the impact of research towards the society in Europe and between Europe and its partner countries. Cooperation and coordination of research activities carried out at national or regional level in the European Member States supports the establishment of European Research Areas networks, improving the coherence and coordination across Europe in several research topics. At the international level with partner countries, in order to increase the exchange of experiences, partnerships and their coordination, the EU employs a series of instruments such as the Development Cooperation Policy.

In the case of this workshop, which involved Europe, Latin America, Africa and China, the JRC aimed at creating an opportunity for exchange between these main partners in development cooperation projects for water resources management. It is with this mutual learning and philosophy of sharing experiences that this conference was prepared.

The NEPAD African Networks of Water Centres of Excellence in Water in Western and Southern Africa are the first examples of a African Research Networks being promoted by the African Union. The EU decided to support this initiative through the JRC (Joint Research Centre) in Ispra. In a similar and parallel initiative, the EU - China River Basin Management Programme has been developed and is a successful example of bilateral cooperation in which European and Chinese experts were able to share experiences. The positive results of this collaboration laid the foundations for the establishment of the China-EU Water Platform, whose experts participated in this JRC workshop. The EUROCLIMA and the RALCEA regional cooperation programmes between the EU and Latin America regions implemented by the JRC are additional examples of the successful exchange of experiences.
3. Partnerships as an opportunity for exchanging experiences

This event was organised in the framework of the European Commission (EC) support project to the African Union/NEPAD Networks of Water Centres of Excellence implemented by the EC Joint Research Centre (JRC). Experts from Europe, China, Africa and Latin America were invited to the conference, which was held at the Joint Research Centre in Ispra (Italy) the 15-18 October 2012, in order to exchange their experiences and share lessons learned in water resources management.

As well as including the NEPAD Networks of Water Centres of Excellence initiative, the JRC took the opportunity of involving its other international water partnerships for water and development to the workshop. The list and profiles of the participating Partners are:

3.1 NEPAD Networks of Water Centres of Excellence

In 2009, in line with the EU Water Initiative’s mission, the EC decided to support the AU/NEPAD Networks of Water Centres of Excellence (Water CoE) in Western and in Southern Africa. The main objective was to find solutions to the challenge that in Africa much of the research and development in the water resource sector is highly dependent on aid and expertise from developed countries - in terms of knowledge and human resources (technical assistance/consultants) as well as financial support. The European Commission is supporting these networks with funding via the Joint Research Centre (JRC) to enable African Research to exploit the diversity of institutions and programmes available across the continent for south to south capacity development and strengthening the links between policy, research and higher education. The NEPAD Water CoE initiative has been officially adopted by the African Ministers Council on Science and Technology (AMCOST) and African Ministers Council on Water (AMCOW) in 2009.

The specific objectives of this initiative are:

- Improve conservation and utilization of the continent's water resources;
- Improve the quality and the quantity of water available for rural and urban households;
- Strengthen national and regional capacities for water resources management and reduce the impacts of water related disasters;
- Enlarge the range of technologies available for water supply and improved access to affordable good quality water.
3.2 RALCEA – Latin American Network of Knowledge Centres in the Water sector

In 2010, with the support of the EU Water Initiative, the EC acknowledged the significance of assisting Latin American countries through the development of a Network of Knowledge Centres (RALCEA) in the water sector for that region. In Latin America there are a number of knowledge institutions with a high level of technical and scientific expertise and a long experience in the water sector. However, these institutions have traditionally worked independently and are often disconnected from the policy level. This Network aims to improve water management and governance, beginning with capacity development at technical level cooperation which can impact decision making at the political level through information-based policies and decisions.

This partnership between the EU and Latin America, also implemented by the JRC, supports the development of a network of knowledge centres, a multi-stakeholder policy dialogue and assistance to institutional strengthening by promoting south-south cooperation.

The specific objectives of this initiative are:

- Poverty reduction and inter-governmental cooperation through increased capacity and improved governance in water resources management at regional and continental level.
- Fostering information-based policy and promoting south-south cooperation in capacity development for the water sector.

3.3 China-Europe Water Platform

At the 6th World Water Forum in Marseille, with the political support of the EUWI, representatives from China and the EU agreed to establish the China-Europe Water Platform (CEWP) for dialogue, joint research and private sector cooperation for better management of water resources. This Platform’s objective and mission statement recognizes that China and Europe face similar challenges in managing water resources, and that water resources are expected to come increasingly under stress from socio-economic development and climate change. The establishment of the China Europe Water Platform comes at the close of the EU–China River Basin Management Programme, a five-year bilateral cooperation programme in which officials and experts from both regions successfully shared experience in water management.
The CEWP will serve for:

- China and Europe, as leading global regions, to cooperate in achieving good governance of water resources
- Achieving a focused and efficient exchange of experiences and best practices for sustainable, environment-friendly integrated water resources management.
- Optimizing synergies of existing and future bi-lateral cooperation, research and private sector involvement.

4. **The objectives**

The four participating continents experience great differences in their water resources challenges, but also share common problems related to climate change, low stakeholder participation in decision making, water scarcity and increasing water demand. A significant objective of the conference was to foster dialogue between the participating high level scientists and sharing their challenges and solutions in order to create a more mutual understanding of approaches and methodologies for better water resources management on a global scale. The specific objectives of the conference were to exchange experiences and lessons learned on the application of innovative technologies, to disseminate the results of projects that successfully defined sound science-based policies, and to establish international partnerships.

5. **The topics**

The topics chosen for this conference were: water stakeholder analysis and participation, water resources balance and assessment, water quality and sanitation.

These themes are already part of on-going investigations and initiatives in each participating continent. They have been already identified by the NEPAD and RALCEA programmes as salient points in which scientific research must be enhanced in order to achieve better water resources management at regional and national level. These topics are especially relevant where partner countries may lack scientific capacity in one or more topics, where capacity exists it is not well coordinated at regional level, or research results are not well transmitted to the political level.

The overall aim of the workshop was that of improving water resources management. The approach was to arrange for the exchange of experiences between researchers of the 4 continents in each of the three topics, which was valuable to all in showing the great
differences as well as the common challenges faced by these regions, and ultimately to identify possible solutions.

5.1 Water stakeholders’ analysis and participation

Stakeholder participation is a process that allows power sharing, mutual learning and is capable of bringing about social change. In general participatory development is considered to be a process that empowers people by including local populations and stakeholders into the development and implementation of policies that will affect their lives and well-being. In water management this participation is an important part of the following principles:

<table>
<thead>
<tr>
<th>Box 1. Water stakeholder’s participation principles:</th>
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<tbody>
<tr>
<td>- Water entails an <em>ethical dimension</em>; there is no life without it. The ethical implication of water management denotes the importance of the participation of all human beings in the institutions responsible of their well-being.</td>
</tr>
<tr>
<td>- Participation in water management is important, allowing people to move from passive acceptance to active choices with regards to the resources that affect their lives; this reflects a democratic civic culture: <em>civic responsibility</em>.</td>
</tr>
<tr>
<td>- Interaction between the <em>political</em> and the <em>technical</em> experts in any developmental program is difficult; this holds true in the case of water management, where experts and politicians often do not work in agreement. Participation is fundamental in bringing together these opposing forces, both of which affect considerably water management.</td>
</tr>
<tr>
<td>- The participatory process is essential to <em>reduce the gap</em> between the geographical (watershed-river basins) and jurisdictional (administrative units) boundaries present in water management.</td>
</tr>
<tr>
<td>- Participation in the case of conflict resolution simultaneously facilitates that people to live together and to develop public interest and community will.</td>
</tr>
</tbody>
</table>

(Adapted from Priscoli, 2004)

Although participation is set as a fundamental principle within the IWRM principles laid down at the International Conference on Water and the Environment in Dublin 1992, in practice the concept of participation has produced little evidence of success, effectiveness or sustainability in the past. In retrospect, this has occurred where important decisions often resulted from top-down approaches. This has proved to be unsuccessful in comparison to projects where true and effective stakeholder participation of all people and institutions directly or indirectly affected by the project were taken into consideration.

In the framework of this international conference, stakeholder analysis with participation was the first theme to be addressed. Different experiences and methodologies of local projects where stakeholder participation was implemented were exchanged. The first day of the conference also highlighted stakeholder analysis as a fundamental tool for centres of
knowledge, academia and policy makers to identify who the key water stakeholders are in their country and what their capacities were.

5.2. **Water resources balance and assessment**

Water is an essential resource for all life on the planet. It is also important because it brings together global questions such as food security, public health, urbanization and energy. However, water is heavily exploited by mankind in an ever-increasing demand for activities such as sanitation, domestic consumption, manufacturing, food production, recreation and agriculture.

For a more sustainable future it is essential to know how we are presently using and managing this vital resource. Successful management of water resources requires accurate knowledge of the availability of the resource, its competing demands, its different uses, and appropriate mechanisms and tools to assess and minimize the environmental impact of human activities on the water resources.

Freshwater, including groundwater, is not confined to any administrative boundaries; therefore the management of this resource implies that an integrated approach between authorities such as countries who share the resources must be established. It is likely that the growing uncertainties linked to global climate change will lead to precarious situations at the local level, and that new management strategies will have to be implemented in order to address growing restrictions in the allocation and management of water resources.

Water resources balance and assessment was the second topic to be addressed at the conference. Water resources management best practices in different continents were presented, as well as studies evaluating consequences of climate variability on water. Specific topics included the development of environmental tools for assessing the ecological status of aquatic systems and presentation of water resources balances case studies on assessing the relationships between demand and supply. The purpose of this session was to share different methodologies, case studies and examples of water balance and assessment strategies for a more sustainable management and use of our resources.
5.3. **Water quality and sanitation**

This was the third topic to be addressed during the conference. Access to clean water and sanitation are considered by many current international agendas and platforms as a basic human right, indispensable for leading a healthy and dignified human life. Access to safe water and sanitation are key components of primary intervention for ensuring improved health and sustainable development. The present global challenge is that 783 million persons still do not have access to safe water and 2.5 billion people do not have access to adequate sanitation facilities (WHO, 2012).

The main challenges faced for providing access to safe water and sanitation are population increase, insufficient funds, increasing urbanisation, poor management of wastewater and increasing levels of water pollution from human activities (agricultural, industrial etc.). Potential solutions to these challenges are dependent on addressing gaps in the global knowledge of effective approaches (particularly for sanitation), and how to take solutions up to scale across diverse cultural, geographic and economic contexts.

On this topic, a range of commercial, industrial and natural sources of water pollution and contamination were discussed at the conference, including their impacts on water quality and the provision of sanitation services. The aim of this topic and the final day of the conference was to create synergies between diverse water experts, and facilitate the implementation of new methods and technologies to address this sector’s gaps by the exchange of solutions.

**References**


WATER STAKEHOLDERS’ ANALYSIS AND PARTICIPATION

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Stakeholder participation in China’s water sector .......................................................................... 19
Participation of stakeholders in the framework of IWRM in the Danube River Basin .............. 23
A stakeholder needs assessment for the SADC Region.............................................................. 28
ABSTRACT: Senegal, with an estimated population of 13 million and 70% rural population, is experiencing rapid urbanization. The demand for water in cities is increasing, requiring heavy investments in equipment and water infrastructure to improve water access and reduce poverty and health problems. Strong government support has enabled the development of good management policies in the water sector for both rural and urban areas, including investment of up to 450 million USD since the mid-1990s. Key success factors include: a strong government, political willingness and leadership to introduce and perform management oriented water sector policies and reforms, donor support and the confidence and full participation of all stakeholders in the decision making process. A number of key stakeholders are identified here, with consultations identifying a list of challenges. With urban migration, earlier respectable percentages of urban water supply are being challenged, while the shortfall of access for rural populations continues. Water quality is becoming more of an issue with salination occurring along coastal zones. Solutions such as desalination of mineralized water and dis-connection of treated water supply for irrigation purposes are among the results of the stakeholder consultation.

KEYWORDS: stakeholder analysis, water demand, water supply, desalination, Senegal

Introduction

Senegal has an estimated population of about 13 Million and around 70% are living in the rural area. However rapid urbanization is experienced which is increasing the demand for water in cities. Heavy investments in equipment and water infrastructure to improve access to water and to reduce poverty and health problems are highly needed.

Senegal institutional water reforms began in the 1970s, focusing on regionalization and decentralization of the water services. In 1996 the Government of Senegal conducted for the first time an ambitious water programme of investment estimated up to 450 Million USD to support water infrastructure projects in the rural and urban areas in order to face the country’s growing demand. Since then, the performance of water supply sector in Senegal has improved at a steady pace.

The key success factors of the water sector in Senegal were mainly due to: a strong government political willingness and leadership to introduce and perform water management
oriented sectoral policies and reforms in both the rural and the urban areas, donors’ support and confidence and full participation of all stakeholders in the decision making process.

**Senegal water sector challenges:**

**The rural issue:** Although the Senegalese government has achieved important successes in enhancing the urban population access to water (especially in Dakar), large discrepancies still remain between urban and rural areas. Urban access to water in 2006 was estimated to be at 93% compared to 65% of the rural one (AMCOW Country Status Overview (CSO2), 2010).

**The quality issue:** the physico-chemical quality of the water is a major issue in Senegal where the salinity level and the fluoride contents of the water often exceeds WHO standards. This is especially true in semi urban areas and some Southern and Central areas of the country.

**Shortages of water:** Populations of towns are growing very rapidly and water deficits have already been recorded in many towns where shortages are experienced. Among the possible solutions, we can mention the desalination of sea water in coastal zones. A desalination plant of a capacity of 50,000m³/day is being planned for construction by 2015.

**Stakeholders Participation:**

Seven main groups of stakeholders have been identified in Senegal by the author:

**Government Institutions:** important projects and reform have been initiated by the Senegalese Government both in the rural and in the urban areas. The Government of Senegal (GoS) has developed a national programmatic approach (PEPAM) to coordinate different sector actors’ efforts under a unified platform to achieve the MDGs for water supply and sanitation. Projects are designed, prepared and negotiated by the national Directorate and include the Rural Hydraulic Directorate (DHR), Urban Hydraulic Directorate (DHU), the Equipment and Maintenance Division (DEM), the Water Resources Management and Planning Directorate (DGPRE) of the Ministry of Water and Sanitation (Ministère de l’hydraulique et de l’assainissement). They control the feasibility of projects and ensure their implementation on the ground throughout the country. In each of the 14 regions, local decentralized water subdivisions (brigades) bring their expertise to local water associations
through technical interventions such as maintenance of borehole installations, conducting awareness campaigns and controlling operations in the rural areas.

**User Associations of Rural Boreholes (ASUFOR) and other water users associations:** in the urban areas water users are very present, active and organised into associations or consumer groups. They usually defend the right for a better quality of service and limiting the increase of water tariffs. They are present in water boards where there is the opportunity to evaluate the impacts of different policies on the population. They manage to engage the Central Government to be more aware of the situation of poor access to water. ASUFORs are local major decision-making bodies. In rural settings on behalf of the state, the ASUFORs manage the production and distribution of water supplied by tube-wells as well as the maintenance of installations and equipment. The strategy is to reinforce the capacity of local people to help them to install and manage their own water infrastructures, including charging the population for its water use. This improves the management and helps to generate financial resources from water service supply.

**Private sector:** reforms have been promoting the increase of private sector participation in water management in Senegal. A strong relationship was built through a public private partnership involving international and local financial institutions with international and local private companies to build up physical water assets and provide social engineering solutions. For the urban water supply, a private operator was designated by the Government to improve the technical, commercial and administrative management of the sector. The private company was controlled by an asset holding company which supervises the infrastructure building and oversees the private company’s other related activities.

**Donors:** donors are key stakeholders in water management for the country. Many bilateral agreements exist between Senegal and European countries (mainly France, Belgium and Luxembourg) and more recently Asian countries (mainly Japan, China and Korea). Other agreements exist with international institutions such as the EU, the World Bank, the EIB, the WAEMU/UMOA, the IDB/BID, the BADEA, UNICEF, USAID and UN HABITAT. Most of the funding from these sources support projects that focus on achieving the MDG that addresses water and sanitation.
Civil society, local and international NGOs: are important actors both in the rural and the urban water sector. The most active groups are Plan International, Enda Tiers Monde and Water Aid. They support investment plans and are very active in awareness campaigns on flooding, protecting water resources and in supporting local communities’ initiatives in the peri-urban areas and villages.

Shared catchment organisations - OMVS (Senegal River Basin Development Authority) and OMVG (Gambia River Basin Organisation). These two catchment basins organisations are under the management of their respective Ministries in charge of Water and have their Coordination unit in Senegal. The OMVS gathers 4 countries (Senegal, Mali, Mauritania and Guinea) for the management of shared water resources around the River Senegal. The OMVG builds cooperation and regional integration between Senegal, Gambia, Guinea Bissau and Guinea around the Gambia River in the Energy sector.

![Diagram of Senegal water stakeholders](image)
Main Challenges

During the stakeholder analysis study, the author identified together with stakeholders the following main challenges:

- to improve access to potable water both in the urban and the rural areas with affordable pricing by mobilizing new innovative infrastructures
- to disconnect the commercial crops farmers from treated water; this would help to economize an estimated 15,000 cubic meters per day by irrigating with untreated water;
- to address flooding in Senegal; recently the Government has designed a 1,180 million euro’s investment plan to solve the impacts of flooding in towns;
- to address the need for training and capacity reinforcement in the water sector in order to support and implement investment plans for the coming years;

References:


Latin America water sector stakeholders analysis

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ABSTRACT: The Latin American network of knowledge centres in the water sector (RALCEA) project was launched in Quito 2010. The project supports the development of a network of knowledge centres in the water sector in Latin America and fosters research in 3 thematic axes, one of which is stakeholder analysis and mapping. The main goals and expected results focus on capacity building. A consultation on capacity building needs is being carried out, and main activities planned to address these needs are regional trainings and workshops, national level courses and the development of tools for evaluating the activities.

KEYWORDS: RALCEA, stakeholder analysis, stakeholder mapping, Latin America, capacity building

Introduction

The Latin American network of knowledge centres in the water sector (RALCEA) project was launched in Quito in 2010. The project supports the development of a network of Knowledge Centres in the water sector in Latin America and fosters research in 3 thematic axes that have been defined in Quito for the first meeting of the RALCEA. Stakeholder analysis and mapping was identified as one of the 3 axes of research. This project aims to improve the water management governance through the network of the Centres of Excellence linking up with their policy maker representatives (known as focal points). This will begin with a technical level cooperation on capacity development in order to impact on the sector decision making at the political level.

In the Quito meeting the Knowledge Centres and the national focal points chose the 3 thematic axes in which they wished to take part. A coordinator for each thematic axis was elected. For the Stakeholders map axis The Facultad de Ingeniería y Ciencias Hídricas de la Universidad Nacional del Litoral, Santa Fe (FICH) was designated as the coordinator.

The coordination team developed a project to implement the main concepts of the axis through a three year work plan.

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The main goals of the stakeholder analysis axis are the following:
- To develop a capacity building strategy for the water sector in Latin America.
- To implement the strategy through different activities such as workshops, courses, seminars, etc.
- To develop and adapt tools to support capacity building in the Water sector in Latin America.
- To learn from the ancestral knowledge as well as modern experiences; promoting and disseminating these experiences across the region.

These objectives will be reached through networking between the Centres of Excellence that will complement each other’s specialties and knowledge to answer to the capacities needs previously identified within their respective National Focal Points.

The expected results and activities of the stakeholder analysis axis:

The 3 expected results are:

1. The capacity building needs will be defined in terms of groups, topics and skills.
2. A regional capacity building strategy for the water sector in Latin America will be implemented.
3. Tools will be developed that will assist the RALCEA partners, knowledge centers and national focal points, to address their needs in order to improve their performance in water resources management in Latin America.

To achieve these results the following activities will be carried on:

- Identification of the priority capacity building needs of national focal points.
- Development of a regional capacity building strategy for water management in Latin America.
- Annual work plans developed for the implementation of the regional strategy.
- Design and implementation of tools for evaluating progress and impacts of activities implemented within the framework of the regional capacity building strategy.
- Case studies and policy briefs for water resources management in Latin America to be drawn up.
- Interim and final reports.
- Develop manuals of good practices and lessons learned.

Some of the expected activities are detailed in the box below:
Box 2. Workshops, courses and tools:

- **1 regional workshop**: For identifying the most important capacity building needs in order to set the basis of the regional strategy (expected result 1).
- **1 regional course**: Training of Trainers (ToT) on the Principles of effective water governance (expected result 2).
- **1 regional workshop**: i) For sharing progress in the development of the regional strategy; ii) Evaluation and monitoring impacts and relevance of the strategy to improve the development of the water sector; iii) agreements on the most useful tools to develop “policy briefs” and “case studies” (expected result 3).
- **7 national training courses or other activities** to be defined in the framework of the proposals presented by the National Focal Points, objective to improve the performance of projects or organizations involved in the water sector (Bolivia, Colombia, Costa Rica, Ecuador, Mexico, Panama, Peru). (expected result 3)
- **5 tools** developed for the Knowledge Centres and National Focal Points to evaluate the impacts of the activities done. (expected result 3)

To address **expected result 1** the project has launched a Call by the National Focal Points for proposals to identify the capacity building needs and requirements. To this end, the team developed the terms of reference, the proposal documents and the guide for evaluation. In the Call, information from the applying institution is required regarding capacity-building related results such as expected improvement of performance resulting from capacity building activities.

The coordination team received 11 proposals from eight countries: Bolivia, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Panamá y Peru. These proposals covered a wide range of topics concerning capacity building needs, which can be summarized as follows:

- Strengthen the institutions to promote a better articulation between public and private sectors.
- Coordinate legal and regulatory frameworks for Integrated Water Resources Management.
- Identification of capacity building activities to be delivered to the water supply and sanitation sectors’ stakeholders.
- Develop strategies of communication and education for society awareness.
- Designing mechanisms for improved social participation.
- Develop and implement an Integrated Watershed Management Plan.
- Increase capacities for democratic water governance.
- Increase capacities for conflict resolution and negotiation.

**Conclusion:**
For the expected result 1 the coordination team will do a first evaluation of the proposals, but the final evaluation and the definition of activities will be done in the regional workshop to take place early in 2013.

Overall, the project aims to improve the performance of water management institutions based on a capacity building process. This is an opportunity for the creation of a new space for collaboration between institutions that belong to the scientific and technological system and the organizations which are responsible for water management in Latin America.

References

Stakeholder participation in China’s water sector

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ABSTRACT: China has long faced the challenges of water shortages, water pollution, flooding and soil erosion, which have constrained growth and affected public welfare in many parts. To address the growing severity of water issues, China has reviewed its traditional practice on water resources management and began a reform agenda in which participatory approach is one of its key components. This began in the 1990s in collaboration with international donors on water resources management projects in China. Stakeholder participatory pilot projects were launched at river basin levels and at the rural level for water supply and sanitation. Positive results from these pilots have been integrated into revised water policies which now promote participatory action and the role of society. This is a new and growing process, which addresses challenges of lack of awareness, information and limited resources for support.

KEYWORDS: China, stakeholder participation, water resources management

History of stakeholder participation in China:

In China the Government is the main decision-making entity and decisions are largely made through a top-down approach. Up until the beginning of this century inter-agency cooperation was weak and the water management sector was characterized by vertical and horizontal fragmentation. Furthermore institutional arrangements for river basin management had not proved to be very effective in dealing with issues such as water allocation among competing uses and jurisdictions (provinces, prefectures, counties), water shortages, water measurement systems and pollution control. With the arrival of international donors’ contributions into water resources management projects in China, new approaches were introduced.

Successful stakeholder participation pilot projects

With the assistance of international donors, China began testing stakeholder participation in water sector as early as 1990s.

The successful implementation of the Loess Plateau Watershed Rehabilitation Project financed by the World Bank demonstrated the potential benefits of participatory watershed planning. The project developed a fully participatory approach which enabled:
- Integration of farmers’ needs for income generation with government’s objectives of poverty reduction and ecological rehabilitation.
- Planning and financing agencies’ involvement both at central and local levels
- Agricultural, animal husbandry, forestry agencies participation at county level;
- Involvement of Women’s Federation in all counties to reflect their views

Later, based on this positive experience the **China Watershed Management Project** was carried out with the support of the Chinese Ministry of Water Resources and DFID (DFID, 2010). The aim of the project was to strengthen results-based monitoring for watershed management and it promoted participatory watershed management through the Participatory Watershed Planning and Design Process model as shown in Figure 1 below:

![Figure 1: The Participatory Watershed Planning and Design Process](image)

The participatory approaches were later extended to the rural water supply and sanitation sector through the **Water Sector Development Project (WSDP)** (WELL, 2010). The project’s main objective was to formulate pro-poor, participatory approaches and methodologies and promote them at the policy-making, planning and implementation levels of government throughout China.

Finally in 2005, through the Water Resources Demand Management Assistance Project (WRDMAP) (DFID, 2006) participatory river basin planning was also introduced along with the introduction of integrated water resources management (IWRM) approaches (see figure 2).
Enabling policies

In parallel with the donors’ efforts, China has been revising its water-related laws, regulations and policies. As the outcomes of these pilots projects, in cooperation with donors, were found to be impressive, the participatory approach has been included in the government policies on watershed management, irrigation and rural water supply. National programs have already adopted the concept such the “Safe Drinking Program” or the “Water Saving Society Program”. Under domestic water programmes, both at national level and local level, public education and participation approaches have been very often recommended. The government is addressing inter-agency collaboration on water issues, and supporting farmers and NGOs to participate in water resources management.
Conclusion:

Looking ahead, stakeholder participation in China’s water sector is still in an early stage which is constrained by several barriers such as insufficient awareness campaigns and information, lack of funds and coordination. Stakeholder involvement has not yet become a routine process and the extent of participation varies across different cases. Capacity to engage stakeholders effectively must be further built within water agencies at all levels.

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Participation of stakeholders in the framework of IWRM in the Danube River Basin

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ABSTRACT: The Danube is approximately 2,800 km long, making it the second-longest European river after the Volga, the catchment comprising of more than 800,000 square kilometers or about 10 per cent of continental Europe and touching 19 countries. The Danube River Protection Convention (ICPDR) was signed in 1994 defining three main areas for action: protection of water and associated ecological resources, sustainable use of water in the basin, and management of floods and ice hazards. Implementation of the Water Framework Directive is a high priority for the ICPDR, and this is achieved by the joint efforts of expert groups, task groups and involvement of stakeholders drawn from member countries of the river basin. In February 2010, the ICPDR hosted a Ministerial Meeting for its contracting parties, where the Danube Declaration was adopted, reinforcing the commitment of the Danube countries for transboundary cooperation in water management and inter-sectoral cooperation.

KEYWORDS: Danube, stakeholder participation, Danube River Protection Convention, Water Framework Directive, transboundary cooperation

The Danube River Basin and the ICPDR

From its source to the Black Sea, the Danube is approximately 2,800 km long, making it the second-longest European river after the Volga. Its catchment area, the Danube River Basin, extends into the territories of 19 countries and comprises more than 800,000 square kilometers or about 10 per cent of continental Europe, encompassing a wide variety of cultures, landscapes and ecosystems.

Historically, human activities such as households, industries and agriculture have put pressure on these ecosystems, contributing to decades of decreasing water quality. Problems built up that could not be addressed by individual countries alone. With the fall of the Iron Curtain in 1989, a new window of opportunity opened for the Danube countries and the need for cooperative water management became more obvious than ever.

The Danube River Basin is outlined by natural watersheds. Of the 19 countries that have territories within this basin, 14 cover more than 2,000 square kilometers. On 29 June 1994, these main Danube countries – some of them not situated on the river, but within the basin –
signed the Danube River Protection Convention (ICPDR, 1994) in Sofia, Bulgaria, defining three main areas for action:

- Protection of water and associated ecological resources
- Sustainable use of water in the Danube Basin
- Managing floods and ice hazards.


**Policies and management plans**

In 2000, the European Union (EU) adopted the EU Water Framework Directive (WFD) (EC; 2000). It mandates integrated water management according to the outlines of natural river basins rather than national or other administrative borders. Alongside the implementation of the EU Floods Directive (EFD) of 2007 (EC, 2007), the WFD is ICPDR’s highest priority as all its contracting parties, including the non-EU countries, agreed to coordinate its implementation.

A major milestone was achieved with the development of the 1st Danube River Basin Management Plan (DRBM Plan) in 2009 (ICPDR, 2009), based on an analysis of the main pressures, water uses and environmental conditions in the basin, and with the involvement of different stakeholders and interest groups during the elaboration process as required by the WFD (Article 14).

**Expert groups, task groups and involvement of stakeholders**

The ICPDR established different expert groups and a number of task groups dealing with specific issues, including inter alia monitoring and assessment, pressures and measures, nutrients pollution, hydromorphology, groundwater, flood protection, questions regarding river basin management as well as public participation and communication.

The expert groups and task groups draw their members from the contracting parties, typically the relevant ministries or agencies of countries, and from water-related stakeholders who have the official observer status within the ICPDR. The latter include organizations (currently
22) from areas such as hydropower, navigation, tourism, the research community as well as from internationally active environmental NGOs.

Observers not only attend official meetings of the contracting parties but are also strongly involved in the technical discussions of the expert groups and task groups, providing important input in the meetings which normally take place twice a year for each group. Although observer organizations do not have an official voting right within the ICPDR, their contributions are often essential for the ongoing work.

**Public participation and communication**

As indicated, one expert group established within the ICPDR is working specifically on public participation and communication issues. Covering those aspects is not only in compliance with the requirements of the WFD and EFD, but also because public participation and communication aspects were recognised as important elements for managing a river basin.

The expert group is facilitating the participation of stakeholders in particular during the public participation process for the development of the management plans according to the WFD and EFD (e.g. organisation of stakeholder workshops).

Furthermore, the ICPDR also works towards awareness raising and education. Each year, the 29th of June is “Danube Day”, celebrated in the Danube River Basin through the efforts of the Danube countries and more than 400 partners. Around 150 different events are organised every year, ranging from creative competitions to educational workshops. Throughout the basin, Danube Day has about 60,000 participants and many more are reached via media campaigns.

Another example of an awareness raising activity of the ICPDR is the “Danube Box” – a teaching kit for teachers designed for children between the ages of 8 to 13. With 10,000 Danube Boxes in English and the languages of the Danube basin, more than a million school children can be reached. The box was distributed in Germany, Austria, Hungary, Romania, Bulgaria, the Czech Republic and Bosnia-Herzegovina. Spin-offs such as the Saar Box or Orange River Box are supported by the ICPDR.
Increased efforts towards “integration”

In February 2010, the ICPDR hosted a Ministerial Meeting for its contracting parties, where the Danube Declaration was adopted. The document reinforced the commitment of the Danube countries for transboundary cooperation in water management, but also emphasised the need for intensified inter-sectoral cooperation. As a consequence, the ICPDR has increased its efforts in the engagement and dialogues with different sectors, in particular with inland navigation, hydropower and agriculture.

An ongoing process with the navigation sector was launched in 2007. This was done in cooperation with the Danube Commission (responsible for inland navigation along the Danube), the Sava River Basin Commission and with involvement of different stakeholders, which led to the adoption of the “Joint Statement on Inland Navigation and Environmental Sustainability in the Danube River Basin” (ICPDR, ISRBC and Danube Commission, 2007). This document formalizes a commitment to sustainable development of navigation by balancing environmental, economic and social aspects.

A further example is the currently ongoing process of elaborating “Guiding Principles on Sustainable Hydropower Development in the Danube Basin”. Due to significant efforts in increasing the share of renewable energy triggered by energy and climate mitigation policies, the ICPDR seeks towards a balanced approach, allowing for hydropower development but at the same time respecting environmental targets. This process was again set up with the involvement of competent public authorities (responsible for energy and environment) as well as with the involvement of representatives from the hydropower sector and environmental interest groups.

For further information on the ICPDR and ongoing activities please contact the ICPDR secretariat via http://www.icpdr.org.

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A stakeholder needs assessment for the SADC Region

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ABSTRACT: Estimates have been made on how many human resources in the education and health sectors may be required to meet the MDGs in these areas. In 2009 a methodology was piloted by the International Water Association to estimate the requirements to meet the MDG targets related to drinking water and sanitation. In 2012 a needs assessment was conducted in the SADC (Southern Africa Development Community) region by the Stellenbosch University. The assessment was undertaken in 2 phases or cycles of surveys, beginning with review of existing studies. The assessment also included an overview of water-related vacancies available in the SADC countries and with the major water-sector employers (private- and public institutions in the region).

KEYWORDS: Southern Africa, stakeholder needs assessment, water supply and sanitation

Introduction

International organizations such as the World Health Organization (WHO) and UNESCO estimated how many human resources are worldwide needed to meet the UN Millennium Development Goals (MDG) on education and health. In 2006, the WHO estimated that 4.3 million additional health workers would be needed worldwide and in 2010 the UNESCO estimated that 10.3 million new teachers would be needed for achieving universal primary education (IWA, 2011). Until recently in the water sector, the human resources requirements to meet the MDG targets related to drinking water and sanitation were unknown.

To answer to this lack of important information in 2009 the International Water Association (IWA) piloted a methodology in different countries around the world to collect data on the human resource gaps. The project was called the ‘Mind the Gap’ project and its outcomes are illustrated in the “Atlas of Professional Capacity”.

The Assessment

In 2012 a needs assessment was conducted in the SADC (Southern Africa Development Community) region by the Stellenbosch University presenting evidence from Mozambique and Zambia ‘Mind the Gap’ study and from the study financed by the European Commission Joint Research Centre and carried out by the Southern Africa Water Centres of Excellence network (SANWATCE). The purpose of this research was to assess human resource capacity
shortages and gaps specifically in the SADC region in the water and sanitation sectors. Southern Africa experiences water stresses which are likely to continue in the future. This situation is exacerbated by growing populations and expanding economies that are struggling to ensure energy and food security. Therefore specific targeted skills to manage the complexity of the water sector in the Region are needed.

The SANWATCE network was contracted by the JRC to carry out an independent investigation into the skills shortages that exist in the SADC region, and to further discuss how the Centres of Excellence members of the SANWATCE could address sector expertise and advocacy for sector development in the region. The methodology of the study will be first discussed followed by the study findings and recommendations.

**Research Methodology**

The following methodology, divided in two phases, was followed:

**Phase 1**

In order to better understand what water-sector skills gaps exist in the SADC-Region, a review of existing studies was undertaken. The results thus provided baseline data for this phase and were later used as secondary data. In order to determine the effectiveness of the survey questionnaire, the assessment of the skills shortages was conducted using an electronic survey as a pilot project in the current SANWATCE member countries (i.e. South Africa, Zambia, Botswana, Mozambique and Malawi). After the pilot study among the SANWATCE members, the survey was emailed to complete to a larger study area- to experts working in the water sector of SADC. A further skills assessment was done using an electronic database (SCOPUS, reference) of research outputs in all of the SADC countries. Universities, colleges and training centres from the SADC region were researched to determine the educational offering in the water sector.

**Phase 2:**

In this second phase an updated survey was designed to capture both qualitative and quantitative data. The data from the survey was analysed at country level and then compared with the results of the other countries in order to get to a regional overview. The survey was circulated to many institutions and networks related to the water sector in the SADC Region.
Conclusions and recommendation:

- The top vacancies in the SADC Region are for engineers, hydraulics engineers and water treatment specialists. Respondents felt that the best approach to develop these skills and fill the gap is by providing Further Education and Training (FET) outside the formal educational system (such as university degrees) and providing capacity building strategies and financing as shown in figure 1.

- Collaboration and cooperation between training institutions in developing new courses aligned with skill shortages. Create partnerships between service providers.

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2 The WISA is currently undertaking a similar project to determine educational skills gaps in the South Africa.
– Research driven capacity building should become a major focus of future investment in SADC in order to address the major backlog in terms of research output in the relevant priority areas for specific countries.
– Private- and public institutions provide the employment opportunities for individuals within the water-sector. Training institutions (such as Higher Education and Training institutions; Accredited Service Providers and Further Education and Training institutions) should align their educational offering to meet this need.
– Funding should also be made available for supporting scholars to attend the appropriate courses that are already available in the SADC region.
– It is evident that artisans; technicians and professionals are required in order to meet the needs of the water-sector in SADC. Promote FET courses to fill the gaps (not only degree courses).

References:


DAY 1 - roundtables conclusions

The first day of the conference introduced all the initiatives (NEPAD; RALCEA and the China-EU water Platform) in which the Joint Research Center and the European Commission are involved in water resources management.

The topic of Day 1 was “Water stakeholder analysis and participation”. Presentations ranged from analysis of stakeholders to case studies of successful stakeholder participation in water management projects.

The roundtables held at the end of the day provided a cue for reflections on the topic by highlighting the challenges, the lessons learnt and the potential solutions for stakeholder’s needs for capacity building, the role of platform and networks to facilitate stakeholder participation in the water sector and to which degree the IWRM framework impacts stakeholder involvement. Many challenges were highlighted, followed by fewer lesson learnt and solutions. This illustrated how complex is the topic and much research and action must be devoted to this important feature of water resources management. The exchange of lessons learned during discussions which followed after the presentations were relevant and important in stressing the differences and the common problems each country faced.

The challenges

- Little involvement of stakeholders in the decision making progress. Difficult for people to access this level of decision making. Push for institutional reforms and awareness campaigns.
- Lack of awareness of different stakeholders on water issues. Poor communication strategies to raise awareness and reduce the lack of participation. This needs appropriate resources, development of more effective strategies and especially time at national and local level to implement the strategies.
- Politics often too tangled in some stakeholder involvement initiatives. Need for some neutrality allowing the stakeholder discussion to be as independent as possible from external pressures and agendas.
- Poor interface between major stakeholders is, limiting the potential for exchange of information and ideas in policy, implementation and management of water resources.
Efforts should be made to coordinate the political level, society and the technical representatives. Where networks do exist, there is often a lack of commitment.

- Lack of capacities of many stakeholders. Building capacity of stakeholders should foster their participation.
- Lack of financial resources and or financial resources not well targeted at the implementation level. Funds from external support and donor partners are not always getting past the institutional gate and down to the level of individuals who need finances to actually implement strategic activities and follow up on management regulations.
- The technical and research stakeholder groups must be more involved with knowledge dissemination to other stakeholders.

Lesson learned

- Research community needs to be involved actively and set up protocols for communication and knowledge dissemination of research results and other relevant information such as syntheses of important issues.
- Important to be realistic to have sufficient time for public participation.
- Important to develop technical training in addition to university courses.
- Water stakeholders’ needs must be analyzed and addressed. This helps greatly in fostering their participation, (e.g. developing technical training).
- Accountability and good governance stimulates stakeholder participation.

Solutions

Stakeholders are the foundation of the water sector and they need tools to be able to contribute, to be involved and to participate actively in decision making processes. Various solutions are showed in the different presentations. One of the most important tools, capacity development, is described in the Southern Africa, Western Africa and Latin American presentations. Once identified there is an urgent need for scientists to set up protocols for science dissemination. Financial solutions should be targeted to people or projects that will be responsible in promoting and implementing on the ground stakeholder participation. Enough time should be given in order for awareness raising campaigns and public participation to have impacts. Finally, the link between science and politics can be built on good diplomatic negotiations between stakeholders; this dialogue should be balanced and
connected with technical exchanges in order to promote an informed decision making process.
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Impacts of climate change on water resources in Botswana

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ABSTRACT: The problem of providing access to water in Botswana is being exacerbated by recent and growing challenges of climate change and urbanization. New strategies such as demand management are proposed as a more sustainable departure from the traditional supply management approach. However, these strategies require solid hydrological information and models that address run-off and precipitation. The models are sensitive to climate change parameters such as shifting rainfall patterns, run-off and temperature. Changing land-use such as urbanization also affects model components such as run-off. In a semi-arid country such as Botswana which under normal circumstances experiences high spatial and temporal variability of precipitation and run-off and complex rainfall mechanisms, constructing a model that can measure effects of climate change is extremely difficult. An attempt has been made to explore the possibility of using artificial neural networks (ANN) for simulating monthly rainfall in a semi-arid catchment in Botswana (Limpopo catchment) and identify key climate variables that act as rainfall drivers.

KEYWORDS: Artificial neural networks, climate change, rainfall, temperature, water demand management.

Introduction

Water is vital to our life and food security. Even if there is enough water for everyone, almost one fifth of the planet’s population today lacks access to safe drinking water (UNWDP, 2006). The problem is largely related to governance issues, in particular, the inability to achieve equitable sharing of water while ensuring sustainability of natural ecosystems. In addition, the world has also been witnessing two other major environmental problems: urbanization and climate change. It is estimated that in the near future, more than 60% of the world’s population is likely to live in urban centres, thus bringing in significant change in the land use in terms of human settlements and industries. This is likely to increase water demand in urban areas as well as produce a substantial rise in carbon dioxide emissions (Parida et al., 2005).

The world is also likely to undergo severe global climate changes such as a rise in average global temperature. It is well known that a rise in global temperature will accelerate the hydrologic cycle involving changes in precipitation and runoff. Furthermore, since the timing and magnitude of global temperature changes are uncertain, their projected impacts at
watershed levels are also unknown. It is however expected that, even in areas with increased precipitation, higher evaporation rates may lead to reduced runoff. Therefore, hydrological uncertainties attributed to changing atmospheric chemistry are likely to persist in the foreseeable future, leading to extreme events such as floods and droughts. Concerted efforts involving socio-economic and scientific solutions are necessary, particularly in water stressed and semi-arid countries such as Botswana (Parida et al., 2005).

**Water resources and climate change**

It has been observed that water demand in Botswana is escalating: demand is projected to double from 88.3 Mm$^3$ (2006) to 186.5 Mm$^3$ in 2035. As population increases; supply sources are less able to respond to demand; sites for future development are often more distant from water resources and therefore more expensive to service (BNWMP, 2006). The traditional top-down, supply led, technically based and sectoral approaches to water management strategies have proved unsustainable. New strategies are therefore required in keeping with the challenges associated with climate change and environmental sustainability. For example, the latest review of Botswana National Water Master Plan (BNWMP, 2006) makes recommendations on the implementations of requisite management instruments. These recommendations help align Botswana’s water management practices with international best practices and foster the Government’s international commitments and treaties such as Agenda 21 of the UN General Assembly and SADC protocols. More importantly, it allows the nation’s water sector vision to shift from an unsustainable “supply paradigm” to more stable and sustainable demand management strategies which are informed by robust hydrological modeling tools. However, there are challenges unique to semi-arid countries like Botswana. Botswana receives its major input in the form of rainfall between the months of November and April, averaging 450 mm per annum. The climate is influenced by four rain forming mechanisms which include: tropical storms and cyclones from across the Indian ocean; influence of the Inter Tropical Convergence Zone (ITCZ - also referred to as Congo Air masses boundary affecting mostly the northern parts of Botswana); localized convective rainfall mainly in the form of thunderstorms; and advection of moisture from across the Atlantic ocean. With average annual rainfall decreasing from the extreme north east to the extreme south west of the country, runoff never exceeds 50 mm per year except over small steep rocky catchments. This average is only 1.2 mm of run-off for the whole of the country. Consequently, most of the rivers originating in Botswana are ephemeral, with an average
flow period of 10-75 days during the year. The rivers flowing into Botswana from outside are, however, perennial. The country can generally be divided into five major systems: The Okavango, Chobe, Limpopo, Nata, and the Molopo. These systems drain about 2100 Mm3 annually (Parida and Moalafhi, 2008).

These challenges make it difficult to quantify the impacts of climate change on water resources through the traditional hydrological modeling and simulation approaches, particularly in semi-arid areas owing to high spatial and temporal variability and complex rainfall mechanisms. Studies in the past have shown that Botswana’s rainfall experienced a regime change after 1981 with a steady decrease of about 1% every year. Also, in some basins where land use changes due to urbanization have been predominant, both climate and land use changes have been found to be equally responsible for changes in runoff generation (Parida et al., 2006).

**Generalised Linear Models (GLMs) and climate data to predict rainfall regimes in Botswana**

Rainfall is the single most important input parameter for hydrological modeling and climate change assessment, but it is difficult to simulate. Various techniques have been developed to simulate rainfall in semi-arid areas, but with limited success due to the above mentioned complexities. However, using the Generalised Linear Models (GLMs) and climate data to predict rainfall regimes in Botswana, it was found that rainfall variability in Botswana is strongly associated with climate (in particular temperature) compared to El Nino Southern Oscillation (ENSO) (Kenabatho et al., 2012a, Kenabatho et al., 2012b) as shown in the figure 1 below.
Conclusion

In this paper, an attempt has been made to explore the possibility of using artificial neural networks (ANN) for simulating monthly rainfall in a semi-arid catchment in Botswana (Limpopo catchment). ANNs have found wide application in rainfall modeling (ASCE, 2000), including rainfall forecasting and flood management (Hung et al. 2009), and for reservoir operation (El-Shafie et al., 2012). The model was used to identify significant rainfall predictors in the catchment using climate data from three (3) rainfall stations. Six candidate climate variables (maximum and minimum temperature, relative humidity, ENSO Modoki Index, Nino 3.4 and El Nino Southern Oscillation Index) were explored as possible drivers of rainfall in the Limpopo catchment. Of these, maximum temperature, relative humidity, ENSO and Nino 3.4 were significant predictors based on their activation weightage and variance explained. The results are consistent with those obtained from other models previously used in the catchment, where the similar predictors were identified (Kenabatho et al 2012a). Although the simulated results were slightly higher than the observed data, there is hope that with further model refinement, the results could improve. Possible areas of improvement under consideration will include (1) the use of rainfall itself as additional predictors such as previous days’ rainfall events, (2) exploring other model structures within the ANN framework, and the possibility of increasing the temporal scale to a daily time step where processes at this scale can be investigated further. With the simulated rainfall patterns,
it will be possible to see future scenarios of flows in the Limpopo catchment (one of the major source of water supply to Botswana) where adaptation strategies in terms of water demand and watershed management can be drawn up.

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Integrated Water Resources Management as a tool for conflict resolution. Case study of Hadejia-Jaamare Komadugu Yobe Basin (HJKYB), Nigeria

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¹National Water resources Institute, Kaduna, Nigeria

ABSTRACT: In Nigeria, the majority of the population does not have good access to water supply and sanitation facilities. Ineffective management of river basins sometimes results in conflicts, but the application of a river basin model for effective IWRM has resulted in conflict resolution between States within Nigeria and Inter country conflicts that shares boundaries with Nigeria. This paper is to share the experiences of IWRM strategies resolving potential conflicts in a basin crossing six States in Nigeria and shares boundaries with two countries. The model addresses challenges such as lack of capacity, inconsistent policies and poor stakeholder participation and recommends institutional reforms, structural interventions, information management (awareness and empowerment campaigns). The model, developed in the HJKY Basin, is now being replicated in other river basins in the country and used to improve transboundary cooperation.

KEYWORDS: water resource, IWRM, conflict resolution, Nigeria, institutional reforms Hadejia-Jaamare Komadugu Yobe Basin, transboundary cooperation

Introduction

Nigeria with a population of over 140 million people is in dire need of adequate water and sanitation facilities in rural and urban areas. The problem of low access to water supply and sanitation especially in the rural areas of the country continues to be a major challenge for the government. Despite all the water supply and sanitation approaches that are being promoted and implemented, the provision of access to adequate water supply will not meet with the requirements for achieving the Millennium Development Goal (MDG) water and sanitation targets. According to WHO/UNICEF Joint Monitoring Programme (JMP) report of 2010, it is estimated that almost 900 million people do not have access to improved drinking water supply worldwide and over 2.6 billion people do not have access to sanitation facilities. Although the world is on track to meet the Millennium Development Goals target for water supply, it is unlikely that it will be met in rural Sub-Saharan Africa (WHO/UNICEF 2010). In Nigeria, the majority of the population does not have good access to water supply and sanitation facilities. In addition, there are problems of effective management of river basins sometimes resulting in conflicts of interest. The Hadejia Jaamare Komadugu Yobe Basin model of effective IWRM has demonstrated conflict resolution between States within Nigeria.
and conflicts with countries that share the basin and boundaries with Nigeria. The purpose of this paper is to share the experiences in resolving potential conflicts by adopting IWRM strategies to managing a basin that cuts across six States in Nigeria and shares boundaries with two countries.

**Nigerian Water Sector**

It has been established that Nigeria is blessed with adequate surface and groundwater to meet its current demands for potable water. However water in Nigeria is unevenly distributed and some regions are water scarce. Government, external support and donor agencies have made efforts to enhance potable water supply and sanitation to all citizens in the country. However, there still exists a wide gap between the demand for, and supply of potable water. The present national water supply coverage is about 57%, consisting of about 60% for urban towns, 50% for semi-urban towns and 55% for rural areas (FMWR, 2010).

**The Hadejia Jaamare Komadugu Yobe Basin (HJKYB)**

![Figure 1: Map of the Hadejia Jaamare Komadugu Yobe basin (IUCN,2011)](image)
The HJKYB is a sub-catchment of the larger Chad basin and it covers a total area of 148,000 km² in the northeastern part of Nigeria and southern Niger (IUCN, 2011). The basin is drained by two main river sub-systems (Fig. 1).

One sub-system includes the Yobe river that is formed by the Hadejia and Jaamare tributaries, which create the Hadejia-Nguru floodplain at their confluence. The second is the Komadugu gana (or Misau river). The basin supports a wide range of ecological processes and economic activities that include recession agriculture, pastoralism, forest regeneration, fish breeding and production and has good tourism potential.

The HJKYB has a population of 15 million and crosses six Nigerian States of Kano, Plateau, Bauchi, Jigawa, Yobe and Borno. At the international level, Nigeria shares the Lake Chad Basin in which the HJKYB is located and shared with four other countries (Niger, Chad, Cameroon and Central African Republic).

The rapid population increase and other recent economic developments in the basin have resulted in a proportionate increase in the demands for water. By 1998, the potential demand for water in the Hadejia system was calculated to be about 2.6 times the available water.

The wetlands of the basin host a biodiversity of global significance including 100 species of fish, five of which are endemic. There are over 370 species of birds already inventoried in the basin with 33% of them being migratory.

Management issues in the basin

Failure in water management institutions has led to rapid environmental degradation in the basin resulting in a serious competition for the remaining available water resources. This includes channel blockage and water scarcity in some places; excessive all-year flooding in others, aquatic weed infestation, Quelea bird invasion, potash encrustation, and the inundation of major roads, settlements, farms and grazing lands. On top of these environmental impacts the combined effects of drought and development activities in the basin have impacted heavily on the agricultural production which has since become increasingly precarious. Conflicts among users and sectors have also arisen, both in the competition for water and the access to land. This has resulted to general increase in poverty levels and a collapse of livelihoods.
The IWRM approach in the HJKYB

In 2004 a national workshop was held in Kaduna State engaging local governmental institutions on how to promote IWRM practices in the basin. Key issues and recommendations were identified in order to start: “establishing a framework for broad-based and informed decision-making process based on agreed principles for equitable use and sustainable management of the KYB” (HYPERLINK "http://www.kyb-project.net/goal-objectives-results.html" Komadugu Yobe Basin, 2012). This was done using Integrated Water Resources Management (IWRM) approaches that incorporate ecosystem concepts to develop and coordinate solutions in the basin. A process was then created fostering the coordination and cooperation of all stakeholders in order to reverse the natural resources degradation trends in the HJKYB. The key issues (see table 1 for further information) identified for proper water resources management and conflict resolution in the basin were:

- Lack of proper coordination and cooperation among key agencies managing land and water in the HJKYB
- Policy inconsistencies
- Ineffective institutional framework
- Conflicting roles assigned to some key agencies
- Conflicting legislations
- Low level of participatory approach in project conception, implementation & management
- Low capacity of line institutions
- Low level of awareness
- Weak knowledge base (hydro networks, water audits)
- Physical problems e.g. typha plant invasion, flooding, desiccation (due to climatic changes & human activities)

For better resources management and conflict resolution in the Hadejia Ja amare Komadugu Yobe Basin the following actions were recommended to be adopted in the short or long term: institutional reforms, structural interventions, information management (awareness and empowerment campaigns) (see table 2). Nigeria is one of the first countries in Western Africa to have established a national IWRM Commission, and since 2009 IWRM offices are spreading across the country. The model of the HJKYB is now being replicated in other river basins in the country and used to improve transboundary cooperation.
Table 1: Summary of HJKYBs challenges and strategies adopted

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Challenges Summary</th>
<th>Strategies for adopting IWRM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hydrological:</td>
<td>1. Development and Review of Policies, Legislations, etc.</td>
</tr>
<tr>
<td></td>
<td>• spatial and temporal variability</td>
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<tr>
<td></td>
<td>• recurring and prolonged droughts</td>
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<td></td>
<td>• increasing desertification</td>
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<td>2</td>
<td>Socio-economic:</td>
<td>2. Reactivate, strengthen and support Coordinating Bodies</td>
</tr>
<tr>
<td></td>
<td>• high and rapid growing population</td>
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<tr>
<td></td>
<td>• increasing urbanisation</td>
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<tr>
<td></td>
<td>• increasing poverty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• inefficient agricultural/irrigation practices</td>
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<tr>
<td>3</td>
<td>Environmental:</td>
<td>3. Establish and Support State IWRM Committees</td>
</tr>
<tr>
<td></td>
<td>• degraded water courses leading to flooding</td>
<td></td>
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<tr>
<td></td>
<td>• water pollution &amp; infestation of destructive aquatic weeds</td>
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<td></td>
<td>• excessive and uncontrolled groundwater exploitation</td>
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<td></td>
<td>• poor environmental sanitation and hygiene practices</td>
<td></td>
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<tr>
<td>4</td>
<td>Institutional:</td>
<td>4. Re-orient Existing Agencies towards IWRM</td>
</tr>
<tr>
<td></td>
<td>• poor &amp; fragmented watershed management (role definition)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• inadequate coordination (horizontally/vertically)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• policy inconsistency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• inadequate stakeholder participation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• insufficient hydro-meteorological information</td>
<td></td>
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<tr>
<td>5</td>
<td>Financial:</td>
<td>5. Secure Political Commitment and Popular Support for IWRM</td>
</tr>
<tr>
<td></td>
<td>• irrational pricing policies for raw/treated water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lack of transparency and</td>
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accountability
• inadequate financing for watershed protection
• inadequate financing for data management

Transboundary Waters:
• Intra states river systems
• downstream of Lake Chad
• growing concern: LCBC, NNJC
• Regional efforts weak

6. Assess Availability, Demand and Uses of Water Resources

7. Develop the HJKYB IWRM Plan

Adapted from: Bashir and Abdulmumin (2005).

Table 2: Recommendations for effective management and conflict resolutions

<table>
<thead>
<tr>
<th>A. Institutional reforms (Short term and long term measures)</th>
<th>C. Information Management, Awareness and Empowerment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short-Term Measures:</strong></td>
<td><strong>Urgent Measures:</strong></td>
</tr>
<tr>
<td>• Reorganisation of the HJKYB Coordinating Committee</td>
<td>• Provision of relief materials to flooded communities</td>
</tr>
<tr>
<td>• Strengthening of Technical Advisory Committee (TAC) of the Coordinating Committee and relocation of its secretariat to the HJKYB</td>
<td>• The National Emergency Management Agency (NEMA) to provide assistance to communities with short-term flood mitigation measures (e.g. dikes, diversion channels etc.).</td>
</tr>
<tr>
<td>• Establishment and institutionalisation of state level Integrated Water Resources Management (IWRM) committees</td>
<td><strong>Short-Term Measures:</strong></td>
</tr>
<tr>
<td>• Inclusion of civil societies (NGOs, CBOs, private sector etc.) in the coordinating committees on IWRM in the basin at all levels.</td>
<td>• Conduct water audit</td>
</tr>
<tr>
<td>• <strong>Long-Term Measures:</strong></td>
<td>• Reactivation and establishment of hydro-meteorological network, monitoring, analysis and dissemination of information in the basin by all tiers of government.</td>
</tr>
<tr>
<td>• Institutionalisation and strengthening of the Stakeholders Consultative Forum of the HJKYB.</td>
<td><strong>Long-Term Measures:</strong></td>
</tr>
<tr>
<td>• Review and harmonisation of relevant policies and legislations</td>
<td>• Establishment of horizontal and vertical networks for information flow</td>
</tr>
<tr>
<td>• Streamlining of functions and responsibilities of the various agencies</td>
<td>• Undertaking of resource use planning at the community level</td>
</tr>
<tr>
<td>• The HJKYB should be treated as one hydrological unit.</td>
<td>• Raising awareness and Involvement of traditional/opinion leaders at all levels</td>
</tr>
<tr>
<td>• Separation of responsibility for water</td>
<td>• Empowerment of communities to demand for services</td>
</tr>
</tbody>
</table>

• Undertaking of Land resources mapping
regulation from that of usage

- Management of land and water at the lowest appropriate levels
- Development of national policy on maintenance of water infrastructure
- Devise broad based sustainable funding mechanisms for implementation of IWRM in the basin.

### B. Structural Interventions

**Urgent Measures:**

- Construction of military type bridge to facilitate passage on Hadejia – Nguru road.
- Use the type of craft that dredge creeks to open up the distributaries of the Hadejia river.

**Short-Term Measure:**

- Rectification of the anomaly of the Kano water supply intake
- Clearance of blockage in the Hadejia river system
- Construction of flow diversion structures at the three bifurcations in the Hadejia river system subject to Environmental Impact Assessment (EIA).

**Long-Term Measures:**

- Restoration of the degraded resources base at the basin level.
- Intensification of unified extension services
- Improvement of soil conservation practices.
- Improvement of income generating activities at the community level
- Raising the capacities of line agencies.

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<th>and zoning</th>
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Balancing water demand and water supply within the Niger Delta Region of Nigeria; Problems, progress and prospects

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ABSTRACT: The Niger Delta region of Nigeria accounts for 90% of Nigeria’s economic growth, with almost all of Nigeria’s oil and gas exports coming from this region. As a result of the high rate of environmental pollution, providing safe and potable drinking water for the Delta region is a great challenge. Balancing water demand with the environmentally impacted water supply within the region was examined using the three P’s approach - Problems, Progress and Prospects. Problems were generally those of water quality, aging infrastructure and poor management either due to lack of guidelines and / or weak maintenance capacity. Progress has been made on all fronts: update on policy and regulation, repair and replacement of aging infrastructure using new technologies such as solar, and boosting operation and maintenance capacity with community training and capacity building. Prospects include future aquifer mapping to feed into a more integrated water resource management program for the area.


Problems

This approach consisted of identifying problems in securing access to clean water within the region. The problems identified are: saline water not readily available for desalination; contamination of surface and ground water with benzene and other hydrocarbon products, poor sanitary conditions contributing to poor water quality, aging water supply systems and losses due to leakages, inadequate water treatment facilities, lack of a sustainable business model, lack of national guidelines for water quality and absence of training of local communities in routine maintenance of water facilities.

Progress

Progress has been made on several fronts in addressing the challenges posed by the above problems, including the adaptation of new technologies and the development of a water resources management system in recent years.
In order to overcome the problems linked to water supply and sanitation a National Water
supply and Sanitation policy was established in 2000 which defined policy objectives,
guidelines and targets for the entire water supply and sanitation sector. It was anticipated that
with this policy in place, duplication would be minimized and effectiveness maximized.
Corruption however has been a major scourge and blockage in policy implementation in
Nigeria.

In order to enhance the quantity and the quality of available water supply, the Federal
Government, through the Federal Ministry of Environment and the National Environmental
standards and Regulation Enforcement Agency (NESREA), established a regulation to
control watershed and catchment areas management. This is known as the “National
Environmental (Watershed, mountainous, Hilly and catchment area) Regulation

Later in 2011 the “National Environmental (Surface and Ground Water Quality Control)
Regulations” were formulated, with the aim to restore, enhance and preserve the physical,
chemical and biological integrity of the country’s surface waters and to maintain existing
water uses. A set of water quality control guidelines based on African Utility Regulators,
World Health Organization, Department of Petroleum Resources (DPR) and Nigerian
Industrial Standards were also developed to control the quality of water for both water use
and sanitation (e.g. chemical ambient water quality criteria for surface water, target and
intervention values for micro pollutants for ground water, microbiological limits for ground
water). It is expected that with these guidelines in place, there will be improvement in the
quality of water supply for both water uses and sanitation in Nigeria.

Within the Niger Delta region, various agencies have been involved in the supply of potable
water. In the Delta region, the major sources of water within the coastal region is
groundwater, whereas both surface and groundwater are the sources of water supply in the
upland states (e.g. Edo, Northern part of Delta State, Imo, Abia, Ondo, Cross river and
Akwa-Ibom states).

In addition, the number of agencies and organization involved in urban and rural water
supply has increased in the last 10 years, following the establishment of the Niger Delta
Development Commission (NDDC) in 2000. The NDDC is a federal government agency
established to oversee sustainable development of the region. Part of its mandate is to plan
and implement water supply projects. Since 2002 the NDDC’s involvement in the water sector has been variable, but reaching an important peak in 2012 (as shown in figure 1).

![Commissioned water project by NDDC between 2002 and 2012](image)

**Figure 1: Commissioned water project by NDDC between 2002 and 2012**

The Ministry of Niger Delta Affairs recently commissioned a consultancy for the feasibility, and prefeasibility studies on the design for water supply in selected towns in the Niger Delta region. The Oil and Gas Mineral Producing Areas Development Commission (OMPADeC) has also embarked on aggressive water supply projects within the various states in the region. Generator and solar powered borehole projects were commissioned in various communities in 2012. Replacements of ageing pipes in many urban areas by various state governments are being carried out. Training of local communities as end-users in the maintenance of the water infrastructure within their area is becoming a regular component of water supply schemes. Local communities within the region are being educated on the necessity of bearing part of the cost for the maintenance of their water infrastructure and service. This also aims to promote a degree of community ownership of the facilities and an interest for them to protect their investment.

With the numerous government and international bodies involved in both Urban and Rural water supply, it is anticipated that the Niger Delta region will likely achieve a balance between water supply and water demand by 2025.

**Prospects**

In terms of addressing future prospects and possibilities, the Niger Delta Development Commission NDDC recently commissioned a study to carry out aquifer mapping and characterization of the entire Niger Delta region as part of the strategy to harness water
resources within the region. It is expected that with this and other measures being put in place by both the state and federal Government, the achievement of a balance in water demand and water supply within the next few years will be reached.

There is an urgent need for a coordinated development and management of water resources through an integrated Basin-wide development approach. Some of the advantages include:

- Development of irrigable lands for agriculture and provision of access to potable and safe drinking water
- Reduction in water borne and water-related diseases through reduction of risk levels, with actions such as the reduction of mosquito breeding places to combat malaria

**Conclusion:**

In order to have a balance between water demand and supply, there is need to adopt measures that will lead to good water resources management. There are many areas of research in water abstraction, treatment, quality and distribution on which West African countries should collaborate. This collaboration can be geared towards filling knowledge gaps, answering research questions and making recommendations that will work towards attaining a balance between water demand and water supply within the sub-region.

**References:**

ABSTRACT: The UNESCO International Hydrological Program (IHP) has been promoting the development of national water balances in Latin America and the Caribbean. The methodology developed by UNESCO-IHP, for calculating the water balance is based on seasonal averages of climate variables. However, in the context of climate change and variability, and significant increase in demand for water resources in recent decades, an approach based on the estimates of extremes is becoming more and more relevant than those based on average values. In this context, the EUROCLIMA-Water and RALCEA projects have been developing a method to improve the existing knowledge on the variability of the components involved in the water balance. The methodology is based on the L-moments approach (Hosking, 1990) since it has the advantage of being less susceptible to the presence of outliers and performing better with smaller sample sizes (Sankarasubramanian and Srinivasan, 1999). Precipitation data coming from more than 7000 ground meteorological stations was used for this analysis. As a result of these two projects, a series of workshops and capacity building activities were conducted to develop the methodology and train scientists.

KEYWORDS: climate variability, precipitation, L-moments

Introduction

For decades the UNESCO International Hydrological Program (IHP) has been promoting the development of national water balances in Latin America and the Caribbean. The methodology proposed by UNESCO IHP based on seasonal statistics variables representing water balance components in reference periods of 30 years, has been widely adopted by several countries in the region. However, in the context of climate variability and change, there is a need to strengthen and complement these national water balances with information characterizing the variability of its components. It is through the collaboration between the EU and Latin American countries that the RALCEA and EUROCLIMA-Water projects established a network of institutions and experts who are working on the dissemination of a regional frequency analysis based on L-moments methodology. This analysis is an analytical tool which helps to characterize the variability of water balance components and therefore contributes valuable information to decision making in the water sector of the region. It is expected that under the overall coordination of the Joint Research Centre of the European Commission (JRC), and with the cooperation of countries, institutions and specialists...
involved in this initiative, regional results will be generated that will integrate the concepts of variability and climate change into understanding and managing the national water balances in Latin American countries and Cuba.

**Regional Analysis Frequency (RFA-LM) with L-Moments – EUROCLIMA methodology**

The RFA-LM is a probabilistic analysis methodology in hydrology. Its origins date back to the 1960's. In 2010, the methodology was improved by Centro del Agua para Zonas Aridas y Semiaridas de America Latina y el Caribe (CAZALAC) for application to water balance components variability assessment (Nunez et al, 2011; UNESCO, 2010).

The RFA-LM approach was chosen because it reconciles the need for a robust statistical method while allowing the characterization of the properties of the series in terms of their mean values and variability. In the context of climate change and variability, and significant increase in demand for water resources in recent decades in Latin America, an approach based on the estimates of extremes is becoming more and more relevant than those based on average values.

**Results**

The geographical location of the meteorological stations used in the EUROCLIMA project, as well as the results of the L-moment analyzes for these stations, are presented in Figure 1. Annual precipitation dispersion, measured through the L-cv, is shown to be higher in the arid regions of Baja California peninsula and Atacama Desert, and semi-arid regions in Northeast Brazil. The spatial patterns are less evident for L-skewness and L-kurtosis. This is expected, given that annual average precipitation patterns follow more closely a normal distribution. Nevertheless, patterns of higher L-skewness values are shown in the coast of Peru and Chile, indicating probability distributions skewed to the left.
Figure 1: Annual L-moments and L-moment ratios obtained from meteorological stations from EUROCLIMA partners.

References:


Promoting water resources management best practices in China

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ABSTRACT: Although China’s Economic and Social Development has been very rapid in the past two decades, this development is confronted by limited water resources, which are also unevenly distributed. Rapid growth has also resulted in pollution of water resources and ultimately an increased competition of the resources, making effective management difficult. To address these challenges, two recent policy initiatives have been introduced and have proven to be best practices. They are the Strictest Water Resources Management Policy (SWRM) and the Social Economic Environmental Accounting for Water (SEEAW). A combination of strategy lines, operating principles and economic water accounting; these policies have assisted greatly in the management of limited water resources. They provide policy makers with indicators and descriptive statistics to monitor these economic and environmental interactions as well as a database for strategic planning and policy analysis to identify more sustainable paths of development.

KEYWORDS: water resources management policy, China, Environmental-Economic Accounting for Water, Strictest Water Resources Management Policy

Introduction

China’s Economic and Social Development was very rapid during the past two decades with an average annual GDP growth of 10.7%. The contribution to the world economic growth rate was over 20% and China's GDP in the world share increased from 4.4% in 2002 to about 10% in 2011. According to World Bank classification standards, China has jumped from being a low income country to become a lower middle income country.

Meanwhile, China's water resources are very limited by various characteristics

- Low level of water resources per capita. The total amount of water resources are 2800 billion m³ while per capita share of water resources is only 2100 m³, very close to the international warning level of 1700 m³.
- Uneven temporal and spatial distributions of water. The total precipitation during the flood and rainy season is within 4 months, from May to September, and accounts for 60~80% of the total amount for the whole year. The total area, population, and farmland in Northern China account for 64%, 46%, and 60% respectively, while the water resources in Northern China only account for 19% as shown in figure below.
Figure 1: uneven spatial and resources distribution. Source: author

- Serious water pollution problems. According to the results of a 2010 water quality assessment on river sections of 154,000km, rivers with better water quality that comply with or surpass the class-III standard accounted for only 58.8% of the total assessed. It means that nearly half of the rivers did not meet the national standard.
- The conflicts between water demand and water usage are large. The average annual water supply shortfall is more than 50 billion m$^3$.

**Best practice 1: Strictest Water Resources Management Policy (SWRM)**

In order to meet the challenge and solve the problems, the Chinese government has carried out a strategy called the Strictest Water Resources Management Policy (SWRM), which has proved to be a very successful practice. The core idea is to set illustrated by three red lines and four principles as shown in figure 2.

The 3 red lines are: red line of water development and utilization, red line of water use efficiency, and red line of water function zones pollution load.

According to the long term targets by 2030:

- national water use quantity target will be limited to 700 billion m$^3$
- the unit of industrial added value will have to drop from 120 m$^3$ (2010) to 40 m$^3$
- agriculture irrigation water efficiency control targets will be increased from 0.5 to 0.6,
Water quality compliance targets in water function zones will be expected to increase from 46% (2010) to 95%.

The four systems are: water use total quantity control system, water use efficiency control system, water function zones pollution load control system, and water resources management responsibility and assessment system.

Under these red lines and systems there are a series of plans and strategies to ensure SWRM works such as: accelerate the formulation of index system for the strictest water resources management, accelerate the formulation of the water allocation plan, define the pollutant absorption capacity of water function zones and formulate plans to limit pollution discharge, strengthen the capacity for water resources allocation and control, accelerate the improvement of systems, policies and legislation for water resources management.

**Best practice 2: Social Economic Environmental Accounting for Water (SEEAW)**

Another water management best practice in China that has been developed is the Social Economic Environmental Accounting for Water (SEEAW). Its objectives are to take water resources into account in a National Economic Accounts System, to supervise and evaluate strictest water resources management, and to establish a set of water indicators. The physical water accounting describes the total amounts, in physical terms, of water existing as surface water, groundwater (i.e. in aquifers) and soil water, and their variation over a certain time period (e.g. a year). It describes both stocks and flows of water. The water economic accounting aims at monetary accounts of all water related activities and is organized...
according to the existing economic accounting principles of the System of National Accounts (SNA). The integrated accounting evaluates the relationships between water resources and the national economy and enables the valuation of water resources, costing of water resources depletion and water environmental degradation, and studies of likely impacts of policy interventions. With these accounts we can establish the statistical indicator system of water resources, improve the coherence and integrity of water related statistical data, determine appropriate water prices, provide support to ecological compensation mechanism. The SEEAW has consolidated existing information and has been able to be used for a range of policy purposes in China.

In conclusion rapid economic development needs water resources which must be managed sustainably over the years. Good water resources management needs a strong and clear water policy. For this purpose the Strictest Water Resources Management Policy was established in China. However for good policy making there is a need of a sound economic environmental accounting for water. This provides policy makers with indicators and descriptive statistics to monitor these economic and environmental interactions as well as a database for strategic planning and policy analysis to identify more sustainable paths of development.

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Impact of climate change on water balance, resources availability and eco-environment in the headwater of Three Rivers Region, China

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ABSTRACT: Global climate change has produced a great impact on the hydrological elements (precipitation/temperature/evaporation/runoff) and hydrological environment (glacier/frozen soil/snow retention/swamp/moss land/plant) of the headwater of three rivers region, China. In the past 50 years, with the alpine ecosystem and permafrost being continually degraded under climate warming, the frozen earth-ecological environment system in this area has changed greatly, the annual runoff decreased continuously, and the variation of the runoff has affected the function of conservation on water supply in the headwater of three rivers region. Therefore, it is increasingly urgent to study the spatial-temporal variation of the runoff in this headwater region. In analyzing data from the hydrological and meteorological stations at Tuotuo River, Wudaoliang, Zhiduo, Qumalai, Yushu and Zimenda; a multiple time scale analysis has done to reveal the annual, inter-annual and decadal variation of the precipitation and runoff. In accordance with the regional distribution character of the precipitation and runoff analysis, the calculated results show that annual runoff of this headwater region changed with the precipitation, the runoff seasonal distribution focused from May to October and had a reduced trend, and decadal changes of runoff did not show obvious regularity. However, these results have a very important scientific value and a practical contribution to the further study on the water resources security and the ecological environment in this area, the sustainable utilization of water resources in the middle and lower reaches of the river, and the security of the regional ecosystem in the Three Gorges reservoir area especially.

KEYWORDS: headwater of three rivers region, climate change, hydrological element, water balance, water resources availability, eco-environment

Introduction

The three-river headwaters region lies to northeast of the Northwestern Plateau in Sichuan, where it is one of the most important areas of the regional source for the Yangtze River in China. Its main function is to maintain the flow of these rivers and to store water resources of high quality for the lower reaches. The changes from the quality and quantity of water resources and from human events in this headwater region will influence the water environment in the middle and lower reaches of the Yangtze River as well as the sustainable utilization of water resources in the Yangtze valley (Qingbai et al. 2002 and Genxu et al. 2004). In recent years, many experts have started their studies in this field. For example, Wang et al. (2006) used the precipitation data from meteorological stations in the source
region of the Yangtze River and the climate data re-analyzed by NCEP/NCAR to find the inter-annual variation of the precipitation; Kang et al. (2007) valuated the impacts on the atmospheric environment caused by human events in the evaluation of ice records; Yang et al. (2003) analyzed the effects of glacial change on runoff; Wang et al. (2007) has done an analysis to reveal the dynamics and the discrepancies of the frigid wetlands system during the recent 50 years using quantitative remote sensing, the study mainly focusing on the composition distribution, spatial framework and water eco-function. In addition, they have analyzed the impacts of the components’ variations in this climate-vegetation-frozen earth system on the runoff, with the results from the testing experiments in the precipitation and runoff observation stations in different vegetation-covered permafrost sites (Wang et al. 2003). Jianting-CAO (2007) and Xuan-YU (2008) did their trend and period analysis on the data of annual runoff at the hydrological station of Zhimengda, respectively using the methods of Mann-Kendall test with trends and the Morlet Wavelet Transform ; Changwei-XIE et al. (2003 and 2004) did a variation trend analysis on the hydrologic components and the environmental changes, as well as a comparison analysis of runoff change. However, the above-mentioned studies specialized more in evaluating the impact of the climate trend on the water resources in the source region of the Yangtze River. There are few systemic ones focusing on the formation of the precipitation and runoff and few gave the causes and the variation characteristics of the hydrological factors. Taking into account the fact that the hydrological and meteorological stations are distributed sparsely, this research systematically analyzed the multiple time scales process of dynamic change to reveal the annual, inter-annual and inter-decadal variation of the precipitation and runoff in this area based on their anomaly.

**The three river headwaters region**

The headwater region of the three rivers lies to northeast of the Northwestern Plateau in Sichuan with a location between (35°45′N, 95°20′E) and (32°26′N, 90°33′E) and is in the interior of the Roof of the World-the Tibetan Plateau. It abuts against the Kunlun Mountain Range on the east; lies close to the Tanggula Mountains on the south; near the Kekexil Basin, Ulanula Lake, as well as Mt. Zhuerkenula on the west and reaches the mouth of the Zhumar River on the east. It is about 400 kilometers long from east to west and the greatest width in south-north direction is more than 300 kilometers; the total area is approximately 102,700
square kilometers at an average altitude of 4500 meters above sea-level. It's an undulating plateau high in the west and lower in the east but more graduate in the inner reaches.

More than 40 rivers in this area consist of a fan-shaped drainage which can be seen in Figure 1. Upwards of the confluence of the Zhumar River and the Tongtian River is the headwater region, including the Tuotuo River, Danqu River and Zhumar River. These rivers disgorge the waters compiled from more than 200 branches feeding into the Tongtian River at the lower reaches. The Tongtian River is a part of the upper reaches of the Yangtze River, which borders the Tuotuo River in Rangjibalong at the upper end and down to the mouth of Batang River in Yushu, connecting with the Jinsha River. It is 813 kilometers, traversing the whole Tibetan autonomous prefecture of Yushu, Qinghai province. Along the main stream, no control station could be found except for the basic hydrological and meteorological observation station of Tuotuo River at the foot of the Tanggula Mountains with an altitude of 4700 meters, and using only the control station of Zhimenda as a reference.

Figure 1: Outline of the Three-River headwaters region and its spatial structure of the water system
Analysis and calculation

In this research, an approach based on the annual distribution uneven coefficient CL, inter-annual variation coefficient CV and the difference product curves is used to analyze the temporal-spatial characteristics of the hydrological factors in our research area.

The calculation of CL and CV

The annual distribution uneven coefficient CL represents the uneven level of the random variables in a year, calculating formula as

$$C_L = \frac{\sum_{i=1}^{k} Q_i - K\bar{Q}}{12\bar{Q}}$$  \hspace{0.5cm} (1)

The inter-annual variation coefficient CV represents the relative discrete degree of the random variables, signified with average and its deviation, that is,

$$C_V = \frac{\sigma}{\bar{Q}} = \frac{1}{\bar{Q}} \sqrt{\frac{\sum_{i=1}^{n} (Q_i - \bar{Q})^2}{(n-1)}} = \sqrt{\frac{\sum_{i=1}^{n} (K_i - 1)^2}{(n-1)}}$$  \hspace{0.5cm} (2)

Where, $Q_i$ is average of runoff; $K$ is sum of the months whose monthly average is beyond the annual one; $\bar{Q}$ mean annual average runoff; $n$ is the sum of the statistical year; $K_i$ is the modulus ratio. In general, the annual distribution will be more uneven as CL becomes bigger, a big CV resulting in a large inter-annual variable amplitude the next year, and vice versa.

The difference product curves

The difference product curves, also called anomaly cumulative curves, accumulate the difference value between the random variables and the average on a yearly basis.

$$\sum_{i=1}^{n} (p_i - \bar{p}) \cdot T$$  \hspace{0.5cm} (3)

While the difference product curves rise, there is a rainy year, and a downward curve with a low-flow year, the slope reflects the changing scope in the high flow and low flow cycles.
Main results

Focusing on the data of the precipitation and runoff at the stations as Tuotuo River, Wudaoliang, Zhiduo, Qumalai, Yushu and Zhimenda, a multiple time scales analysis has been done to reveal their annual, inter-annual and decadal variation in this research. The calculation result and analysis is indicated below:

1) Precipitation

The annual distribution of precipitation at each station was very uneven, mainly focused in May to October; the inter-annual difference was great, the difference between largest inter-annual precipitation and the smallest one was about 200mm. And the decadal variation was evident too, the precipitation in the 80's changed most obviously in the entire source region. From northwest to southeast, the curves of average monthly precipitation changed from the single-peak to bimodal, and it tended toward relative uniform in the direction from northwest to southeast; the inter-annual rainfall increased by degrees. The inter-annual precipitation of south-east was more balanced than north-west.

2) Temperature

The temperature seasonal distribution of all sites changed with seasonal climate and demonstrated the phenomenon of warm winters. The annual average temperature of all sites showed an upward trend and the whole source region decreased by 0.019°C.a⁻¹. There was a turning point in the north-west in the late 60’s and another turning point in the whole region in the mid-80’s. The most notable temperature increase was in the 80’s. Both the maximum temperature, minimum temperature and average temperature showed the following relationship: The lower temperature the higher latitude, the higher temperature the lower elevation. The temperature of south-east was higher than the north-west. And the heating rate of the east was faster than the west.

3) Runoff

Runoff changed along with precipitation at the stations of Tuotuo River and Zhimenda, the annual distribution of runoff showing a large variability both on time and space. The runoff seasonal distribution mainly focused in May to October, presenting a reducing weak trend, and the annual distribution uneven coefficient (CL) is 0.67. Decadal changes were also great
in the runoff, but did not show obvious regularity. Because the upland water originates from rain and snow and ice melt-water river, the spatial decreasing characteristic in southeast-northwest direction was very apparent in the main.

Acknowledgment

This study was funded by National Natural Science Foundation of China (41271045).

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Genxu WANG, Yuanshou LI, Yibo WANG and Yongping SHEN, “Impacts of alpine ecosystem and climate changes on surface runoff in the headwaters of the Yangtze


Promoting water resources management and assessment best practices, case study in Europe

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ABSTRACT: The Blueprint to Safeguard Europe's Water aims to ensure the availability of good quality water in sufficient quantities for all legitimate uses. It is within this policy framework that JRC carries out research on hydrological simulation modeling to assess current and future water availability versus current and future water demands from different economic sectors. A modeling environment has been developed to assess optimum combinations of water retention measures, water savings measures, and nutrient reduction measures for continental Europe. Six different types of models are linked together with a multi-criteria optimisation routine. The study shows that modeling can deliver optimum scenario combinations, indicating optimum measures that can be taken and where further work needs to be done.

KEYWORDS: water quality, EU Blueprint, Europe water resources, water availability, water demand, hydrological simulation modeling, multi-criteria optimization

Case Study: Modeling

The Blueprint to Safeguard Europe's Water is the latest EU policy response to emerging challenges in the field of water resources in Europe. It aims to ensure the availability of good quality water in sufficient quantities for all legitimate uses. It is within this policy framework that JRC carries out research on hydrological simulation modeling, aiming to provide scientific assessments of generally available water resources, floods, droughts and water scarcity. The main aim of the research activity is to assess current and future water availability versus current and future water demands from different economic sectors. The JRC activities are carried out at the continental scale and at relatively high spatial resolution. A modeling environment has been developed to assess optimum combinations of water retention measures, water savings measures, and nutrient reduction measures for continental Europe. This modeling environment consists of linking the agricultural CAPRI model, the LUMP land use model, the LISFLOOD water quantity model, the EPIC water quality model, the LISQUAL combined water quantity, quality and hydro-economic model, and a multi-criteria optimisation routine.
Simulations have been carried out to assess the effects of water retention measures, water savings measures, and nutrient reduction measures on several hydro-chemical indicators, such as the Water Exploitation Index, Environmental Flow indicators, N and P concentrations in rivers, the 50-year return period river discharge as an indicator for flooding, and economic losses due to water scarcity for the agricultural sector, the manufacturing-industry sector, the energy-production sector and the domestic sector. Also, potential flood damage of a 100-year return period flood has been used as an indicator.

**Conclusion**

The study shows that technically this modeling software environment can deliver optimum scenario combinations of packages of measures that improve various water quantity and water quality indicators, but that additional work is needed before final conclusions can be made using the tool. Further work is necessary, especially in the economic loss estimations, the water prices and price-elasticity, as well as the implementation and maintenance costs of individual scenarios. For Europe, the most promising individual measures to improve water resources are ‘water saving in households’, “re-Meandering of rivers scenario”, the “Crop practices Scenario”, which simulates the effects of the implementation of combined methods.
of improved crop practices (reversed/reduced organic matter decline and increased mulching and tillage), and installing desalination plants along the coastlines.

A similar water resources optimisation activity is currently being developed.

![Estimated annual freshwater generation](image)

**Figure 3: Estimated annual freshwater generation**

**References:**


Environmental management tools supporting decisions in basins with mining activities

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ABSTRACT: The socio-environmental conflicts related to water quality and quantity associated with mining in the Andean region is cause for concern. There is a role for scientific data and social participation in mining related conflicts and the evolution to an ecosystem approach in water management, however few academic studies can be found which assess the environmental problems in the region and proposing methodologies adapted to mining contexts. The Jequetepeque river basin, located in Northern Peru, was chosen for action-research carried out from 2006-2011 and included a sequence of projects involving different local stakeholders (government, universities, NGOs). The application of hydrological modeling, “smart” environmental monitoring and the use of aggregated indices on raw data for management is evaluated. The approach facilitates innovative work in the water sector, while partners that participate gain knowledge and capacities to take informed decisions related to mining and water resource management.

KEYWORDS: mining, ecosystems, hydrologic modeling, environmental monitoring, socio-environmental indicators

Introduction

The socio-environmental conflicts related to water quality and quantity associated with mining in the Andean region are cause for concern and increasing interest worldwide (Bebbington et al. 2008, Sosa and Zwarteveen, 2012). It is however difficult to find literature dealing with the use of environmental management tools in these contexts. As presented in Mining, water and human rights: making the connection (Kemp, D. et al., 2010), a possible sector strategy could be to handle conflicts through technical, scientific and engineering-based approaches to water management; although other authors highlight some drawbacks of these practices (Velásquez, 2012).

Water resources management - an ecosystem approach

The global trend for water resources management practices in recent years has changed from a management style focused on control of pollutants to a vision that is based on ecosystems and an integrated approach (Hering et al. 2010).
Europe adopted policies that promote the protection, improvement and sustainable use of water as a whole, with an ecosystem approach, through the Water Framework Directive, WFD (European Commission, 2000, EEA, 2012.)

This paradigm is based upon the status of biological, hydro-morphological and physicochemical quality elements. All these elements should be considered in order to comprehensively assess the ecological status of aquatic systems, especially those elements that would most likely affect the biota of the system and those providing relevant information of the impacts on the biota.

The debate about the role of scientific data and social participation in mining related conflicts and the evolution to an ecosystem approach in water management should deal with the evaluation of the impacts and pressures on the aquatic ecosystems and involve the stakeholders interested and implicated in the hydrological cycle. In fact, during recent years, the Andean countries have included some of these innovative concepts in their water and environmental policies, but there is a lack of plans and measures to effectively implement them. Moreover, few academic studies are available which assess the environmental problems in the region and proposing methodologies adapted to mining contexts.

**Goal and methodology of the environmental tools**

The goal of this work is the development and assessment of environmental management tools in Andean basins that are characterized by significant mining activities. The main hypothesis of the study is that the participatory development and use of these tools may enhance the decision makers’ capacities to deal with water related conflicts and at the same time promote innovation in the water management and technology sector.

The proposal focuses in three specific instruments: (i) hydrological models that allow the stakeholders to simulate and evaluate the water and sediment dynamics of the basins (Chung, and Lee, 2009)], (ii) environmental monitoring that generates knowledge about the status of the ecosystems at short and long term and helps to discern the origins of the impacts on the ecosystems quality (Allan, 2006), and (iii) multidimensional assessment of water poverty through a composite indicators that integrates the concept of causality through the Pressure – State – Response approach (Pérez-Foguet and Gine, 2011). The use of evaluation frameworks based on the concept of cause–effect relationships is widespread, and they have been
extensively applied for supporting catchment management (Chaves and Alipaz, 2007, Walmsley, 2002).

**The case study and the tools**

The Jequetepeque river basin, located in Northern Peru, was chosen as reference example. The action-research carried out within the period 2006-2011 included the implementation of a sequence of projects involving different local stakeholders (government, universities, NGOs, etc.). They contributed according to their own capacities throughout the project cycle, including the analysis of the results and discussions.

The spatial and temporal dynamics of the basin are evaluated using the Soil and Water Assessment Tool, ArcSWAT (Yacoub and Pérez-Foguet, 2011, Yacoub and Perez-Foguet, 2012). The model was calibrated and validated, and used to assess the impacts of land use changes. A specific environmental monitoring including water, sediment and biota matrices has been defined and carried out (Yacoub, Pérez-Foguet, Miralles, 2012, Acosta et al. 2009). Field surveys have been repeated in different seasons and years. Data available from other sources has been pre-processed and incorporated in the analyses. Conclusions about actual impacts and appropriated methodologies have also been elaborated. And finally, a proposal of an aggregated index developed to better understand the links between poverty and water in basins has been defined and applied (Pérez-Foguet and Gine, 2011). The index evaluates water scarcity by taking into account physical estimates of water availability and the socioeconomic drivers of poverty. It includes a measure of the socio-environmental conflicts within the index structure.

The results highlighted:

- The proven ability of the hydrological models. After a good calibration, they are capable of quantifying the hydrological cycle dynamics and relationships, and evaluate the possible impacts on water cycle from different soil uses. Influence of spatial discretization in model calibration and simulation has been analysed. Some rules for practical calibration and use of this kind of models have been devised.
- The importance of “smart” environmental monitoring. It should be appropriate and adapted to the specificity of the possible environment impacts due to mining and the social context of the region, including the ecosystem approach and methodologies for the posterior application for local surveillance.
- The holistic approach of aggregated indices. Because of its simplicity, in contrast with complexity of raw data, it appeals to water managers and decision-makers for
planning, performance monitoring, and resource allocation. As river basins are the natural territorial planning unit, such policy tools need to be applied at this geographic scale. Information data and routines of the health system, the environmental management system and the local and regional authorities can be properly processed and communicated but an adequate governing structure is needed to sustain the update of information.

Conclusion

To conclude, the relationships between the three tools are analyzed. Their complementarity, integrality and sustained applicability in conflict contexts are discussed. The main hypothesis formulated is confirmed, at least, to some extent. The approach facilitates innovative work in the water sector while partners that participate gain knowledge and capacities to take informed decisions related to mining and water resource management.

References:


Groundwater management in Southern Africa

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ABSTRACT: Although treated as separate entities, groundwater and surface water are related due to the fact that some rivers depend significantly on aquifer discharge to sustain their dry-weather flow. This means that good river basin management must include groundwater management. The major challenge is that by the nature of its occurrence, groundwater is a hidden/invisible resource. One way to make it visible is through monitoring its characteristics such as groundwater levels or groundwater quality. Although most countries in the Zambezi River Basin are bound by Protocols on shared water courses, promotion of sustainable development, utilization and management of the Basin’s groundwater resources will require addressing technical as well as administrative challenges in order to integrate groundwater into good basin management.

KEYWORDS: Southern Africa, groundwater management, monitoring, Zambezi Basin

Introduction

Groundwater forms a considerable component (22%) of the total global fresh water resources. While a number of dams can be seen over the Zambezi Basin from remotely acquired images, especially in Zimbabwe, there is no indication of the distribution of boreholes exploiting the groundwater resource. This is because this resource is invisible. As such:

- Millions of cubic metres of water are pumped from aquifers every year, yet it is not certain if it is monitored, by who and how
- The resource is subjected to numerous sources of pollution, whose locations, nature and quantities involved are not known, and consequently how vulnerable these aquifers are.
- Hundreds of thousands of users that are not registered are abstracting water from these aquifers and the abstractions are subsequently not controlled.
- Tens of thousands of wells/boreholes have also been constructed that are not registered, whose locations, abstraction levels, water levels and water quality are not known.

Groundwater and surface water – different resources?

Although treated as separate entities, groundwater and surface water are related due to the fact that some rivers depend significantly on aquifer discharge to sustain their dry-weather flow (Figure 1). However, one of the major differences is that surface water flows relatively
rapidly in small streams, which feed main rivers draining catchment area(s), while groundwater moves through aquifers from areas of recharge to areas of discharge, normally at slower rates ranging from hundreds of metres per day to as little as one metre per year (Figure 2).

**Figure 1**: The relationship between groundwater and surface water.

**Figure 2**: One major difference between groundwater and surface water.


By the nature of its occurrence, groundwater is a hidden/invisible resource. One way to make it visible is through monitoring its characteristics such as groundwater levels or groundwater quality. Data from such monitoring activities would enable water managers, hydrogeologists and users to appreciate the nature and status of the resource; creating and promoting a better understanding that will help to manage it sustainably.

**Transboundary aquifers in the Zambezi Basin and their possible constellations**

Availability of information on the state of groundwater resources is especially critical for benefit-sharing and apportionment of obligations in the promotion of transboundary aquifers such as those found in the Zambezi Basin. Transboundary aquifers in the Zambezi Basin may present different constellations demonstrated by the situations shown in Figure 3.
Figure 3 shows three of the many possible aquifer constellations that may exist between/among member states of the Southern African Development Community (SADC):

1. Type A, in which two Countries share the same aquifer
2. Type B with:
   a) A phreatic (water table) aquifer.
   b) A river connected to groundwater in the aquifer.
   c) Inflow of the river water originating from uphill in state A across the border.
   d) State A being outside the aquifer, and just connected by the river.
3. Type C showing:
   a) A confined, deep aquifer
   b) Aquifer having no relationship with surface water
   c) Recharge (free water table) only in state A, but with a confined aquifer that is shared by states A and B

Although most countries in the Basin are bound by Protocols on shared water courses, promotion of sustainable development, utilization and management of the Basin’s groundwater resources will require addressing, among others, the following challenges:

Challenge 1 – Hydrological/Hydrogeological issues, requiring that:

- Volumes and the quality of groundwater discharging into our River Basin are known and well quantified.
- The extent of catchment areas contributing to groundwater flow in the Basin is well delineated.
- Interconnections between surface water and groundwater bodies in the Basin are well understood.
- Over the year, with its dry and wet seasons, the extent to which the river is actually groundwater-based, i.e. depending on groundwater discharges during the dry season, is also well understood.
Challenge 2 – Institutional-administrative issues, requiring that;

- Staff is adequately skilled/trained to understand and manage the complex hydrogeological conditions in the Basin
- The potential is available to develop managing institutions’ capacity further.
- There are co-ordination and co-operation mechanisms on the acquisition and sharing of groundwater data.

Conclusions

In order to appropriately share benefits of groundwater development and utilization as well as equitable apportion obligations for its management, riparian states of the Zambezi basin must make groundwater visible through monitoring. This will facilitate implementation of protocols to distribute the shared water resources equitably and sustainably.

References

Challenges and technological needs for sustainable water resources development in China

ABSTRACT: We will discuss four main challenges that China faces in water resources management, explore some feasible ideas and solutions that the country can adopt, and also examine the technological needs to meet these challenges. We will also present a simple case study for Beijing city to demonstrate what measures have been put in place to overcome these four main challenges.

KEYWORDS: Floods, water shortage, soil erosion, ecological deterioration, water pollution, technologies, economic growth, China

Introduction

In the 21st century water has been recognized as a key factor in the future of both society and the environment. The UN listed water resources as one of the top 5 major issues to be addressed and resolved in this century. China, like many countries in the world, is facing severe water resource challenges due to pressures from rapid population growth, industrialisation and urbanisation, climate change and food insecurity.

China’s main water resources challenges

China, as a rapidly developing country, faces a lot of pressure in terms of natural hazards, resources shortages, income disparity and sustaining economic growth. Regarding water resources, there are four main challenges that are particularly critical: flooding, water shortage, soil erosion coupled with ecological deterioration and water pollution.

China has always been a country that experienced floods which create a serious threat to socio-economic development. Population, production and subsequent wealth tend to concentrate around downstream areas with the result that flooding upstream tends to propagate progressively downstream, where flood impacts increases. China is also not immune to other forms of flooding such as dam-failure, coastal inundation or upstream flooding caused by river-flow blockage from landslide/ mudslides. Local smaller scale
flooding occurs every year but there have been 7 major flood events since the 1990s resulting in economic losses amounting to 1% of national GDP3.

For the past 2500 years, China’s approach to flooding has been to construct flood defenses in the form of levees, dykes, dams and relief channels, and also to improve dredging in order to increase flow capacity in rivers. However, modern thinking has it that it is impossible to control flooding and the more effective response is to regulate human activities in order to leave space for water movement during flooding. Taking this approach means that more land needs to be reserved for flood alleviation purposes, with potential conflict between land development for industries and housing versus natural hazard management.

The second challenge, water shortage, is a major constraint to socio-economic development. There is an annual shortfall of 40 billion cubic metres of water between available water and water demand for the whole country. Water scarcity does not only affect Northern arid to semi-arid regions, but in recent years, historically water rich regions such as South China and mid-stream Yangtze river have also experienced droughts which exacerbates the existing water shortfall. One of the responses to the water shortfall has led to over-abstraction of groundwater. The depletion of groundwater resources in some areas has been so great as to have caused substantial ground subsidence and also allowed for salt water intrusion near coastal areas. Although the intensity of water shortages differs among parts of China, there are common solutions to deal with such water shortages. One proposed solution is to develop a water conservation society supported by reservoir construction and water transfer. For example, matching groundwater abstraction to the recharge will prevent surface subsidence or coastal saline intrusions.

The third challenge is erosion, which can have different origins. The effects of drought include soil depletion in the form of desertification, drying of rivers, retreating lake water levels, and increased sand storms. Desertification can also be caused by deforestation or other forms of reduced vegetation land-cover. A direct impact of desertification is the increase in the amount of siltation in river channels, causing a reduction in channel flow capacity which leads to flooding, economic, social and ecological disaster. In order to resolve the problem of nutrient depletion, erosion of soil and other ecological problems, the latest thinking is to utilize the self-healing properties of nature. With time, if sufficient water resource is present

and human interference and intervention is reduced, vegetation will return to dominance restoring the balance of nature. Schemes such as strict regulation of logging to allow tree growth, reforestation, restricted grazing on sensitive grasslands or turning agricultural land to woodlands can allow for stabilized land surfaces, reduced erosion and less extreme water flows which often result in flood events.

In the final challenge, China is facing severe water pollution problems more than any time in its history. There has been an increase of 9.7 billion tons in direct wastewater discharge from urban and industrial activities from 2000 to 2005. Based on a survey conducted in 2005 (on a selected river basin covering a total length of 133,000 kilometers), more than 20% of the water quality has dropped beyond the lowest quality grade (grade V). A solution would be to develop and adopt a green economy practices which can reduce the pollution discharge and, in combination with water conservation methods, link pollution control with water resources management.

In summary, evaluating the critical challenges of the water resources situation in China shows that:

- Water resources projects at present are not reflecting sustainable socio-economic development and do not include suitable and critical evaluation of ecological needs. They tend to be traditionally hydraulics-based project such as construction of dams and dikes.
- Uncontrolled and unregulated economic growth has heavy impacts on water resources quantity and water quality parameters. The needs from continuous and uncontrolled economic growth for a country such as China have high social and environmental costs.

Research Needs

Along with conventional wisdom and known engineering solutions, China is acutely aware of the needs for research to identify ways of sustainable water resources management that can tackle these new challenges. The Ministry of Water Resources, together with the Department of Water Resources (IWHR), proposes eight priority areas of research needs which are to:

1. Strengthen fundamental understanding of the total water cycle;
2. Develop new assessment methods concerning climate change;
3. Establish methods to quantify ecological water requirements and allocations;
4. Model all components of the water cycle to ensure effective water utilization;
5. Develop new means to protect water resources;
6. Develop new techniques for ecological restoration;
7. Regulate complex water resources systems with multiple water reservoirs to optimize water flow (and energy generation where applicable);
8. Integrate water resources management into urban processes.

Beijing Case Study:

Beijing is the capital city of China with a population of 20 million inhabitants. Climate-wise, it is scientifically a semi-arid region with an average annual precipitation of 585mm (1956-2009 data). However, the average precipitation from 1999-2009 has dropped to 470mm. Consequently, the total amount of surface water availability has decreased from 25 billion m³ (measured in 1980) to the current 4.5 billion m³ in 2009. In addition, the groundwater table has dropped from an average depth of 15 metres in 1999 to 25 metres below surface in 2010. In terms of water quantity, the water environmental carrying capacity has dropped from 65% (1999) to the current 45% (2010). Because Beijing has low water resources per capita of 202m³, and in part due to soil erosion, the water shortage problems are amplified.

The Beijing municipality authorities have been working on solving the water shortage problem for many years and have taken a parallel approach of both water conservation and water resources development. With regards to water conservation, the approach is to control and restrict the increase in domestic water usage, freeze the increase in industrial water usage and decrease the agricultural water usage. In order to provide water for ecological purposes, the use of recycled water is actively encouraged. With regards to water resources development, the South-North water transfer project, when completed, will provide an additional annual amount of 1 billion m³ of water in 2014. An integrated resources management approach is being taken for planning of urban growth, requiring that water resources availability and demands of rural and peri-urban areas are taken into account. New regulations are also being proposed as part of the new water resources management regime.

In this presentation, we have highlighted the pressures of population increase and economic development on China's water resources, in terms of water shortages, water quality deterioration, erosion and increase frequencies of floods and droughts. Population growth has a large impact on water resources, and we urge that water resources management should be integrated into urban and population management. Urban planners must consider the availability and quality of water as key elements in future planning.
Conclusion

In conclusion, we have presented and discussed the four main challenges in water resources that China faces in the 21st century and also concepts, approaches and potential solutions corresponding to each of the challenges. We have also discussed and prioritized research needs for achieving sustainable solutions for water resources challenges. The case study of water resources management in Beijing city serves as an example of how China can address flooding, develop sustainable water management and tackle water pollution problems arising from unregulated economic development.
DAY 2 - roundtable conclusions

The roundtable discussion for Day 2 addressed the topic of water resources balance and assessment, profiting from the presentations which preceded the roundtables. The sub-themes proposed to orient the roundtable discussions for this day were:

- Promoting water resources management best practices
- Water resources and climate variability
- Knowledge management for Water Resources

Not all themes were addressed by each group or to the same degree during the roundtable discussions, but in keeping with the above broad lines the conclusions from the discussions are as follows:

Challenges

- Water Resources Management (WRM) theory for a regional scale is easy to develop but difficult to implement in practice with measuring and evaluation often needing to be adjusted from basin to basin
- Duplication of management of services sometimes results in lack of accountability where parallel agencies have overlapping mandates but different priorities of service
- There is not enough innovation and use of technology to interpret knowledge. This is compounded by a lack of good quality data, especially data dealing with climatic information, and with collection systems not always standardized. Good data and good interpretation will help quantify to what extent extreme events are influenced by climate change or human activities such as land use.
- Implementation of Water Resources Management, especially where supported by external partners or donors, is sometimes ‘project driven’ and consequently can be isolated from a wider policy perspective or other sectors. A symptom of this is poor land use due to poor land-use planning.
- There is a lack of clarity and common understanding of IWRM among stakeholders at all levels, which can contribute to the lack of effective international cooperation within transboundary catchments.
- IWRM also needs to be understood across other sectors as well. An example is the link between water security to food security and the green economy.
Difficult to convince policy makers to invest in data collection, partly because of a lack of monitoring and feedback to policy makers, donors or funders. Also because it can be an expensive exercise to develop and maintain.

There is a lack of appropriate education or training to address needs at different levels (technical, management, administrative, awareness raising…) and for different stakeholders.

Some data which is collected is not always shared or placed into the public domain (e.g. data collected by private sector actors such as the mining sector), and there is not always a regulatory obligation concerning data sharing.

Lessons learned

IWRM helps clarify issues such as not separating water supply and water demand, and ensuring that water resource protection is taken into account when planning water supply.

Knowledge available in other countries can be taken and adapted to another country’s situation.

Past experience is not meant to be carried automatically into the future as a basis for strategy. China’s experience shows the added value and necessity of using new data and starting fresh with new ideas, processes and strategies in water management.

IWRM is not regarded as a new concept and is sometimes not considered. However new challenges such as Climate Change can also be an opportunity to help us look at IWRM in a new way for a more effective approach.

Solutions

The importance and role of data in good water resources management was clearly identified as being of key importance. Solutions proposed often included elements of good knowledge management and contained elements of innovation. A concept of Data Governance is proposed along with an independent institution centralizing collected data, like a central observatory that functions for organizing the availability of data. The institution can also act as an oversight agency for promoting data sharing from institutions, organizations or private sector actors who may not feel obliged or willing to share data. In keeping with innovation the roundtables suggest that data collection and calculation can be done through alternative means such as grass roots engagement of actors and stakeholders employing simple
methodologies and low material investment, while still allowing for wide data collection coverage.

Promoting a common understanding of IWRM and benchmarking of IRM experiences should be done at all levels. For the wider public it is important to communicate policy, but roles and responsibilities should be clear in this process, not only in the message itself but also in how the stakeholders can take on board the information. Emphasizing good governance and advocacy is very important. People at the local level usually accept the laws and regulations applied, but would become more participative with a better understanding of legal and regulatory processes. Where conflicts over water resources arise at local level, IWRM can be proposed as a well-structured tool for promoting discussion, negotiation and ultimately a resolution between conflicting parties.

The above cannot be achieved without the development of a communication strategy that includes a good use and identification of effective media and other appropriate mechanisms to disseminate knowledge, appropriate information and effective messages. This should incorporate communication and dissemination at a grass roots level for WRM which can lead to improved understanding and stakeholder participation in decision-making and the implementation of activities. Experience in Nigeria has shown that bringing the media and journalists on board when attempting to mediate conflict allows for a more balanced picture of the problem, whereas poor communications and contact with the media can exaggerate already difficult situations. A good communication strategy and results from innovative data collection strategies can build a foundation to advocate to government or donors for the allocation of resources to support improved data collection and monitoring of water resources and the more challenging climate change impacts.

Finally it can be beneficial to actively collaborate between networks in Europe, China, Africa and Latin America. Similar problems exist in all these regions but sometimes with different solutions. Exchanges of experience can lead to adapted solutions and help orient future collaboration between networks which can include joint research.
WATER QUALITY AND SANITATION

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The challenges of defining harmonising objectives at the continental scale: the Water Framework Directive intercalibration exercise

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ABSTRACT: The European rivers, lakes and coastal waters which are subjected to high anthropogenic pressure and human impacts have resulted in degraded ecological status. The Water Framework Directive (WFD) sets the scene on how to handle these challenges and to achieve at least “good” ecological status by 2015. Key to harmonizing quality classifications within and between Europe’s river basins is intercalibration which assists countries to compare their classification of ecological status for similar ecosystem types. This helps resolve inconsistencies and incomparability of values in data collected. One of key success factors is the Intercalibration expert network for rivers, lakes, coastal and transitional waters which consists of more than 50 expert groups which collect international datasets, compile information on the ecological assessment methods and harmonize assessment methods and ecological targets.

KEYWORDS: Water Framework Directive, Intercalibration, ecological status, Europe

Introduction

The European rivers, lakes and coastal waters are subjected to high anthropogenic pressure (eutrophication, acidification, alien species, and climate change). In many cases, these human impacts have resulted in degraded ecological status and limited water uses.

The Water Framework Directive (WFD) sets the scene on how to handle these challenges. Member states should develop ecological status assessment systems for all biological communities and set river basin management plans to achieve at least “good” ecological status for all waters by 2015. In the case of the European Water Framework Directive (WFD; European Commission, 2000) there is the requirement to express results of these assessment methods as an Ecological Quality Ratio (EQR), by comparing monitoring data with equivalent data on reference conditions (i.e. from undisturbed areas). This EQR, which ranges from 0 (bad) to 1 (high), is then subdivided into five quality status levels (high, good, moderate, poor, and bad status), depending on the deviation from reference conditions. The WFD specifies high, good and moderate status through normative definitions. The most important boundary is that between good and moderate status because, if the quality status is
less than good, countries must undertake actions or put into place an appropriate programme of measures to improve and restore aquatic systems until good status is achieved.

**Challenges**

A key element in harmonizing quality classification within and between Europe’s river basins is the intercalibration exercise stipulated by the WFD. In this exercise countries compare their classification of ecological status for similar ecosystem types (i.e. common intercalibration types) across large geographical areas. The aim of intercalibration is to ensure a consistent level of ambition in the protection and restoration of surface water bodies among member states of the European Union. In simple terms, the intercalibration exercise ensures that, for instance, an Irish water body in good status according to the Irish assessment method would also be classified in good status by the Polish or German methods if that water body was located in Poland or Germany, respectively (Birk and Böhmer, 2007).

In theory (European Communities, 2011), the intercalibration process identifies and resolves:

- any significant inconsistencies between the member states’ view on the values for the good ecological status class boundaries and the values for those boundaries indicated by the normative definitions of the WFD, and
- any significant incomparability between the values established for the good status class boundaries by different member states.

The process is organized separately for each water category: rivers, lakes, coastal and transitional (i.e. estuaries and lagoons) waters. Within each category countries that share a similar biogeographical region belong to a Geographical Intercalibration Group (GIG) (Table 1). The exercise is performed among countries that support similar types of aquatic ecosystems within a GIG. The GIGs set up expert groups for each relevant biological quality element (BQE; i.e. phytoplankton, benthic flora and invertebrates, fish) composed of national specialists. To date, the exercise has involved about 70 expert groups intercalibrating more than 300 biological assessment methods for over 100 common intercalibration types of 27 European countries.
Table 1: Geographical Intercalibration Groups and participating countries.

<table>
<thead>
<tr>
<th>Water category</th>
<th>Geographical Intercalibration Group</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers and Lakes</td>
<td>Northern</td>
<td>Finland, Ireland, Norway, Sweden, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>Central-Baltic</td>
<td>Austria(^a), Belgium, Czech Republic, Denmark, Estonia, France, Germany, Ireland(^a), Italy(^a), Latvia, Lithuania, Luxemburg(^a), Netherlands, Poland, Slovakia, Slovenia(^a), Spain(^a), Sweden(^a), United Kingdom</td>
</tr>
<tr>
<td></td>
<td>Alpine</td>
<td>Austria, France, Germany, Italy, Slovenia</td>
</tr>
<tr>
<td></td>
<td>Eastern Continental</td>
<td>Austria(^a), Bulgaria, Croatia, Czech Republic(^a), Greece(^a), Hungary, Romania, Slovakia(^a), Slovenia(^a)</td>
</tr>
<tr>
<td></td>
<td>Mediterranean</td>
<td>Cyprus, France, Greece, Italy, Malta, Portugal, Romania(^b), Slovenia(^a), Spain</td>
</tr>
<tr>
<td>Coastal and Transitional Waters</td>
<td>Baltic</td>
<td>Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden</td>
</tr>
<tr>
<td></td>
<td>North-East Atlantic</td>
<td>Belgium, Denmark, France, Germany, Ireland, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>Mediterranean</td>
<td>Croatia, Cyprus, France, Greece, Italy, Malta, Slovenia, Spain</td>
</tr>
<tr>
<td></td>
<td>Black Sea</td>
<td>Bulgaria, Romania</td>
</tr>
</tbody>
</table>

\(^a\)only rivers, \(^b\)only lakes, \(^c\)some exercises (e.g. intercalibration of very large rivers or lake phytophenthos) were carried out across groups.

Intercalibration is a complex task that takes into account current scientific knowledge about the structure and functioning of aquatic ecosystems, and how human activities influence them. We have developed step-by-step methodology for comparison and harmonization of different ecological assessment methods. The most important steps include the method validation, compilation of common dataset from all countries, comparison of assessment results, and harmonization of ecological class boundaries to ensure coherent assessment among the countries.
One of key success factors is the Intercalibration experts network for rivers, lakes, coastal and transitional waters. This network consists of more than 50 experts groups which collect international datasets, compile information on the ecological assessment methods and harmonize assessment methods and ecological targets.

The first results (ecological class boundaries of approximately 110 harmonized ecological assessment methods) are published in the EC Decision on Intercalibration results (EC, 2009), the second phase results will be published in 2012.
A sector-wide response to key water challenges: water sustainability flagship

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ABSTRACT: A number of strategic water related challenges in Africa are well recognized and documented. Initiatives to address these challenges have been considered by key water sector role-players across the continent. Among them is the country’s Council for Scientific and Industrial Research (CSIR) who introduced a sector-wide coherent program in response to water challenges through its water sustainability flagship (WSF) programme in 2010. This presentation reports on the WSF which serves as a key mechanism to focus the CSIR’s research and development (R&D) capabilities and invites collaboration from strategic partners in contributing to solving the country’s water challenges as well as fostering similar partnerships to enable regional-level water related strategic impact-driven approaches.

KEYWORDS: South Africa, Water Sustainability Flagship, sector wide approach, water

Introduction

A number of strategic water related challenges in Africa are well recognized and documented. Various initiatives to address these challenges have also been considered by a number of key water sector role-players across the continent. In South Africa, the Water for Growth and Development (WfGD) framework and National Water Resources Strategy (2nd draft edition) represents the country’s strategic advocacy in managing its water more effectively in order to enhance socio-economic imperatives. This coherent approach is further complemented by the country’s National Development Plan (its roadmap for the future), in particular the parts on water resources and water services. However, there still appears to be a fragmented and isolated approach within the water sector itself in responding to these water challenges which often result in ineffective solutions at the national level, let alone the dire need to purposefully strengthen regional-level water related initiatives.

In 2010, the country’s Council for Scientific and Industrial Research (CSIR) introduced a sector-wide coherent program in response to water challenges through its water sustainability flagship (WSF) programme. This flagship programme is one of three such programs (the other two focusing on Health and Safety and Security) and is aimed at advancing a set of
large-scale practical and effective science-based integrated solutions. The CSIR- NRE has a wide range of skills and trans-disciplinary research skills in:

- Water science – catchment, transboundary river basins including oceans & coasts (global change)
- Systems modelling, economic and social sciences
- Development of decision-support tools to inform integrated water planning frameworks, strategies and policies

The objective of the WSF is to contribute to the equitable, efficient and sustainable use of water to ensure that South Africa attains its national, social and economic growth and development aspirations. Through this WSF programme, four strategic clusters of outcomes have been identified (in consultation with key stakeholders) to be addressed namely: infrastructure, governance and land-use; water quality; water quantity; water and energy use efficiency. The WSF programme will address the above fragmentation and initially focus on wastewater treatment with a strong emphasis on all the aforementioned four strategic clusters of outcomes being identified. It will link human settlement planning, technology and management options, and downstream user requirements to effectively manage wastewater and deliver water of good quality to support downstream social and economic development. Initial impacts of the WSF program demonstrate that integrated planning and service delivery has resulted in long-term solutions to water quality, quantity and effectiveness. It has promoted alignment with stakeholders and key initiatives such as the National Water Resource Strategy (NWRS II), the Water for Growth and Development Framework, the National Development Plan for SA and others.

**Conclusion**

South Africa's water situation presents us with range of research and development opportunities, most of which are appearing as insurmountable problems. The CSIR ensures alignment of its water R&D focus area with relevant strategic initiatives and also strategic engagements with stakeholders. The CSIR’s water sustainability flagship is a large-scale impact-driven response to a water problem which serves as a good platform to further direct other water related research and development.
References


Innovative technologies for filtration and sanitation in developing countries

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ABSTRACT: The increasing demand for water and the impacts of a changing climate call for innovative water resources and sanitation technologies. The Water and the Environment Centre of Kwame Nkrumah University of Science and Technology (KNUST) is carrying out research in the field of innovative technologies for sanitation and water quality improvement.

KEYWORDS: water resources, water technology, sanitation technology, water quality

Introduction

The increasing demand for water and the impacts of a changing climate call for innovative water resources and sanitation technologies. There is an increasing impact from urban waste and wastewater discharges on water resources in developing countries. To deal with this situation, there is a need for innovative and low cost wastewater and drinking water treatment technologies to ensure environmental protection and improved public health. The provision of innovative sanitation technologies seeks to protect environmental quality and address pressing issues such as preventing eutrophication of lakes and rivers and algal proliferation in water bodies.

Ghana’s innovative technologies

An assessment of technologies in Ghana shows a trend of the uptake of emerging water and sanitation innovative technologies that contribute to the effort which is being made to measure and control water quality of rivers and lakes and to address pollution problems. The Water and the Environment Centre of Kwame Nkrumah University of Science and Technology (KNUST) is carrying out research in the field of innovative technologies for sanitation and water quality improvement. The promising water/wastewater innovative technologies to deal with water quality of drinking water include:

- MACAFE filtration unit - adsorptive removal and simple filtration process to remove high concentrations of iron and manganese from groundwater
- Adsorption of fluoride onto aluminum oxide coated bauxite and charcoal,
- Modular water treatment centres (media and ultraviolet units)
Current research ongoing in developing fluoride and arsenic removal.

The innovative sanitation and waste water technologies being piloted are:

- Faecal sludging dewatering technology (drying bed),
- WSUP-Unilever Uniloo toilet,
- Urine diversion/elevated compost toilet,
- Standalone Biofil Digester
- Compost Toilet Technology.

Conclusion

These emerging sanitation technologies emanate from ecological sanitation (Ecosan) concept where faeces, urine and wastewater are resources are seen as existing in an ecological loop. The innovative water and sanitation technologies are still on pilot scale, and the uptake needs commitment and support of private sector and government agencies.
The impact of gold processing activities and water quality challenges in communities affected by lead poisoning in parts of Zamfara State NW Nigeria

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ABSTRACT: A joint Centre for Disease Control (CDC) and World Health Organisation (WHO) investigation on the outbreak of acute lead poisoning in Zamfara State reported illness and deaths among children mostly under 5 years old in some communities in Bukkuyum and Anka Local Government Areas (LGA) (CDC, 2010). Based on the findings of this report and consultations with UNICEF and Zamfara State Ministry of Water Resources, the National Water Resources Institute (NWRI) decided to send in a 5-man technical team to carry out an assessment of the quality of the water from the various drinking water sources of the affected communities in the two LGAs of Zamfara State. The Team carried out a comprehensive assessment that included:

- Drinking Water Quality Assessment (on-site and laboratory analyses);
- Participatory Rapid Appraisal (sanitary inspection, health issues, socio-economic impacts); and
- Geo-chemical assessment of the mined rocks being processed in the communities.

This paper presents the findings of the assessment of the impacts of the processing of mined rocks on the populations of four affected communities.

KEYWORDS: Zamfara State, Nigeria, water quality assessment, gold processing activities, lead poisoning

Methodology

The team met with and discussed the evaluation project with the Zamfara State Stakeholders. In each village visited, the team conducted focus-group discussion on the various socio-economic aspects of the tragedy with the Head of the village, his Councilors and some of the community members. The following information was obtained from the focus-group discussion:

- Demography (estimated population, number of compounds, range of households per compound, range of population per household);
- Major economic activities;
- Available infrastructure (schools, clinics, roads, water supply sources, electricity supply, telephone services, etc.);
- Gold processing activities (when they started, sources of the mined rocks, processing procedures, number of households and people involved; costs of the various processes, income from the processing activities, etc.); and
- Number of children that died from this crisis and when the current crisis began.
In order to assess the factors responsible for the possible sources of the pollution, the geology and hydrogeology of the affected areas were appraised. In addition, the geochemical constituents of the mining rock materials collected from the affected communities in the two Local Government Areas (LGAs) of Zamfara State were determined.

Drinking water sources were strategically selected for analysis which covered the various sections of each village visited. Based on the sizes of the assessed villages, a total of 18 water sources were sampled. These included 2 boreholes in Abare, 2 streams (1 each in ‘yargalma and Abare), 2 concrete wells (1 each in Dareta and Abare) and 12 unprotected dug-wells (4 in ‘yargalma, 1 in Rumbuki, 2 in Tungar Guru, 3 in Dareta and 2 in Abare). Rumbuki is an unaffected village in between two affected villages (‘Yargalma and Tungar Guru). The major well in this village was sampled for comparison as a control.

At each selected measurement site, geographical coordinates (latitude (oN) and longitude (oE)), temperature, appearance, pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity and static water level (SWL) of the sampled water well were measured on-site. Fluoride (F), nitrate (NO3), sulphate (SO4), bicarbonate (HCO3), iron (Fe), faecal coliforms (FC) and total coliforms (TTC) were analysed on the sampling day. To minimize changes in physicochemical characteristics, samples for analyses of other parameters (Lead (Pb), Chromium (Cr), Arsenic (As), Calcium (Ca), Magnesium (Mg) and Manganese (Mn)) were acidified with concentrated nitric acid in the field and analysed in the laboratory in Kaduna.

**Gold Extraction Processes by the Communities**

Figure 2 shows the sequence of the processes that the local communities employ for the mining of gold from the rocks obtained from the viable gold deposits communities at Bukkuyum and Anka LGAs of Zamfara State. During the grinding and washing processes, virtually everybody in the community (including men, women, the youth and the children) was involved. These processes were carried out both inside and outside the households until after the current crisis started that the State Government ordered that all the machines and equipment should be removed and relocated away from the villages.

However, in virtually all the villages visited, the community members were still processing the rocks in the new locations outside the villages as shown in Figs. 3 to 7.
Figure 1: Gold processing cycle as reported by the community processors - Geochemical Analysis

The result of the geochemical analyses is presented in Table 1. The rock samples were prepared by crushing and digestion. The Inductively Coupled Plasma Optical Emission Spectrometry method was used for the analyses of the samples.

Table 1: Trace elements analyses of rock samples from some mine sites in Zamfara State

<table>
<thead>
<tr>
<th>S/N</th>
<th>Source</th>
<th>Ag</th>
<th>As</th>
<th>Cd</th>
<th>Co</th>
<th>Cr</th>
<th>Cu</th>
<th>Pb</th>
<th>Se</th>
<th>Tl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Lambargudu</td>
<td>243.3</td>
<td>403.0</td>
<td>43.74</td>
<td>21.67</td>
<td>804.7</td>
<td>11,220</td>
<td>350,200</td>
<td>158.</td>
<td>145.</td>
</tr>
<tr>
<td>2.</td>
<td>Lambargudu</td>
<td>5.86</td>
<td>261.9</td>
<td>3.63</td>
<td>110.9</td>
<td>838.4</td>
<td>984.0</td>
<td>21,240.0</td>
<td>0.0</td>
<td>101.</td>
</tr>
<tr>
<td>3.</td>
<td>Sunke 1</td>
<td>66.26</td>
<td>335.7</td>
<td>3.00</td>
<td>130.2</td>
<td>896.9</td>
<td>946.0</td>
<td>10,540.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4.</td>
<td>Sunke 2</td>
<td>6.92</td>
<td>272.7</td>
<td>4.24</td>
<td>180.3</td>
<td>833.5</td>
<td>202.3</td>
<td>798.2</td>
<td>65.8</td>
<td>29.5</td>
</tr>
<tr>
<td>5.</td>
<td>Nagako</td>
<td>33.01</td>
<td>272.2</td>
<td>5.63</td>
<td>173.6</td>
<td>843.9</td>
<td>306.5</td>
<td>9,049.0</td>
<td>117.</td>
<td>63.7</td>
</tr>
<tr>
<td>6.</td>
<td>Gwashi</td>
<td>44.73</td>
<td>20,360</td>
<td>516.3</td>
<td>81.45</td>
<td>937.1</td>
<td>775.2</td>
<td>48,440.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>7.</td>
<td>Kwali</td>
<td>0.00</td>
<td>238.6</td>
<td>3.50</td>
<td>114.1</td>
<td>1,437.</td>
<td>28.3</td>
<td>49.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Average Value</td>
<td>57.15</td>
<td>3,163.4</td>
<td>82.86</td>
<td>116.0</td>
<td>941.6</td>
<td>2,066.0</td>
<td>62,902.3</td>
<td>48.8</td>
<td>48.6</td>
<td></td>
</tr>
</tbody>
</table>

Results

Results of the field, petrographic and laboratory geochemical analysis indicated the occurrence of high concentration of lead and other trace metals like chromium, silver, arsenic, cadmium and other trace metals associated with the gold mineralization. Some of the major challenges are the mining processes that entail improper mining practices, use of children and women in the mining activities, the mining processes being carried out in homes, and the resulting pollution of the rivers, streams and the soil due to the use of mercury as a means of gold recovery chemical during the gold processing operations.

Aesthetic Parameters

These are the parameters that indicate palatability of water for consumers. Table 2 of the presentation shows the results obtained. The water appearance ranges between clear – dirty, with the dirty appearance being from streams used for panning and processing of the mined product. **Turbidity** ranges between 2.11- 753NTU, with highest values being from the streams. Data of both the turbidity and appearance signifies that water sources are slightly unobjectionable to the community members, though only 22% satisfied the allowed level of clear appearance and 5 NTU turbidity recommended by National Standard for Drinking Water Quality (NSDWQ) and World Health Organization (WHO). 61% of well water sources that did not satisfy the guideline values have turbidity ranging from 6.27 – 29.70 NTU. The sources of turbidity in the hand dug wells might be from surface introduction through bucket and rope used for drawing the water as none is hanged and run-off water as most has no or very low headwall.
Table 2: Aesthetic quality of drinking water

<table>
<thead>
<tr>
<th>S/N</th>
<th>Location</th>
<th>Lat. (N)</th>
<th>Long. (E)</th>
<th>SWL (m)</th>
<th>Temp. (°C)</th>
<th>Aesthetic</th>
<th>Turb. (NTU)</th>
<th>EC (µS/cm)</th>
<th>TDS (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YARGALAMBA VILLAGE - 10th June, 2010; 1:30 - 4:20 pm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Mal. Amadu Ward</td>
<td>11°38.96'</td>
<td>05°30.96'</td>
<td>8.40</td>
<td>29.4</td>
<td>S. Clear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Dorawa Ward</td>
<td>11°58.42'</td>
<td>05°30.93'</td>
<td>9.45</td>
<td>30.0</td>
<td>Clear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mal. Buwai Compound</td>
<td>11°58.41'</td>
<td>05°31.00'</td>
<td>9.50</td>
<td>29.5</td>
<td>S. Cloudy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Alh. Umaru Compound</td>
<td>11°58.34'</td>
<td>05°31.05'</td>
<td>9.85</td>
<td>35.8</td>
<td>S. Clear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Stream (panning/proc.)</td>
<td>11°58.47'</td>
<td>05°30.92'</td>
<td>34.3</td>
<td>753.00</td>
<td>Dirty</td>
<td></td>
<td>113.1</td>
<td>56.8</td>
</tr>
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|     | RUMBUKI VILLAGE - 10th June, 2010; 4:40 pm |          |           |         |            |           |            |            |            |
| 6   | Central Mosque Well            | 11°57.07' | 05°29.42' | 8.46    | 28.9       | S. Clear  |            |            |            |
| 7   | Hakimi Ward                    | 11°55.98' | 05°29.67' | 4.90    | 28.2       | Cloudy    |            |            |            |
| 8   | Malamai Ward                   | 11°55.96' | 05°29.72' | 7.80    | 27.8       | Cloudy    |            | 666.0      | 337.0      |

|     | DARETA VILLAGE - 11th June, 2010; 11:37 - 12:26 pm |          |           |         |            |           |            |            |            |
| 9   | Sarkin Dutse Comp.             | 12°01.82' | 05°57.23' | 11.30   | 30.2       | Clear     |            |            |            |
| 10  | Moh. Nasiru Comp.              | 12°01.87' | 05°57.35' | 5.95    | 28.6       | Clear     |            | 1135.0     | 568.0      |
| 11  | Yamutse Concrete Well          | 12°01.89' | 05°57.30' | 8.60    | 36.2       | Clear     |            | 1036.0     | 520.0      |
| 12  | Umaru Musa Comp.               | 12°01.77' | 05°57.29' | 9.37    | 30.7       | S. Clear  |            | 1027.0     | 293.0      |

|     | ABARE VILLAGE - 11th June, 2010; 1:18 - 2:36 pm |          |           |         |            |           |            |            |            |
| 13  | Geben Sabo Stream              | 12°04.38' | 05°57.40' | 34.3    | Dirty      | 560.00    | 40.3       | 20.3       |
| 14  | Mosque Concrete Well            | 12°04.66' | 05°57.38' | 9.44    | 34.5       | S. Clear  | 19.40      | 478.0      | 240.0      |
| 15  | Musa Makeri Borehole           | 12°04.71' | 05°57.32' | 34.2    | Clear      | 2.11      | 501.0      | 250.0      |
| 16  | Alh. Lawal Well                | 12°04.65' | 05°57.33' | 6.00    | 30.4       | S. Clear  | 6.27       | 268.0      | 134.0      |
| 17  | Sabongari Old Borehole         | 12°04.60' | 05°57.47' | 36.6    | Clear      | 4.97      | 296.0      | 148.0      |
| 18  | Tsohon Sarki Well              | 12°04.62' | 05°57.34' | 9.26    | 39.1       | Clear     | 2.41       | 468.0      | 234.0      |

Microbiological Parameters

Lack of safe drinking water and inadequate sanitation often lead to outbreak of water-borne diseases such as cholera, dysentery, salmonellosis and typhoid. Diarrhoea is the major cause of death of more than 2 million people per year worldwide with children under the age of five accounting for largest numbers (WHO, 2004). The evaluation of potable water supplies for coliform bacteria is important in determining the sanitary quality of drinking water. Groundwater, though much higher in microbiological quality than surface water however, can also be susceptible to faecal contamination from on-site sanitation (Ince et al., 2006).

High numbers of total coliforms ranging from 7 cfu/100ml –TNTC were detected in 14 of the 16 water samples. Samples from the 2 streams were not tested for total coliforms because of
obvious environmental factors. Faecal coliforms were not detected in most of the water samples; only 3 (17%) samples tested positive for faecal coliforms ranging from 153–560 cfu/100ml. The values of 153 cfu/100ml and 244 cfu/100ml were recorded for open hand dug wells while the value of 560 cfu/100ml was recorded for the stream at Abare Village (Table 2 and 3, NWRI, 2010).

Conclusions and Recommendations

In the course of the assessment survey of the affected communities, laboratory analyses showed the presence of lead in the water samples collected from the hand dug wells, boreholes and the streams where the mining materials are being washed into. Community members involved in the mining activities carry out the processing of mining materials within and outside their households. It was noted that both adults and children are involved in the mining processing of the gold and that there is generally poor hygiene and sanitation practices around the wells and the areas around the household where these mining activities are been carried out.

There is the need to discourage irresponsible small-scale mining and seek cleaner processes for gold and precious metals production that are in accordance with human rights, social and environmental criteria which will protect the human living environment and health. Other conclusions include:

- Artisanal mining activities of this nature are expected to provide employment and generate resources for the socio-economic development of the communities. However, due to the improper mining practices and the lack of basic infrastructures, the gold extraction processes in Zamfara State has not resulted in improved standard of living but has resulted in deaths, environmental pollution and loss in livelihoods.
- These mining activities have resulted in the contamination of the main sources of potable water-wells and streams through indiscriminate dumping of tailings (mining waste material) accumulated during gold extraction.

Recommendations

- The artisanal miners should be encouraged to use proper mining methods through awareness creation and capacity building;
- Simple safety rules such as wearing of nose covers, safety caps, safety boots, hand gloves must be encouraged and enforced in the mines field and processing locations;
- Proper handling of mercury and other chemicals for gold recovery should be promoted and enforced to prevent further pollution of the environment, particularly water sources;
- The communities should be encouraged to form cooperative societies to facilitate access to capital and credits to ensure adequate purchase of mined products and processing equipment and materials for enhanced revenue generation and improved quality of life;
- Zamfara State Government should provide appropriate facilities for proper disposal of mine tailings injurious to human health, to avoid reoccurrences of the lead poisoning episode;
- Governments at all levels and the Development Assistance Agencies should, as a matter of urgency, provide infrastructures essential for human health such as; good roads, schools, clinics, and improved water supply facilities;
- The communities should be assisted and empowered to establish WASHCOM committees that will enable them operate and maintain their water supply and sanitation facilities and improve their hygiene practices; and
- All the communities should carry out all mining and related activities at locations far away from their homes. Basic precautions should be put into place for all mining activities to avoid consequent sources of pollution. Regular monitoring and pollution control should be carried out in all sites of mining activities, especially with regards to all sources of water supply for the communities.

References


Example of united operation of water resources in Pearl River Basin

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ABSTRACT: This study first introduces the general situation of water resources in the Pearl River basin. The influence factors of salt tide intrusion are analyzed and the corresponding solution for controlling salt tide intrusion, which is the integrated management of water resources, is proposed. As a case study, the integrated management of water resources during the winter and spring period from 2007 to 2008 is presented.

KEYWORDS: Pearl River basin, salt tide intrusion, IWRM, China

General Situation of Water Resources in Pearl River Basin

The Pearl River, the largest river in southern China, is comprised of the West River, North River, East River and Delta along with numerous branches. It covers a drainage area of 453,700 square kilometers.

The total amount of water resources in the basin is 338 billion cubic meter (West River 230, North River 51, East River 27 and Delta Area 30) with the per capita equivalent of 4,700 m³. However the distribution in space and time is extremely variable. During non-flood period (from October to March) only 22% of the volume is presented, while during flood period (from April to September) 78% of the volume moves through the system.

Influence of Salt Tide Intrusion and Solutions

Salt tide intrusion is an annual natural disaster influenced by runoff and tide and has posed a great threat to South China's coastal areas from November to February each year. Runoff is the main influencing factor on salt tide intrusion.

The salt tide intrusion is severely threatening the fresh water supplies in south China's Guangdong Province where 15 million people lived in the affected area. It continually occurred for 3 to 4 months of the study period. There have been serious salt tide events regularly occurring since 2003. The salt tide gravely affected drinking water supplies in the densely populated Delta, where major cities such as Macao, Zhuhai, Zhongshan, Panyu,
Dongguan, Guangzhou and Shunde are located. The chlorinity of water was as high as 800mg/L, 3 times higher than the national standard.

To safeguard the drinking water resources, there are two measures which can be adapted: One is the application of engineering measures, including building water resources allocation projects to regulate runoff and building local reservoirs in the Delta to regulate water supply. Another way is the application of non-engineering measures which depend mainly on the integrated management of water resources in the whole basin.

Integrated management of water resources in Pearl River Basin must be implemented to safeguard drinking water because there is not enough water resources currently allocated. The experience of integrated management in Pearl River Basin shows the united operation is an active and significant way to solve water resources problems in Pearl River Delta.

**Integrated Management of Water Resources**

Based on the available reservoirs in the river basin the management addresses the challenge as follows: first analyzing the runoff, salt tide flow, water supply and water demand; and then planning the operation by aiming to balance the above elements for refining the operation, and finally optimizing the plan using revised forecasts and real-time information.

Implementation of the management plan dynamically controls the discharge at Wuzhou in West River; when drought is very serious, water resources are limited and the discharge reduced during the spring season.

The risks and the challenges of the operation are as follows: the total operation needs 6 months. The distance is about 1300km and the flow time is about 7 days. As it is a multi-reservoir operation, the arrival time and discharge magnitude must be strictly scheduled. Many provinces and special administrative regions are involved. As the operation may damage or benefit some infrastructure, businesses and enterprises, the cooperation is very difficult to achieve, making the application of the mechanisms for controlling of salt tide intrusion very complicated.
United Operation of Water Resources in winter and spring from 2007 to 2008

In 2007, according to the weather prediction, there was a drought predicted for the Pearl River in the upcoming winter and next spring. Many hydro-power stations would be expected to go into operation and store amounts of water at the same time. Water amounts in the West River would be reduced greatly and salt tide intrusion would be serious in delta area if the integrated management and operation were not carried out.

This integrated management operation guaranteed the water supply during the strong salt tide intrusion period. Implemented 8 times, fresh water was transferred downstream in the watershed, with an estimated volume of 0.104 billion tons water. From 20 December to 28 February, 27 million tons of fresh water was supplied to Macao. The chlorinity of water was as low as 100mg/L, far lower than the national standards. Longtan, Guangzao, and Changzhou hydro-power stations stored water 10.1 billion tons, and achieved their planned operation goals.

Conclusion

To conclude, integrated management of the water resources in Pearl River Basin is a success and necessary way to safeguard drinking water of Delta Area. In the future, we need continue improving with upcoming projects such as the building of the Datengxia Project and to make integrated water resources management part of the policy and operation of water resources in Pearl River Basin.
ABSTRACT: Fundacion Chile (FCH) is a non-profit corporation actively involved in the technological development of Chile. FCH developed a Smart Water Program which aims at identifying specific solutions in the field of water efficiency, new sources of water, wastewater treatment, Integrated Water Resources Management and governance. The organization is the coordinator of the Centers of Excellence chosen under the RALCEA project for the thematic axis “water quality and sanitation”. Priorities for research on water quality and sanitation have been decided for the region amongst the Centres of Excellence which are also developing a Good Practice Guide on Water Treatment.

KEYWORDS: Smart Water Program, water efficiency, wastewater treatment, IWRM, water quality, sanitation, RALCEA

Introduction

Fundación Chile (FCH) is a private non-profit corporation created in 1976 by the Government of Chile and the ITT Corporation of the USA. In 2005, BHP Billiton actively joined the board of the Foundation. For more than three decades the institution has played a significant role in the technological development of Chile, incorporating new technologies to its production and service sectors, with particular emphasis on Food and Biotechnology (including aquaculture and chemical metrology), Sustainability and Climate Change (including environment, water, eco-mining, carbon, renewable energies and energy efficiency), Digitalization (information and communication technologies), and human capital (including school education, workforce development, and innovation management).

Fundación Chile currently works with over 146 foreign organizations (companies, governments, technology centers) in 35 different countries. By mandate, every endeavor it takes on board must be in collaboration with other partners - i.e. technological, financial, potential clients, etc.
FCH has developed the Smart Water Program that works on specific solutions, either through internal developments or by adapting and optimizing proven solutions and successful transfer. This program aims at identifying specific market needs in the fields of:

**Water efficiency:** 1) Monitoring and prediction of water infiltration in distribution systems; 2) Decrease of water losses through evaporation within irrigation systems in the mining sector; 3) Treatment systems for water reuse; and 4) water accounting using GRI, Water Footprinting and water accounting framework for mining industry.

**New sources of water:** 1) Water transport towards water scarcity areas; 2) Use of salt or saline water for bioleaching

**Wastewater treatments:** 1) Bio Treat, passive treatment using wetland system; 2) ABAR, boron removal in natural and rural water supply; 3) Zeo Treat, removal of cations and anions using natural and modified zeolites; 4) MILAF, treatment of acid wastewaters with high sulphate and arsenic content; and 5) OAC, catalytic advance of oxidation for degradation of persistent pollutants

**Integrated Water Resources Management, Governance:** 1) Institutional capacity building for integrated water resources management; 2) Creation of framework for water policy; 3) Technical support in Huasco and Copiapó Basin bureau; and 4) development of a Water Observatory for Atacama, Arica and Parinacota Region in Chile.

**RALCEA – water quality and sanitation research axis**

In 2011 FCH was selected as one of the Centers of Excellence under the RALCEA project. This project provides a unique opportunity to share experiences from 12 different countries, learning from each other’s realities, solutions, barriers and opportunities. Specifically, FCH is coordinating the area of water treatment and sanitation. The project under this component is planned to finish on the first part of 2014 and its total budget is 321.72 Euros, where 80% of the budget is EU contribution, and the remaining 20% is a contribution by the regional centers.

Its objective is to improve the knowhow on water quality and sanitation issues in Latin America. The main tasks that have been defined by the partners include: Definition of a project portfolio to be implemented by the Centers of Excellence, aimed at addressing the main challenges related to water quality and treatment; the Development of a strategy for
implementing each of the initiatives; Capacity building on water quality and sanitation for the participants; and to develop and adapt tools for water quality and sanitation.

The current members are Agualimpia (Perú), CIRA-UNAN (Nicaragua), Fundación Chile (Chile), Universidad Nacional de Colombia (Colombia), CAP-NET (UN), UNICAMP (Brazil), CEDEX (España), CETA UBA (Argentina), and Zamorano (Honduras). The Focal Points are: Argentina, Bolivia, Chile, Colombia, Honduras and México.

From September to November 2012 the Centers provided ideas and priorities on water research. The proposed topics were grouped as follows:

- Water treatment of naturally occurring contamination of water bodies (As, B).
- Human activity contamination (Cr, Hg, pesticides, organics.)
- Eutrophication
- Treatment of industrial waters
- Water monitoring and reuse
- Aquifers recharge
- Development of water health indicators
- Urban drainage
- Eco-hydrology
- Math modeling

Additionally, in the workshop that took place in Honduras in the second part of 2012 (July), it was agreed by the parties that the development of a Good Practice Guide on Water Treatment would be a useful product coming from RALCEA, so this guideline is currently under development. This guideline could include issues such as: Management instruments for Water in LA, Case studies, Water discharge regulations, water quality regulations (human health, ecosystem), Definition of quality objectives for ecosystem protection, Successful case studies of Monitoring at catchment level, Water treatment case studies (technical and economic analysis for various contaminants).

A second workshop with all parties involved is planned for March 2013 in the context of the first Water Week Latin America Forum to be held in Chile. Additionally, the updated work plan expects by the end of 2013 the following main results: a complete good practice guideline, three project proposals to search for funding, three case studies, plus the identification and application of other tools that may be relevant to the water and sanitation Research Line.
The identified benefits for the participants include: being part of an innovative platform focusing on water and sanitation, having access to training on several issues related to water and sanitation, being part of in-situ demonstration activities and access to results and tools.

Finally, all the participants have expressed their interest and willingness to actively contribute to the success of this network and search for mechanisms and ensure its long term sustainability and lasting impacts.
Innovative technologies for water quality management in irrigation: China case study

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ABSTRACT: As a country with a population of more than 1.3 billion water resources play a major role in China's food security, poverty reduction and environmental sustainability. China successfully feeds and clothes 20% of the world’s population with its 6% of the world's water resources and 9% of the arable land. Agricultural irrigation takes up more than 75% of the total water consumption. In the practice of more efficient water-saving irrigation, the Chinese government has set clear targets of making an efficient use of water resources and improving the overall agricultural production capacity.

KEYWORDS: China, water quality, technologies, irrigation, water efficiency, food security

Introduction

As a country with a population of more than 1.3 billion, China is the biggest food consumer in the world. Feeding its 1.3 billion population has been viewed as one of the most important problems in China. Water resources play a major role in China's food security, poverty reduction and environmental sustainability. In China’s rural areas, shortages and quality of water resources have significantly affected people’s life. Being the largest water user, agricultural irrigation takes up more than 75% of the total water consumption. In the process of agricultural irrigation, apart from water resources consumption, the irrigation water return flow back into river or into the soil through the drainage system has been found to have a great impact on the quality of water in rivers and underground.

China successfully solves the problem of feeding and clothing 20% of the world’s population with 6% of the world's water resources and 9% of the arable land in which the role of irrigated agriculture has proved irreplaceable. In China, irrigation and drainage take a prominent position in food security. However, as the first major water user, water irrigation & drainage are extremely important to water management and water environmental protection. Therefore, the development of water-saving irrigation and the improvement of agricultural water management constitute an essential part of water management and water quality protection.
China’s water irrigation and drainage measures

The Chinese government has prioritized water conservancy in national infrastructure construction and taken rural water conservancy as one key task of the rural infrastructure construction. The Chinese government has boosted irrigation and water conservancy, intensified renovation of irrigation districts and water conservancy construction, vigorously developed water-saving irrigation, enhanced rural water management, innovated institutional mechanisms of water conservancy development, constantly improved the overall agricultural production capacity, and strongly supported the protection of national food security.

In the practice of water-saving irrigation, the Chinese government has clearly set the target of efficient use of water resources and improving the overall agricultural production capacity; it has taken water-saving irrigation technology development as a major measure, including anti-seepage in the channels, pipeline conveyance, sprinkler irrigation, micro-irrigation. China attempts to speed up water-works construction, strengthen water management reform, rely on technical support, improve service system, integrate demonstration site construction with cluster promotion, accelerate water saving development, facilitate the modernization of rural water conservancy, and enable sustainable use of water resources under the leadership of government with farmers’ participation, enterprises’ cooperation and social support.

By the end of 2010, China’s irrigated area had reached 995 million hectares, and the effective irrigation area was 905 million hectares, accounting for 49.6% of the arable land in the country. Water-saving irrigation projects covered an area of 410 million hectares, among which 177 million hectares benefited from spray irrigation, micro-irrigation and pipe conveyance irrigation technology, taking up 43.2% of the total water-saving irrigation project area. Thanks to the national rural drinking water safety project, over 670 million people have the access to safe water in the rural area and the tap-water supply coverage is 54.7%.

Conclusion

The Chinese government attaches great importance to monitoring rural water quality, and it has been actively estimating the impact of pesticide and fertilizer residues on the quality of water in rivers and underground. However, at the current stage, there are neither mature technologies nor effective measures to curb the problem of rural source diffuse pollution.
Effects of climate change on the river flow regimes in the mangrove and tropical rainforest region of West Africa.

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ABSTRACT: Climate change has a profound effect on the hydrological environment in various parts of the world. As a result of climate change, the rate of flooding and drought has increased tremendously. In the coastal mangrove forest and the adjoining rainforest region of West Africa, flooding is a major concern particularly during the rainy season from April to October. As a result of the climate change, there have been uncertainties in farming seasons. While the effect of drought is bad for crop yield, the effect of rainfall and river flooding is more catastrophic as farm lands are washed away, lives are lost and in many instances properties worth millions of dollars are irreparably damaged and rivers and streams are polluted. The paper examines the effect of climate change on river flow regimes within the mangrove and rainforest region of West Africa.

KEYWORDS: Climate change, Precipitation, Evapotranspiration, Drought, Flood, Mangrove forest

Introduction

The Nigerian coastal zone sprawls a total of nine states out of the thirty-six states of the federation, namely: Akwa-Ibom, Bayelsa, Cross River, Delta, Edo, Lagos, Ondo and Rivers. The coastal states are estimated to account for 25% of the national population. The coastal areas stretch inland for a distance of about 15km in Lagos in the West to about 150km in the Edo/ Delta and about 25km East of the Niger River. The coastline stretches for about 853km, comprising inshore waters, coastal lagoons, estuaries and mangrove especially in the Niger Delta.

The areas chosen as case studies for this research are Benin City the capital of Edo State of Nigeria which is located within the rainforest region and Calabar the capital of Cross River State which is located within the coasted mangrove swamp region. The rainy season lasts for eight months beginning in April and ending in November. Relative humidity is high, ranging from 94% in April to 97% in August. The topography in Calabar is basically low lying flat terrain typical of the coastal plain.

Benin City is the capital of Edo State and is located within the rainforest region with mean annual rainfall of 2100mm and mean monthly temperature ranging from a minimum of 23°C to a maximum of 27°C. This region is also characterized with relative high rain fall. Two
distinct seasons are distinguishable, the wet (rainy) season and the dry season. The rainy season occurs between the months of April to October with a short break in August. The dry season lasts between November and March with dry harmattan spread between December and February. The city lies on a gently sloping coastal plain in a drainage divide between the head waters of the sub catchment system of Ikpoba and Ogba rivers.

Effects of sea level rise on rivers within the zone

As a result of rising in sea level at a rate faster than the rate of land aggradations, due to sedimentation, there has been a decrease in land elevation particularly in the area around Calabar. The reduction in land elevation causes an increase in inundation by rivers overflowing banks at full stage flooding. By reducing the gradient of river flow, the amount of river discharge has decreased thus creating a corresponding back water effect inland. The back water effect caused by sea level rising, has contributed to the occurrence of recent increases in flooding of adjacent lands caused by river water ‘piling up’ at the Cross River, Calabar, the River Niger and Ikpoba River in Benin City.

Data collection

Data used for modeling are rainfall and stream discharge collected over a designated period, designed to accommodate both the wet and dry season.

Data modeling

The collect rainfall/stream discharge for the different periods was modeled using IHACRES version 1.03. IHACRES is a catchment–scale rainfall-stream discharge modeling methodology. Its purpose is to assist hydrologists or water engineers to characterize the dynamic relationship between basin rainfall and stream flow.

Interpretation

Interpretation of the model was done on the basis of the coefficient of determination. In addition to the modeled stream flow, the cross correlation coefficient between model residual and effective rainfall (x1), the cross correlation coefficient between model residual and stream flow (u1) and the maximum value of nonlinear storage, which measures the volume of rainfall that eventually transforms to overall runoff rate, were determined.
Model results and discussions

Results of rainfall/stream flow modeling for the wet and dry seasons were determined: the modeled total observed rainfall for the wet season was given as 4337.900mm while that for the dry season is 57.1200mm. The modeled total observed stream flow for the rainy season was computed as 1040.5300 cumecs (cubic meters per second) while that of the dry season was given as 26.7800 cumecs. This shows that, the dynamic response of streams to precipitation rate is higher during the raining season, resulting in the associated high flood rate around the coastal areas. The modeled dynamic behavior of the stream flow for the rainy and dry seasons was developed. The cross correlation coefficient between the modeled residual and the effective rainfall (x1) which account for the fitness of the data set to the model was obtained as 284.8 and 28.1 respectively. The catchment wetness index, which shows the amount of excess water that subsequently may lead to flooding, was also determined. The overall data collection/analysis has shown that climatic change occasioned by higher temperatures resulted in high rate of precipitation, the consequence of which is the resulting high rate of flooding especially within the coastal region.

Rainfall distribution for Calabar in the coastal rainforest region has remained relatively high within the period under study (1977-2006). The distribution pattern reveals that, although there is a rise and drop in the total annual rainfall in Calabar, the highest rainfall is normally noticed in the month of May to September of every year.

Temperature distribution also follows a rise and fall pattern within the period under study with the highest temperature experienced in the year 1998-2000 and the lowest temperature experienced in the year 2002.

Conclusion

In the coastal mangrove forest and the rainforest regions of West African flooding is of major concern. The study has shown how climate change has altered precipitation pattern within the study areas. Rainfall and stream discharge data were collected for both wet and dry seasons. The results revealed that the dynamic response of streams to precipitation rate is higher during the rainy season, the result of which is the high flooding rates commonly experienced in this region.
Analysis of precipitation and temperature data was also carried out. The result revealed that higher stream discharge is characterized by higher temperature conditions in the region. Precipitation within the West Africa region decreases with distance from the Atlantic Coast River flooding in this area is attributable mainly to climate factors. The results of the study show that the current increase in the rate and frequency of river flooding is attributable to the effect of climate change. Finally, the study proposes the need for multi-dimensional and coordinated approach by various stakeholders in regulating river flow regimes taking cognizance of the effect of climate change and variability.

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A territorial approach to the European Water Framework Directive including water quality management: case of the Artois Picardie basin in France

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ABSTRACT: This paper is a presentation of a brief explanation of the French water governance system. It explains what is the local water management scheme, how local water management schemes take into account the Water Framework Directive and especially the program of measures, gives examples of measures implemented by the local water management schemes in the Artois Picardie basin to achieve quality statements and provides a choice of indicators for follow-up management.

KEYWORDS: France, Artois Picardie Basin, water governance, local water management, Water Framework Directive,

Presentation of a short overview of the French water governance system

The Artois Picardie basin is located in the Northern part of France next to the Belgian boarder. It belongs to the International Schelde District which includes the Artois Picardie basin, Belgium (the Flanders, Walloon and Brussels capital as well as the Federal state of Belgium) and the Netherlands.

In France, water governance is managed according to four steps or levels:

- the European Union level which sets up directive through the European Commission and controls the Directive implementations
- the national level through:
  - the national assembly which translates directives into French laws and endorses programs for the water agencies as well as fees level
  - the ministry of environment which sets objectives and guidelines of water policies in coordination with other ministries (e.g. agriculture, budget).
- the basin level with the basin committee (there are 6 basin committees in France) which builds a share vision of the river basin and stakeholders dialog. The basin committee endorses the Management Plan and the Program of measures from the Water Framework Directive as well as the 6 years program and the level of the water fees to implement.

At the basin level, France has 6 water agencies, created in 1964, which prepare the management plan and the program of measures of the Water Framework Directive together
with the regional direction for the environment. The water agencies collect water fees and finance water assets and measures. They can dedicate 1% of their total budget for solidarity cooperation in developing countries for the access to water and the protection of water resources.

The regional directions for the environment deliver and control permits for water abstraction and discharge at the watershed level with the local river commission in the local water management schemes which implement the works stated in the program of measures and apply local policies in stake areas.

**What is the local water management scheme?**

This is a strategic water planning tool implemented by the French Water Act of January 1992. It fixes water management rules and administrative status and objectives to be achieved in accordance with the program of measures and the management plan from the Water Framework Directive. It is based on dialogue between stakeholders and has regulation standards.

The local water management scheme is therefore a land planning document which, when confronted with conflicting situations, helps lead to mutual agreement for the management of water.

**How do local water management schemes (LWMS) take into account the Water Framework Directive and especially the program of measures?**

With the 2006 Water Act, the LWMS must be compatible with the statements of the management plan of the Water Framework Directive. All schemes implemented before 2010 were reviewed and taken into account for the management plan (MP). At each modification of the MP, local schemes will be reviewed.

The program of measures of the WFD is addressed locally at the LWMS level. For each of them there is a list of the main global measures to be implemented, with its financial costs, in order to achieve the requirements of the WFD (good state of water bodies) and thus avoid European Union litigations. It highlights water managers in the achievement of European objectives.
Examples of measures implemented by the LWMS in the Artois Picardie basin to achieve quality statements

- Sanitation measures: improve collective sanitation systems
- Diffuse pollution: use alternative techniques to pesticides, management of agriculture land to fight against erosion

Example of actions implemented in the Canche LWMS

- In cooperation with the chamber of agriculture, technical and financial grants were implemented for the plantation of hedges in fields as well as grass strips or tree plantations in groundwater protected boundaries to reduce the impact of pesticides.
- Land purchases were done in areas where the water quality is a priority and the water agency allocated 50% grant in areas classified as a priority in the management plan.

Examples of actions implemented in the Sambre LWMS

- Implementation of technical and financial grants for the development of organic agriculture among farmers in strategic drinking water areas, with subsidies allocated by the regional and local council as well as the water agency.
- Cooperation with an NGO promoting organic agriculture with the use of a facilitator for counselling farmers. These actions have allowed converting 6% of the total agriculture territory into organic agriculture.

Choice of indicators

Choosing indicators allows following up the implementation of the measures stated in the WFD documents as well as those of the LWMP. It is also a way to see the efficiency of the policies applied and it facilitates reporting to the European Union. For more information please visit the following web sites www.eau-artois-picardie.fr or www.developpement-durable.gouv.fr

References

DAY 3 - roundtables conclusions

The roundtable discussions of Day 3 addressed technical issues on innovative technologies for water quality management, water treatment adapted technologies in developing countries and innovative technologies for filtration and sanitation.

Challenges

- Management of the monitoring process is important. Comprehensive monitoring including data collection, biomonitoring, ecotoxicology and water chemistry is essential as well as compliance monitoring to ensure proper regulation and control of water resources use.
- Technologies are often not available, appropriate or affordable. There is also the reluctance of industries to invest in available technologies which is compounded by Governments and stakeholders being very conservative towards accepting new technologies.
- Although problems vary from country to country, the main water quality problems include contamination from chlorine, fluoride and nitrogen; surface and groundwater contamination from poor sanitation practices and poor solid waste management; mineralization of soil and groundwater from poor agricultural practices and saline intrusion on coastal zones.
- On the issue of technology vs. polluter pays principle, in developed countries actors can afford to function under a polluter pays principle, but in developing countries this approach may not be affordable, therefore other policy and technological solutions need to be considered.
- Technological solutions to water quality do not always consider ecological and biological concerns (i.e. ecohydrology) collectively. To compound this situation, responsibilities and roles for managing public resources are not always clearly defined.
- Inadequate preparation of end users to take up delivered technologies, including maintenance capacity, especially in rural areas.
- Often solution from developed countries cannot be applied to developing countries where all institutions may not be at the same level of adapting certain
technologies, or solutions may not really meet water requirements for large populations.
- Finally, with ever-increasing migration of people from rural areas to cities, the urban context is a growing challenge.

Lessons learned

- Available technologies need to be assessed based on their appropriateness, since experience has shown that no one-size-fits-all technology is applicable for all stakeholders, institutions or contexts.
- A top down approach may sometimes be necessary to ensure proper regulation of water resources and to this end it can be interesting to consider the high level of compliance and self-regulation being applied in developed countries.
- There is a cost attached to treatment of water and wastewater and these costs will have to be passed on to the consumer, meaning that there is a need to be mindful of costs when choosing and implementing a specific technology.
- Cultural adaptation and good behaviour (e.g. hygiene, boiling water or other simple technologies such as carbon treatment) should not be underestimated and these can be revitalized and supported by communication and training.

Solutions

Researchers need to consider investing in technologies and solutions that have a short to medium term impact and not just focus on the long term research. This can help promote the relevance of research within the relatively shorter cycle of political decision-making. This does require a more tailored approach for specific issues, but can also help to link long term research to immediate needs of populations as well as political considerations.

Solutions could be found by revisiting old technologies and existing and basic practices such as boiling water, but cultural practices (e.g. some good hygiene practices) also need to be considered. Application of these can be supported by training, capacity building and awareness raising.

Innovation should include trying to be more cost effective and pay attention to the cost recovery. Efforts need to be made to demonstrate the effectiveness of new technologies, but sometimes, as well as cost, appropriate regulations may be needed to implement these new
technologies. This can provide incentives for some of the new technologies such as dry sanitation, waste management and recycling.

Finally there is the added value of developing countries and research networks to share their success stories and exchange best practices and solutions to networks in other regions such as has been achieved between China, Latin America, Africa and Europe during this workshop.
CONCLUSIONS OF THE CONFERENCE AND CLOSING REMARKS

This workshop on Exchange of experiences in water resources management between Africa, China, Latin America and Europe has been organized within the framework of the European Commission’s support to the NEPAD African Networks of Centers of Excellence in Water Science and Technology. This was not a typical scientific workshop with fixed tasks and objectives, but was rather launched as an initiative to provide an opportunity and a platform for members of various Networks of Centres of Excellence to exchange experiences on the issues of water sector stakeholders and participation, water resources balance and assessment and water quality and sanitation.

The most interesting and greatest added value of this workshop was the participation from the Centres of Excellence water research institutions representatives from Africa, Latin America, China and Europe. This has been a rare opportunity for professionals and researchers of numerous countries from four regions of the world to not only present research activities as one might do in a conference, but most importantly to share their daily work, regular challenges, exchange lessons learned and finally to identify possible solutions or new ways to address challenges.

On the first day of the Workshop the theme of water sector stakeholders and participation was addressed. Technical and scientific water experts are often skeptical and unaccustomed to dealing with such themes, seeing them as being more appropriately addressed within sectors of socio-economics and politics. Remarkably, these issues were taken up for discussion by the attendees with interest, energy and a willingness to incorporate them into their list of challenges and objectives. The result was an immediate success for the facilitation role of the workshop.

Issues of common interest identified on the first day include: a need for improved coordination between institutions managing water resources; promoting positive aspects of increased accountability and good governance in order to increase participation; targeting and adapting information for specific identified stakeholder and adapting it to user needs and understanding; and formulation of policies and best practices based on scientific results which are relevant and clearly understood by the stakeholders who will apply them. This will
require science and research actors to develop protocols and tools for disseminating science and the role of technology and research in managing the water sector. This dissemination should be targeted towards water resource consumers and users as well as actors at the political level. Broadcasting results should be accompanied by scientific and technical work and research results, but may need to be adapted to be able to contribute to the political discussion as well as distribution to the wider public. There is also a perceived need for information to be managed independently from institutional authorities, such as by independent institutions involved in collecting data or providing a central archive facility.

The second day addressed water resource balances and assessment, including elements of climate variability and knowledge management. It was agreed by all that water resources management is easy to present in theory but much more difficult to implement in practice. Challenges to implementation identified included poor access to data generally as well as poor access to good quality data. Not only is it challenging to quantify data components such as indicators and indexes, but this quantification often needs to be adjusted from one basin to another. Also, some organizations (mining companies were an example) are generating very useful data but are not sharing it - either to local stakeholders or with government authorities. Another challenge in some partner countries is that the development of water resources management is too much project driven by external support and strategies, often resulting in the collapse of service initiatives and the loss of valuable data and experience with the close of projects.

Finally on the third day, discussion focused on water quality and sanitation. A range of commercial, industrial and natural sources of water pollution and contamination were explored, including their links to water quality and the provision of sanitation services. Natural contamination phenomena included varied sources such as coastal saline tidal events – exacerbated by inland droughts and low river flows – and toxic contaminations at village level occurring from local small-scale artisanal mining practices which produced toxic by-products.

Some proposed solutions to these challenges were more technical, including controlling river flow and timing increased discharge of fresh water to minimize the impact of peak saline tidal flows. Other solutions were more management and policy responses, including engaging government authorities to control and also facilitate the activities of artisanal mining
practices; encouraging safer practices around this small but locally important economic activity.

Overall, in addition to the sharing of project activities from the various participating partners and countries, the greatest added value of this workshop has been the sharing and exchange of experiences, lessons learned and in some cases identifying solutions to common problems. This has been done within discussions during presentations, open exchanges in the roundtables and the equally important networking and informal discussions and exchanges that took place around the programmed events. The sharing of experiences between Africa, China, Latin America and Europe highlighted the great differences in the challenges between these regions but equally those which are common and shared by all. The sharing of lessons learned, especially on these common challenges, was extremely valuable for everyone, and has led to identifying some solutions to these challenges and exploring ways to identify new ones.

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Abstract

The conference “exchange of experiences in water resources management between Africa, China, Latin America and Europe” was organised in the framework of the European Commission (EC) support project to the African Union/NEPAD Networks of Centres of Excellence in Water Science and Technology implemented by the EC Joint Research Centre (JRC). High level experts on water resources management from Europe, China, Africa and Latin America contributed to the conference held at the Joint Research Centre in Ispra (Italy) during 15 to 18 October 2012. Participants exchanged experiences and shared lessons learned on the following topics: water stakeholders' analysis and participation, water resources balance and assessment and water quality and sanitation. These proceedings collect the exchanges of lessons learnt and good practices across four continents proposing common solutions towards the sustainable management of water resources.
As the Commission’s in-house science service, the Joint Research Centre’s mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.