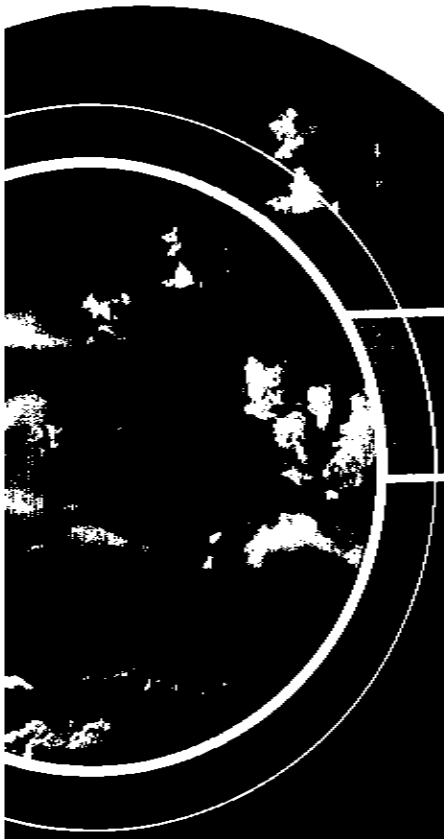
ACADEMY OF SCIENCE OF SOUTH AFRICA
ASSAf

Water Research Commission



IAP
WATER PROGRAMME
Regional Workshop for Africa

PROCEEDINGS REPORT

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The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996 in the presence of then President Nelson Mandela, the Patron of the launch of the Academy. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science for the benefit of society, with a mandate encompassing all fields of scientific enquiry in a seamless way, and including in its ranks the full diversity of South Africa's distinguished scientists.

The Parliament of South Africa passed the Academy of Science of South Africa Act, Act 67 in 2001, and the Act came into operation on 15 May 2002.

This has made ASSAf the official Academy of Science of South Africa, recognised by Government and representing South Africa in the international community of science academies.

Table of Contents

Acknowledgements

The following institutions/persons are gratefully acknowledged:

Workshop participants and notably the African Academy representatives who presented papers on behalf of their respective Academies.

The South African Water Research Commission (WRC) for accepting the invitation to jointly organize the workshop with the Academy of Science of South Africa (ASSAf).

Sponsors (in alphabetical order) without whose contributions, the workshop would not have been possible: ASSAf, IAP and WRC.

Session chairpersons: Dr Rivka Kfir, the CEO of WRC; Ms Eiman Karar and Dr Kevin Pietersen, both also from the WRC.

Keynote speakers: Mr Dhesigen Naidoo and Dr Sibusiso Manzini, from the South African Department of Science and Technology, and Dr Marcos Cortesão from the Brazilian Academy of Sciences.

Dr Richard Clark and Marketing Support Services for producing this publication, respectively as scribe/editor and production house.

Preface

The Academy of Science of South Africa (ASSAf) is a young organisation and a veritable baby amongst the world's established national science academies. This is both a drawback and an advantage – one has a short track record of doing useful things, but one can also piggy-back on the experience of others and perhaps make quicker progress towards one's objectives. One of the key insights is that synergies must be created between the Academy's work in its own country and that which it can productively do with partners in other countries, within a region or further afield.

Water is a fundamental concern of virtually every nation, playing a diverse and often inter-dependent but vital role in the individual and collective lives of its entire citizenry. A single country like South Africa may well seek to "solve" its water-related problems by itself, but most of these have dimensions that extend beyond the borders, and many lessons learnt elsewhere may well be applicable at home. The Academy function is perfectly designed to bridge the gap between the knowledge and capacity of one country to be put to work, and harnessing regional or global solutions. This workshop is a good example. Conducted under the auspices of the world-wide InterAcademy Panel (IAP) and well supervised by the national science academy of a particular developing country (Brazil), it took place in another developing country (South Africa) on another continent, organised jointly by that country's national science academy (ASSAf) and its highly effective and focused agency for sponsoring and coordinating basic and applied research on the topic (the Water Research Commission, WRC). Many academies from other African countries participated, and the outcome is a pleasing reflection of shared interest, enthusiasm and networking, which will surely have a significant impact on development on the continent.

ASSAf is proud to have been able to co-host this highly productive workshop, and warmly thanks Dr Rivka Kfir and the Water Research Commission for strenuous efforts designed to extract maximum value from the meeting and its product, this Report and Proceedings. All academies and other participants are also thanked, as are the Brazilian Academy of Sciences (represented at the Workshop by Dr Marcos Cortesao) and the IAP itself.

Wieland Gevers, MASSAf
Executive Officer
September 2006

About ASSAf

OBJECTIVES

Scientific thinking for the good of society

According to the Act the **objectives of the Academy** are:

- to promote common ground in scientific thinking across all disciplines, for example the physical, mathematical, life, human, social and economic sciences;
- to encourage and promote innovative and independent scientific thinking;
- to promote the optimum development of the intellectual capacity of all people;
- to provide effective advice and facilitate appropriate action in relation to the collective needs, opportunities and challenges of all South Africans; and
- to link South Africa with scientific communities at the highest levels, in particular within Africa, and further afield.

VISION

An engine of excellence in scholarship and intellectual cooperation

ASSAf aspires to be the apex organisation for science and scholarship in South Africa, internationally respected and connected, its membership simultaneously the aspiration of the country's most active scholars in all fields of scientific enquiry, and the collective resource making possible the professionally managed generation of evidence-based solutions to national problems.

MISSION STATEMENT

Clarifying the niche of the Academy

Like democratic South Africa in general, ASSAf aspires to play both a national and an international role, particularly with respect to the African continent. We see the Academy as usefully at arm's length from government and other organised sections of the state, comprising an assembly of excellent scholars from many disciplines who are well-networked both nationally and internationally, and have shown their interest in and capacity for promoting the development of a prosperous and a fully enabled society. Membership of the Academy (by election) is both an honour and an obligation to work individually and collectively (as the Academy) to ensure that decision making requiring scholarly scrutiny and analysis is based on the best and most integrated understandings and insights available to the country. The Academicians thus represent an organised, independent but responsive scholarly voice to help guide the development of the country and its people.

The mission of ASSAf is thus to

- become increasingly associated in the mind of the nation with the highest levels of scholarly achievement and excellence in the application of scientific thinking for the benefit of society;

- consolidate its infrastructure and capacity, and to expand and mobilise the membership to ensure that scholars from a full disciplinary spectrum are available for its work, and that these are indeed both thinkers and doers, willing to put significant effort into the Academy's activities;
- embark on a programme of systematic studies of evidence-based issues of national importance, some proposed by government or other sectors, and some identified by the Academy itself;
- develop a sound and robust methodology for constituting study panels, organising their work, including conferences and workshops, and producing authoritative reports that are well-disseminated and have significant impact;
- publish science-focused periodicals, especially a multidisciplinary journal of high quality (the *South African Journal of Science*) and a science magazine that will showcase the best of South African research to a wide national (and international) audience (*Quest - Science for South Africa*); and to promote the development in South Africa of an indigenous system of research journals of internationally recognised quality and usefulness;
- develop productive partnerships with other organisations, especially (but not only) the departments of Science and Technology, Education, Health and Agriculture; the National Advisory Council on Innovation; science councils; higher education institutions, etc., with a view to the building of capacity in science and its applications within the National System of Innovation (NSI);
- create new and diversified sources of funding for the sustainable functioning of an independent Academy;
- communicate effectively with the general and specific publics, as well as with partners and sponsors;
- develop a plan for the expansion of the activities of ASSAf in partnership with the national science academies of other countries, including contracted partnership with the US National Academies; and
- play a significant role in the international science system, particularly in Africa, through organisations such as the InterAcademy Panel (IAP) and the InterAcademy Council (IAC), the Academy of Sciences of the Developing World (TWAS), the International Council on Science (ICSU), as well as the Network of African Science Academies (NASAC), all in the context of the New Partnership for Africa's Development (NEPAD).

MEMBERS

Core asset of the Academy (each styled "MASSAf")

After nomination by four existing Members (at least two of whom do so from personal knowledge of the candidate), new Members of the Academy are elected in a secret ballot. The normal criterion for election is significant achievement in the advancement or application of science, and, in addition, Members should be persons who can be expected significantly to assist the Academy in achieving its objectives. By October 2006, ASSAf had over 250 Members drawn by self-categorization from the earth, economic, life, mathematical, physical, social, technological, education, and agricultural sciences as well as the humanities.

COUNCIL

Steering Academy activities and taking responsibility

The affairs of the Academy are governed by a Council comprising 12 members, each of whom holds office for four years. This Council is elected by the Members every two years. For the sake of continuity, six members continue to serve a further term, while six new members are elected once they have been nominated according to the constitutional mechanism. To provide a better balance of race, gender or disciplinary area, the Council can coopt additional members from persons who were nominated for election to the Council.

The office-bearers are, respectively, the President, two Vice-Presidents, a General Secretary and a Treasurer. Committees can be formed in order to carry out specific functions but each must be chaired

by a Member of the Academy or, preferably, of its Council. Reports drawn up by its committees or *ad hoc* task group are approved by the Council before entering the public domain.

INTERNATIONAL CONNECTIONS

Crucial catalyst for Academy-type activities

ASSAf is an active member of the IAP, a growing organisation that embraces the national science academies of over 90 countries. The Academy of Sciences for the Developing World now has an office in Africa based in Nairobi, and the Network of African Science Academies, of which the President of ASSAf is a Vice-President, is also located in that city.

ASSAf became an "intense partner" of the US National Academies (together with the Nigerian and Ugandan Academies of Science) as part of the African Science Academy Development Initiative (ASADI), receiving a substantial 5-year grant to build its capacity for generating evidence-based advice for the government and the nation in general.

STRATEGIC PLAN AND POLICY DEVELOPMENT

The way to go

ASSAf has developed a comprehensive strategic plan following a thorough process for identification of its strengths, weaknesses, opportunities and threats. Through its governing Council, the Academy has developed policies and guidelines for its activities. The initiation of the ASADI partnership with the US National Academies prompted the generation, proposal and adoption of the following items:

- Guidelines for proposals of science-based topics in terms of the ASSAf Act
- Guidelines for proposals of science-based topics (project proposals)
- Guidelines for the appointment of study panels and forum steering committees
- Policy on conferences
- Formation of a Committee on Science for the Alleviation of Poverty (first example of an ASSAf "Board")
- Panel for the Consensus Study on Nutritional Influences on Human Immunity, with special reference to clinical tuberculosis and HIV infection (first ASSAf Consensus Study).

ASSAf's strategic plan and the Academy's policies and guidelines are publicly featured on the ASSAf website at http://www.assaf..org.za

RESEARCH PUBLISHING

The core of the quality assurance system for the dissemination of research findings

The Academy of Science of South Africa signed a contract in 2001 with the Department of Science and Technology (DST) for various activities in connection with the "strategic management" of research journals published in South Africa. The first component was a comprehensive study of the present and best-possible future role of research journals published in South Africa, now completed through the release of a full report in March 2006, with evidence-based recommendations, and a range of follow-up project integration and implementation strategies.

SAJS

Publishing the *South African Journal of Science*: a Nature for South Africa

The *South African Journal of Science* is the leading multidisciplinary research journal in Africa, and features a great diversity of original work by researchers throughout the country and abroad, concentrating on articles that have an appeal that is wider than that of single disciplines. Among the highlights of the volume published in 2005 were articles featuring the research at historically black universities supported by the Royal Society-NRF bilateral programme. The journal appears six times a year, and is accessible online as one of the e-publications managed by SABINET.

QUEST

Publishing *Quest*: A quarterly magazine of high quality, presenting science for South Africa

The Academy publishes the national science magazine *Quest: Science for South Africa* that was launched in 2004. Quest serves as a platform for communication about scientific research done in South Africa. It strives to showcase South African science in action, and is aimed at the broad scientific community, decision-makers, the public, students, and especially the senior grades at secondary schools.

About the Authors

- **Rivka Kfir** is the Chief Executive Officer of the Water Research Commission (WRC), where she has from July 2001 onwards successfully piloted the organisation through a comprehensive phase of strategic refocusing, restructuring and transformation on the way towards fulfilling its mission as South Africa's hub for water-centred knowledge. Previously, in 2000 she joined the National Research Foundation (NRF) as Executive Director: Knowledge Management and Strategy. Prior to that, from 1996-2000, she was Technology Manager in the CSIR, which entailed managing the CSIR's internal investments. Between 1978 and 1996 Rivka worked at the Council for Scientific and Industrial Research (CSIR), progressing from Senior Research Officer at the National Institute for Water Research to Programme Manager (Health Programme) and later Acting Director of the Division of Water Technology.
- **Dhesigen Pydiah Naidoo** is currently Group Executive: S&T International in the Ministry of Science and Technology and is the head of Science and Technology International Co-operation and Resources in South Africa. He has previously served as Chief Director Environmental Planning and Co-ordination and was for 18 months seconded to be South Africa's Policy and Substance Co-ordinator for South Africa's participation and chairing of the World Summit on Sustainable Development in 2002. He has also served as South Africa's first Water Conservation Director and has in this capacity set up a national Water Conservation and Demand Management competence in South Africa. Since 1990 he has been a biotechnology researcher at the University of Cape Town. He is a Council member of the Water Research Commission and also a Council member of the Africa Institute of South Africa.
- **Sibusiso Manzini** is the Director for African Cooperation in the Department of Science and Technology (DST), responsible for promoting bilateral and multilateral cooperation in Science and Technology in Africa. He has played a substantive role in the development of the NEPAD S&T platform, contributing to the formulation of its institutional and structural mechanisms and the organization of its inaugural ministerial conference. Prior to that, in 2001 he worked at the Department of Education as a Deputy Chief Education Specialist, focusing on international cooperation in education and charged with managing South Africa's science and technology relations within the Southern African Development Community (SADC), the African Union (AU) and the United Nations (UN) system. He spent 12 years working as a science educator and educationist at various levels within South Africa's Department of Education, his research interests includes science, technology and innovation (STI) policy, S&T diplomacy and science communication.
- **Marcos Cortesão Barnsley Scheuenstuhl** is an economist, since 2004 when the Brazilian Academy of Sciences was designated lead Academy to the Water Programme of the InterAcademy Panel on International Issues (IAP); he has been working with the networking of water researchers and managers, aiming at the enhancement of water management capacity in the developing world. Prior to that, in 2000 he was invited to help organize the Office of International Affairs of the Brazilian Academy of Sciences; where he played an important role in the structuring of the InterAmerican Network of Academies of Sciences (IANAS). For many years he worked at the State University of Rio de Janeiro, with his research focused on Higher Education Policies and Funding of Higher Education in Latin America. He also worked for the Interunion Department for Socioeconomic Studies and Statistics, where he developed studies on the Brazilian national financial system.
- **Eiman Karar** joined the Water Research Commission in October 2005. She has 15 years of experience ranging from plant ecology as her basic training to plant tolerance to variable saline regimes, and further

engagement with modeling for water use accounting in sub-saharan Africa. For the last nine years, she has been intimately involved in the implementation of the new water legislation in South Africa from developing operational policies as Director for Catchment Management at the National Department of Water Affairs and Forestry to her current portfolio in shaping national research agenda for water resources management.

- **Wieland Gevers**, MASSAf and ASSAf Executive Officer. Previously he was Senior Deputy Vice-Chancellor responsible planning and academic process at the University of Cape Town from 1992-2002. He was twice President of the South African Biochemical Society, and President of the Academy of Science of South Africa from 1998-2004. He is a Fellow of the Academy of Sciences of the Developing World, was Acting Chairperson of the Education Committee of the South African Universities' Vice-Chancellors Association during 2001-2002, and represented all South African Universities on the South African Universities on the South African Qualifications Authority from 1996-2002. Gevers was awarded the Welcome Gold Medal for Medical Research, and the Gold Medals of both the South African Society for Biochemistry and Molecular Biology, and the South African MRC. In 2004, Gevers was given the NSTF's "Achievements as an individual over a lifetime" Award.
- **Kevin Pietersen** is currently employed with the Water Research Commission (WRC) as the Director: Research Coordination and Partnerships, which is an executive position in the organization. He has worked for the past 15 years in the water sector focusing on Integrated Water Resource Management (IWRM). Previously, he was the Director: Water Resource Management; and before that the head of the crosscutting domain: Water and the Environment and Research Manager responsible for the groundwater research field. Before his employment at the WRC, he was a hydrogeologist with the CSIR focusing on community water supply and sanitation and integrated groundwater management.
- **Abdoulaye Dia** is a Member of the National Academy of Sciences and Technics of Senegal (NASTS). From 1993 to present has been the Director of the Earth Sciences Institute activities in applied Research, Geology, Mineral and water Resources and Environmental impacts Management, Water Quality Researches. Previously from 1995 to 2000 he was the General Manager of the Senegal Mining and Geological Survey. Prior to that from 1995 to 2000 he has been the Permanent Secretary of the General Council of Mines of Senegal. He is President of Expert Committee for the studies of the effective modalities of starting the High Authority for the Development of the Sahara and the setting up of the Great Green Wall. From 2004 present he has been coordinator for the NASTS of environmental, natural risks and water resources Management reflections. In 2004 he was President of the scientific committee of the special session of the NASTS about Floodings and Urban Management: the case of Saint Louis, (SENEGAL), the Senegal River's Impacts and the effects in Groundwater Resources.
- **Mathias Fru Fonteh** is currently an Associate Professor and Head of the Department of Agricultural Engineering at the University of Dschang, Cameroon. His current research/development emphasis include Irrigation water management (specifically performance evaluation of irrigation systems, sustainable management of large and small-scale irrigation systems, disengagement of the state in large-scale irrigation systems and crop water requirements of indigenous crops); Implementation of Integrated water resources management at national level; Environmental, industrial and agricultural water use and demand in Cameroon. He is presently a Member of the Central African Technical Advisory Committee (CAFTAC) of the Global Water Partnership and coordinator of the Master of Science Programme in Water Management in the Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon.
- **Albert Rugumayo** is currently the Coordination Manager of the Energy for Rural Transformation Programme, in the Ministry of Energy and Minerals Development in Uganda. Rugumayo has been a Visiting Lecturer in the Department of Civil Engineering, for the past ten years, where he has taught hydrology, water resources engineering, design, professional affairs and the role of the engineer in society. He worked with Gauff Consulting Engineers for 11 years before joining Government. Initially he was in the Ministry of Health as a Senior Engineer. He later moved to the Ministry of Natural Resources as a Technical Advisor for a rural water supply project and then as a Coordinator of Technical Education Projects in the Ministry of Education and Sports. He has been actively involved in Uganda Institution of Professional Engineers and is

a Past President. He is a Registered Engineer Uganda, Chartered Engineer, UK and a Fellow of the Uganda Institution of Professional Engineers and the Institution of Civil Engineers, UK.

- **Daniel Ochieng' Olago** is a Senior Lecturer at the Department of Geology, University of Nairobi, and is also the Senior Scientific Officer for Pan African START Secretariat, Nairobi, Kenya. He obtained his D.Phil. in Physical Geography/Quaternary Geology at the University of Oxford, England. In 1998 he won the International START Young Scientist Award. Olago is cited in the Who's Who in Science and Engineering, 2005-2006, and was also nominated International Scientist of the Year for 2005 by the International Biographical Centre, Cambridge, England. He is currently a member of the Variability in African Climate System (CLIVAR-VACS) Panel; Member, International Lake Environment Committee (ILEC); Vice-Chairman of the Geological Society of Kenya; member of the East African Natural History Society; and member of the Kenya National Academy of Sciences. He is also a Lead Author in the Intergovernmental Panel on Climate Change Fourth Assessment Report.
- **Clavery Tungaraza Tungaraza** is currently employed by the Sokoine University of Agriculture, Faculty of Science as a Lecturer in Environmental Chemistry and Environmental Ecology (Atmospheric chemistry, water chemistry, and aquatic pollution and control). He is also involved in Teaching general chemistry to undergraduate students as well as Supervision of undergraduate environmental special projects. He is also Deputy Co-ordinator SUA-VLR project for Research and capacity building. During the period of 1988–2000, he worked as a Fisheries Officer involved in planning and supervision of fisheries projects at National Service, Ministry of defence, Tanzania. He is the former Head, Department of Physical Sciences, 2001- June 2005.
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- **Hannes Rautenbach** is currently Head of the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria (UP). His research interests vary from atmospheric modelling to community based fog water collection initiatives. He has published 17 papers in scientific journals and has presented more than 80 talks at national and international conferences. He is currently also vice-president of the South African Society for Atmospheric Research, and is a member of the Editorial Board of the Water Research Commission (WRC)'s Water SA.
- **Gerhard Offringa** currently heads the research thrust for water supply and health projects at the Water Research Commission. He is a registered Professional Engineer and since 1971 has been managing both national and international research and development projects in various branches of chemical engineering, uranium enrichment and water and the environment. He has been involved in water and wastewater research projects since 1982. He is a Senior Fellow of the Water Institute of Southern Africa and is active in a number of International and South African water-related institutions.
- **David Mutombo** is presently a Project Leader at BHP Billiton South Africa. He is an Associated Member of the WISA and registered as a Professional engineer with ECSA. He has Intensive experience in design, installation, commissioning, and operation of sludge dewatering equipment and also Intensive experience on high rate anaerobic domestic and industrial wastewater treatment systems (USB, EGSB, IC etc). Highlight: Design, construction and commissioning of the IC-Circox effluent treatment plant for Guiness brewery in the city of Benin in Nigeria. Design, construction and commissioning of the IC-WAS effluent treatment plant is Lagos Nigeria. Design and contract award of the zero discharge waste water treatment plant for Tonic Emballage in Algeria and also Intensive Experience in process design for domestic and industrial wastewater treatment Concentional WAS process, Membrane Bio Reactor (MBR) processes etc.

- **Harrison Pienaar** joined the Department of Water Affairs and Forestry in 2001 where he currently holds the position of chief director responsible for the development of policies, strategies, systems, methodologies and guidelines for resource directed measures (RDM), particularly the Reserve determination, water resource classification and specification of associated resource quality objectives. After several years in the energy sector with Eskom, being responsible for environmental projects of sustainable linear development initiatives, he continued his career as consultant, managing numerous large scale environmental and related projects in association with various consulting firms.
- **Balt Verhagen**, following his formal retirement is an Honorary Research Fellow, fostering initiatives in research with environmental isotopes in the School of Geosciences initially in the School of Physics at the University of the Witwatersrand, Johannesburg where he became an Associate Professor in the Schonland Research Institute (then Centre) and built up the Environmental Isotope Group (EIG) and laboratory. He has been an invited scientist in Germany, Israel, Austria and China. He is often engaged as expert and consultant in IAEA programmes and is involved in various local and international projects with the private sector. Recently, he completed two research contracts in Namibia. He was awarded the Ground Water Medal in 1998 and received the Honours Award of the Geological Society of South Africa in 2001. He is a member of an international UNESCO/IHP working group on ground water for emergency situations (GWES).
- **Nikisi Lesufi** is the the Environmental Adviser to the Chamber of Mines, responsible for all environment-related regulatory, technical, policy and stakeholder engagement matters. After lecturing at the University of the North (now Limpopo), he joined the Department of Water Affairs and Forestry as an Assistant Director, Water Quality Management: Urban and Rural Development. He then became the Deputy Director: Environmental Health at the Department of Health responsible for development of drinking water standards, chemical safety, management of hazardous substances, capacity building of environmental health officers and prevention of nuisance conditions. He rejoined the Department of Water Affairs and Forestry as Deputy Director: Water Quality Management: Mining, responsible for the management and prevention of mining related water quality impacts. He then became the regional Director: Water Resources Management responsible for the provision of water supply and sanitation, and the protection of the water resources.
- **Hanlie Hattingh** has since 2002 to the present been an Environmental Scientist and Project Manager (NRE) at the CSIR: Natural Resources and the Environment in Pretoria. From 1999 to 2002 she worked for V3 Consulting Engineers in Pretoria as an Environmental Specialist. In 1991 to 1999 she worked for the National Department of Environmental Affairs & Tourism in Pretoria as an Assistant Environmental Officer, Environmental Officer, Senior Environmental Officer, Assistant Director. She is a Member of IAIAsa Registered Professional Natural Scientist: Environmental Science at the SA Council for Natural Scientific Professions. Some of her Achievements include the CSIR Environmentek award for "Innovative project", 2005 and runner up for CSIR Environmentek "Integrating project award", 2004. Hanlie is on the Water Research Commission Reference Group on "Industry – Government partnerships in the development of sector-based standards for the water environment", and the Water Research Commission Steering Committee on "Persistent organic pollutants (POPs) in the water environment".
- Jay **Bhagwan** is a civil engineer and is currently a Director: Water Use and Waste Management and Thrust Manager: Water and Sanitation. He holds the following memberships: GARNET - international information sharing on water supply and sanitation research, WATER INSTITUTE OF SA and currently SECOND VICE-PRESIDENT, Gauteng Water Cycle Management, Water Services and Sanitation Forum, JASWIC (Joint Acceptance Scheme for water installation components), Local Coordinator of the International Water Supply and Sanitation Collaborative Council (WSSCC), the International Water Association (IWA), SA Minister of Water Affairs and Forestry Advisory Committee and the UNEP-IETC Advisory Committee.

Opening Ceremony

Chairperson: Rivka Kfir

Opening and Welcome

Dhesigen Naidoo – Department of Science and Technology, South Africa
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Mr Naidoo welcomed all, particularly the visiting delegates from warmer climes, and apologised for the prevailing cold weather that greeted them on their arrival.

Mr Naidoo elaborated on the issue of the changing role of science in the world. In the past, and indeed, still now, science has been centred much on the expansion of man's knowledge-base. More recently, it began to direct itself more to the "upper-end" of the economy, with high-end technology for economic competitiveness. There has been a move in the last decade to address problems in the area of social development, and specifically, the predicament of the poor. This raises the dilemma of sacrificing merit science for application science. Current achievements are proving that excellent work is still possible, while focussing on the problems of the developing world.

There is an emerging discourse on global science and technology, with various fora emerging therefrom. South Africa and Brazil, amongst others, have been involved in the recent G8 gatherings, with their many interests, including the predominant political and security issues. The subject of science and technology has gradually moved more to the front of the stage, in the form of the Carnegie Group (science ministers of the G8) as well as the Academies Group. Five developing countries have become part of this current discourse, which has included perspectives on development of their brief. This is evidenced in declarations and outcomes, as well as in investments that have been made by the richer world. ECOSOC, in the United Nations, has lobbied in favour of the Commission for Ecoscience and Technology having a much more prominent status, taking forward the findings of the World Summit on Information Society. The CSD (Commission for Sustainable Development) discussions enjoy a high profile, world-wide, with more focus on scientific agenda. This is a useful indicator, also being followed by the developing countries. Brazil and South Africa are currently convening the G77 Ministers of Science Meeting on 3rd September. The driving force is an increased recognition in the broader economic debate; that science and technology research and innovation are core base structures to whatever socio-economic strategy is going to exist, either globally, regionally, nationally or sub-nationally. The topic of this current workshop that we attend today is fundamental to our development, human health, environmental health, all part of a broader equation referred to as development.

There is a trend in convergence of stake-holders. Increasingly, but perhaps insufficiently, academia is talking to policy and decision-makers in a much more real way. They are talking to communities who are converting themselves from recipients of intervention, to becoming active and contributive beneficiaries. These issues emerge in Dr Sibusiso Manzini's presentation, that will follow.

There is an analysis of the role of Science Research, Technology and Innovation, albeit that these terms can mean different things to different people. They enjoy an increasing estimate in value by the highest decision-makers of the world, particularly with reference to the Millennium Development Goals. As noble as the pronouncements were at the Millennium Summit in 2000,

they are far short of the 2015 target, both globally, as well as regionally. Only a few counties give evidence that they will reach projected targets. Comparisons have been made of extrapolated time-lines, based on current progress, with what these lines could be, if more innovative approaches, with substantive knowledge intervention, were taken. The Millennium Task Force on Science and Technology has concluded that a 15-year time-frame is feasible, if an innovative approach is adopted. The existing and slower alternative route, with the current interventions, has been projected to achieve the same goals after 147 years, the targets being based only on current numbers of poor people in the world. These issues drive the debate as to what should be happening at global, regional, and inter-organisational levels (our Inter-Academy Panel being one example), at national level, and at the entity level. Challenges are immense, but offer opportunities, yet needing higher investments in the tasks that require being done. One objective of the G77 Meeting during September is to converge the priority of investment in science and technology research and innovation amongst developing countries. We must benefit through sharing in what we have, in order to be able to surmount our hurdles.

Africa Consolidated Science and Technology Action Plan

Sibusiso Manzini, Director of Science and Technology, South Africa
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Water resource protection, water provision and management have a central place in the theme of African Development, and sites itself within the Science and Technology Programme.

There is much debate on the origins of the African Continent, and how, in future, it could prosper. Many have articulated visions, but these require consolidation into an action plan. Science and Technology (S&T) has a general history of good organisation, but political will and governance, together with the associated upheavals, have tended to thwart the attention that we (in Africa) should have given to S&T. Government has had a broad vision of how S&T should interface with the National Economy. Professor Odiahambo has referred to a long period of darkness in Africa, which we would wish to see as part of the past. Thought has been given to how the (African) Continent could focus its effort in the direction of social and economic development, named the New Partnership for Africa Development. The African Union adopted this as a blueprint for economic development. Power arises from a new search for the so-named African Renaissance, besides fostering political will and corporate leadership, and recognising the role of S&T and Innovation in social and general economic development. There is a global emergence of technological opportunities, example being information and communication, biotechnology, and nanotechnology, that offer developing countries a leap ahead in S&T development, especially in the niches that offer prospects of greatest success. Change of international view, within the G8 and other allied structures, include the realisation that investment in knowledge development is critical for social advancement. These new circumstances have lead to a new plan, adopted in Senegal in September 2005. There have been two subsequent and ground-breaking African conferences on S&T. Governance, structures, international recognition, and commitment goals have been identified as priorities. Some programmes, such as the African Institutes for Medical Sciences, and the African Biosciences Initiative, are already operational, generating useful and promising results. The African Ministerial Council for S&T met in Johannesburg in 2002 to formulate an S&T agenda for the Continent, and to galvanise political will. More than forty countries were represented at senior and ministerial levels. There was an agreement on priorities, structures to be set in place, and programmes were set in motion. A business plan, based on these decisions, was adopted in Dakar, Senegal, two years later. There have been future projections on implementation, and the prospects of innovation partnerships, particularly international partnerships. An aim has been to improve the structure of R&D activity on the Continent, to develop a new Africa of scientists, technicians and engineers, to convert knowledge to products and services, to promote good science and innovation, and to create an African demand for science and technology. Principles that underpin the plan are based on own priorities. The last two Ministerial Meetings and various committees responsible for this plan convened with no external consultant service. Focus was on the needs of the Continent, working towards common consensus. Collective action on common challenges included ownership of the African Union, shared commitment and responsibility, adding new value to exiting national, regional, and continental effort. Primary

intent has not been on creating new institutions, but new programmes, where identified needs arise, sharing the problems and issues of broad impact across the Continent, across borders, in substantive joint programmes, and programmes under the NEPAD Plan. We learn, as we progress, adjusting through feedback from experience. It is important to note the differences in capabilities that exist on the African Continent. These can be addressed by sharing resources, infrastructure and institutions. Although we jealously guard it as a plan owned by the Africans for the Africans, it is open to international partnerships, and we see cooperation, in this respect. The plan will stand, or fall, on the basis of Africa's steps forward. Human capacity development is a central issue, as is indigenous knowledge, not only in terms of indigenous technology, *per se*, but also with respect to indigenous ways of doing things, enabling policies at government level, and underpinning regional diversity, that takes account of regional differences. The path to this plan is participatory, which is a departure from past practices. Scientists, at top levels, have been drawn in as contributors to the plan, with high levels of political engagement that involve the AU Commission. There is an institutional framework required, but we also need to deliver results that will inspire motivation and confidence, using the learning process, and adjusting to priorities. The African Ministerial Council for Scientific Bodies is concerned with policy-making, this body consisting of all ministers that are responsible for Science and Technology on the African Continent. There is a steering committee that operates at official level, with respect to the implementation of the Plan. The AU Commission provides political and policy leadership, being owner of the Plan. NEPAD is responsible for the financial and technical resources, as well as the day-today administration. The Council of Ministers has its current chair in Senegal, in the governance structures. Meetings are biennial. The AMCOST ministerial bureau has twelve members, one from the chair country, one from the host country, and two, per region, in the five nations of the Continent. Finance provisions are formulated, and coordination created, as needed. Expert panels are put together, as required. Steering committee members are North Africa and Indonesia, Ghana, Malawi, Moçambique, Ruanda, Congo, and others yet to be determined. A range of twelve technologies, in five clusters, has been identified as areas of need. These include water technology, which has a bearing on the development of other areas of overlap. Mathematical modelling has since been identified as a thirteenth area. Institutions have been identified for being responsible for particular research areas. These institutions are linked in a trans-border network, working on the same programme, that addresses common priorities and needs. Each network will have a hub, responsible for administration, and driving of the programme. It is a continental plan, but does not overlook regional concerns and priorities. There are four networks in the biosciences, these being between North, West, South and Central-East Africa. The bioscience network, based in Nairobi, Kenya, East Africa, will focus more on agricultural applications, while the southern network will deal more with health and industrially related problems.

The R&D programme is only one third of the responsibility. There are matters of governance of science and technology. The African Sciences and Innovation hub has been located in Cape Town, there, to establish capacity, collect data from the rest of the continent, create capacity within the continent, foster human resource development, foster cooperation, as well as monitor progress of the plan, dealing with changes, as and when they take place. Bilateral partnerships between African countries and outside partners exist, but the wish is rather to see countries collaborating on a multilateral basis. Public participation is important in the advisory process, when it comes to issues such as biotechnology, informing heads of state as to concerns on matters such as GMO (genetically modified organisms).

A last word can be said about the African Science Innovation Science Facility. There is a need to manage and drive plans into the future. Responsibilities will include resource mobilisation, to allocate and to monitor resource use. Many African countries contribute only 0.2%, GDP to R&D, this being very low in relation to the generally accepted benchmark. The next summit of the AU will be forecasting on S&T, with various programmes on its agenda.

IAP Water Programme – Regional Workshop for Africa

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Dr Cortesão acknowledged the pivotal role of the South African Water Research Commission, on behalf of the Academy of Science of South Africa, and the valuable efforts of Dr Rivka Kfir, its Director, in the affairs of the IAP Water Programme.

IAP (InterAcademy Panel on International Issues) is a global network, launched in 1993, with a current membership of 92 Science Academies from around the world. These include national Academies and Institutions, as well as regional and global associations of scientists. A number of other scientific organisations also participate in IAP meetings and activities, as observers. Examples of these associations and organisations, in Africa, are the African Academy of Sciences and the Network of African Science Academies.

IAP is headquartered in Trieste, Italy, being under the administrative umbrella of the Academy of Sciences for the Developing World, formerly known as the Third World Academy of Sciences(TWAS). IAP receives substantial support from the Italian government, which passed a permanent law in year 2004 that provided a secure funding basis for the activities of the network. Member Academies also contribute to the programme activities of IAP. Today's workshop, hosted by the Academy of Science of South Africa is an example of such support, meeting expenses with national funds.

The primary goal of IAP is to promote collaboration between member Academies, and to advise citizens and public officials on the scientific aspects of critical global issues. IAP assists young and small Academies, in particular, to achieve these goals. It helps member Academies raise both their public profile among citizens and their influence among policy makers through the communication links and networks created by its programmes and activities.

Science and the development of knowledge have international characteristics, namely, a dependence upon the close interaction between scientists, world-wide. Science, and the benefits derived therefrom, are not equally distributed and shared, especially amongst people in developing countries. IAP intends to serve as an international instrument to help in the overcoming of this situation. The achievement of sustainable development and of a more egalitarian world – where famine, poverty and lack of access to water and sanitation services are no more at issue – represent an enormous challenge to which the international scientific community must be committed.

The IAP Water Programme focuses on concern with the emerging "water crisis" that threatens many people in many regions of the world. About one-third of the world's population is living currently under moderate or severe water stress, most notably in the Middle East and North Africa. One billion, three hundred million people lack access to adequate water supply, and two billion people do not have access to adequate sanitation. Water pollution contributes to millions of preventable deaths every year, especially in children. Vigorous scientific, technological and managerial action is necessary to improve existing water supplies, to recover degraded surface and groundwater reserves, and to secure the necessary water resources for the future.

The Brazilian Academy of Sciences presented the IAP Executive Committee with a proposal of a new IAP programme on Capacity Building in Water Resources Management. This proposal was discussed within the Academies and at the last IAP General Assembly, held in Mexico in December 2003, the IAP Water Programme was established, committing 54 Academies of Sciences throughout the world.

Conceptual discussions and strategic planning have been covered, and Pretoria holds the third of a set of six regional workshops that have been planned in 2006. An initial workshop was organised in June, in Beijing, by the Chinese Academy of Sciences, covering the East Asia and Pacific Region. The Americas held their regional workshop in July, in Guarulhos, São Paulo, under the auspices of the Brazilian Academy of Sciences. The Polish Academy of Sciences will be organising the European workshop in September in Lodz. Two other workshops are still planned, one for Central Asia, and one for the Middle East and South Asia region, but definitions from the local organisers are awaited.

The objective of these workshops has been to bring together high-level water researchers and managers to discuss, at regional level, the major problems faced in water management, and to determine how science could contribute to solutions. A regional perspective will help in the identification of specific and general demands, and generate an agenda for the programme. These workshops also play a crucial role in the consolidation of the IAP Water Network.

The summarised general objectives of the IAP Water Programme, *via* the Science Academies of the world, are: (1) development of local capacity building in water resources management; (2) networking of water researchers and managers, to enhance water management capacity in the developing world; (3) improving policy and decision making processes; (4) increasing public awareness on the emerging water crisis; and (5) bringing to the table the major international water programmes and initiatives, to discuss complementary work, avoiding wasteful duplication of effort and funds.

Although the hydrological cycle links all forms of water on the planet, surface and ground waters have not traditionally been viewed or managed on an integrated basis by professionals, either as scientists or managers. This disconnection between policies is an important issue to the IAP Water Programme. Events at a watershed level will impact on aquifers, qualitatively and quantitatively. Pollution of water has the most serious human impact. More and more contaminants, both in type and quantity, pollute both surface and ground water supplies, especially in urban and industrialised regions. Pollutant origins may be point and non-point, and can include landfills, sewage treatment lagoons, disposal pits, urban runoff, fertiliser/pesticide-contaminated agricultural run-off, and "dirty" industry. These all contaminate both surface and ground waters. Effective management relies on an understanding of the component processes. This includes water regime and quantity, aquifer recharge rates and recharge quality, and catchment issues, in terms of land use and terrestrial input.

The existing dichotomy regarding surface and groundwater issues can be better handled through a watershed and integrated approach. Instead of being reactive, management must be pre-emptive, foreseeing problems, instead of only responding to them. The IAP Water Programme raises this new paradigm. Hydrogeologists, limnologists, engineers and ecologists, among others, need to collaborate in cross-sectorial and regional approaches to management, optimising investments, both human and financial. This requires innovative approaches in research, management and capacity building.

This said, the dominion of knowledge is a necessary, but not sufficient condition. Sustainable management of surface and groundwater resources will only be possible if scientists bridge professional and cultural gaps. Furthermore, if we fail in getting our knowledge across to the managers, our effort will have been in vain.

The Water Programme proposes the implementation of International Training Centres as part of a framework for accelerating the development of human resources, and integrating research and

management. This will provide focal points of training, development of new technologies, and identify field facilities for case studies. These training centres do not need to be new structures, but can be based on existing institutions and networks. These centres will be linked throughout a network that will provide a facility for exchange of programmes, scientific data, research information and training programmes. They will also stimulate, integrate and catalyse ongoing activities, fostering innovation.

Proposed international training centres will focus on the water problems of the world in a unified approach. They will integrate scientists and managers, who will address the pressing problems of water supply, while furthering knowledge. These centres should promote publication, and support exercises in public awareness. They should provide managers and scientists with appropriate training courses, collaborating with local universities and related institutions. These centres should cooperate at all times with the other international centres, securing a competent network that will foster advanced scientific research. Partnerships between public and private institutions should be accelerated, integrating climatology, hydrology, hydrogeology, limnology, ecology and research, development, innovation and management.

Many international programmes and initiatives currently deal with water issues through a wide variety of approaches. The IAP Water Programme's view is that lack of integration, amongst other hurdles, leads to wasteful duplication of effort. There is limited focus, and too much disciplinary research, that thwarts a systemic approach. The IAP programme proposals represent an innovative approach, and could generate a new step forward in water research and management. The prestige of the Science Academies could give credence to the call to table of the major existing initiatives, to discuss the importance of a new paradigm in water management, where there is more collaboration between different programmes.

The response that we are receiving gives us confidence in our programme. The need to ensure access to clean water, both to the present and future generations, is paramount, being an important contribution towards the fulfilment of the UN Millennium goals.

May I quote an old African wisdom: "The earth is not ours. It is a treasure we hold in trust for our descendants".

SESSION 1

An African View on Water Research

Chairperson: Eiman Karar

Water Resource Management in Africa – Capacity Building Issues

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My topic covers general issues that relate to capacity building, and water resource management. These concepts come through the African Task Group, and other researchers who are focusing on the African scenario. The African Water Vision 2025 is embodied in the statement, "An Africa, where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation and the environment". We need capacity, as well as knowledge, in order to achieve this.

There are more than 80 internationally shared river and lake basins in Africa. Water "ignores" national borders. Most of African surface water resources are concentrated in the Congo, Niger, Ogooue, Zambesi, Nile, Sanga, Charilongone, and Volta river basins, and in the Great Lakes basins in Eastern Africa.

Less than 10% of Africa's river and lake basins are covered by wetlands. Wetlands are an essential part of freshwater systems, as they provide a wide range of benefits, such as flood and erosion control, water storage, filtering, and decontamination, and offer a range of food and material products, as well as opportunities for recreation. Healthy wetlands are an essential part of the fresh water system, necessary for improvement and maintenance of water quality.

Many drainage basins, such as the Nile, Volta and Zambezi include large dams (exceeding 60 metres in depth) for water supply and power generation. New dams are under current construction in the Niger, Orange, and Oued Draa river basins. The rate of construction of new dams has decreased considerably in the last decade. Issues concerning the environmental impact of dams remain a controversial matter, but their value lies primarily in the safety and security of water supply.

Groundwater has been described as "blue gold". The African Continent can be divided into the following groundwater regions: Atlas Mountains, North African Basins, West African Basement, Sub-Saharan Basin, East African Basement, East Africa Rift and associated basins. They are independent aquifers, with different utilisations. Annual groundwater recharge, per capita is lowest for Northern Africa; 144 m^3 per capita, per annum, for the Atlas Mountains, and 350 m^3 per capita, per annum, for the North African Basins. The degree of groundwater development in these regions is a respective 49% and 22% of mean annual groundwater recharge. Annual groundwater recharge, in the other regions, ranges from 2 400 to 9 900 m^3 per capita, per annum. This is a huge diversity.

The urban population of Africa is increasing at a rapid rate, raising demand for potable water, particularly in urban areas. Groundwater can be a viable resource to meet this demand, provided the necessary protective and institutional measures are in place, and are enforced. Sanitation is an inevitable associated issue.

Challenges that face Africa, and its progress towards its millennium goals, include both natural and human factors. The Continent suffers from one of the most unstable rainfall regimes (in time, and space) worldwide. There is uneven distribution of both surface and groundwater resources,

causing severe aridity is areas such as the Sahara and the Kalahari, while creating extremely humid and tropical conditions in areas such as the Congo Basin. There are consequent extreme climatic events (droughts and floods) that pose a continuous risk to Africa's population, their livelihood, and their national economies. Associated with the phenomenon of global warming is the incidence of malaria, in locations that were previously free of the disease.

We deal with the human factors. Africa's internal renewable freshwater resources average 3950 km³/year. This represents 10% of the globally available freshwater resources, and equates to Africa's share of world population (12%). Certain water-scarce regions of Africa have succeeded in providing water supply to large segments of their populations, while in other parts of Africa, water-supply and sanitation coverage is restricted to less than half of the population, in spite of availability of abundant water. Issues facing water resources in Africa, thus, do not involve water availability alone. The human factor, in the form of water management capacity, plays its role, as well. Human factors relate to governance, legislative and institutional frameworks, water over-exploitation and pollution, conflict and political instability, inadequate technical competence, inadequate institutional capability, and low priority given to water and sanitation, in terms of securing the financial resources required. These factors are compounded by an increase in demographic mobility that accelerates urbanisation.

We examine the water supply coverage in rural and urban settings from 1990 to 2002. The water and sanitation scenario for urban areas is reasonably acceptable, in spite of the complication of growth. If one considers the rural areas, however, there are more serious shortfalls with targets, especially with respect to sanitation. United Nations, through their Economic and Social Committee, recognised water as a human right in 2002. Potable water for domestic use is prioritised as the most urgent water need. At that time, 51% of rural areas, and 86% of urban areas, had been provided with water supply. Sanitation figures are lower.

Water efficiency, equity and resource security can be depicted diagrammatically by a triangle, with apices labelled as follows: Efficiency – maximised benefit from the water used; Equity – aspiration for better access to safe water; Security and cooperation – to ensure (environmental) stability and viability of resources. These interacting and mutually competing factors bear on issues of allocation (Agriculture, hydropower, etc) and conservation, and they impact on policies, in terms of how human and other needs (such as stable ecosystems) are met. This may be portrayed as a water "trilemma", and requires more information (more data) of reliable quality about availabilities and needs, in terms of water, to avoid incorrect allocations.

Urgent needs that have been identified are safe drinking water and sanitation, food security, public health, environmental degradation, and disaster management. The African Water Vision 2025 is, "an Africa, where there is equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation and the environment". Four thematic areas are governance, water wisdom, urgent water needs, and finances. Water wisdom is equivalent to capacity-building. The vision and framework for action provides a basis to support the priorities and targets, as formulated by the NEPAD and Millennium Development Goals.

The challenges to water wisdom have been identified as follows. Statements are very general. Authorities lack adequate human (technical and managerial), financial and material resources, to plan and implement water and sanitation policies and programmes. There is a shortage of know-how, and of institutional "strength", particularly in the area of IWRM. Africa is also faced with the problem of capacity retention of trained and highly skilled personnel. Talented people go abroad under bilateral agreements, and then settle there, instead of returning.

There are limitations in terms of information generation and management, as follows. Inadequate financial and human capacity (at national, sub-regional and continental levels); lack of data of adequate quantity and quality on water resources, a prerequisite for effective and sustainable water resource management; water related data and information are often too general

or diffuse, due to inconsistencies, inadequate length and incontinuity of available records that arise from unreliable instrumentation, or interruption by political instability; shortage of facilities and of skilled people, at various levels, to collect and process information and data, for longer-term water management.

There are knowledge gaps. There is an information bias, generally towards water quantity, against quality (a hydrological, rather than a health-focused perspective); information on groundwater resources is inadequately detailed and inaccurate, in comparison with surface water resources; more information is needed in the areas of climate variability and change, water pollution and environmental crises (disaster management); data and analyses of a longer-term, and time-series nature are needed, and what still needs to be resolved is the often restricted access to databases, and the inadequate sharing of transboundary information.

Needs for the improvement of water wisdom are perceived as follows. Enhancing capacity through development of tailor-made capacity-building programmes, through the following measures: strengthening networking of education and training institutions, nationally and internationally, and strengthen partnerships; developing human and institutional capacity for IWRM at appropriate levels; mainstreaming gender issues in IWRM capacity-building (a lot of African subsistence farmers are women), and at all levels in water resource policies and programmes, including decision-making and implementation; securing and retaining skilled and motivated water professionals; enhancing research and development; developing effective systems for monitoring, collection, assessment and dissemination of data and information on water resources; improving or re-establishing water resource monitoring and assessment; improvement of access to and sharing of water-related information and data.

There are knowledge gaps that require to be addressed, as follows.

Establishing better and longer-term time-series of water-related data and information, especially on water quality (pollution) and groundwater resources; establishing impact of climate variability and change on water resources;

strengthening disaster management of extreme environmental events (e.g. early warning systems); exploring different mechanisms that fit into the social and cultural context of communities, for increasing women's access to decision-making processes and participation in IWRM.

The Evolving Science System in South Africa

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Dr Manzini, on behalf of the Department of Science and Technology of South Africa has already given an outline of what is happening in Africa, developing an integrated governance and strategic approach of its own, and defining its own aspirations. My address concerns the situation of South African science in this context. The opinions in my presentation are personal, and not the view of the ASSAf, or of anyone else, and are drawn from forty years of involvement in South African science. It touches on some of the themes already discussed this morning, namely, the movement from a fragmented and uncoordinated "system" of science and technology to a more understandable and role-differentiated, better governed and better coordinated and more efficient and effective system for South Africa, and the Continent.

This address is given as three topics. The first lists the "plusses" of our present evolving system.

South Africa has a separate department for Science and Technology (DST) that has proved to be an effective advocate in Cabinet for the notion that S&T is an intrinsic and important part of national, economic and social development. The other ministries have bought into this, with the acceptance by the cabinet of a target expenditure, public and private, of 1% or more of GDP on R&D by the year 2008. The last two year's respective figures were 0.81 and 0.87%. Current trends indicate that we are on track. This is probably because the target is couched in language that is understandable by politicians. It allows the mobilisation of resources from Treasury toward this sector. There is a DST division dealing with international relations and resource leveraging from the rest of the world into South African S&T. A good example would be the now-completed Southern African Large Telescope (SALT) that began as a South African Project, subsequently getting support from Europe, USA and the Far East, with South Africa ultimately contributing only a minor part of the total expense. The DST is a plus for the Country, effective in the Cabinet, and committed to increasing and well-targeted expenditure on worthwhile endeavours.

A second plus is that we had a National System of Innovation by statute, since 1999, with a National Advisory Council (NACI). This Council advises on needs and policies, providing an effective voice to get matters moving, since it can pick up on any sector, and then formulate recommendations. We have the Human Sciences Research Council (HSRC), which (independently) can generate, quantify and interpret indicators that measure National S&T progress and productivity. This provides the Advisory Council with "real numbers" to tell them what is happening, on a measurable basis.

The third element is the existence, since 2000, of a National Research Foundation (NRF), which is primarily an agency for implementation of policy. It is an effective grant allocator, doing this on a very competitive basis, which is fundamentally important for the country. This is part of a policy framework that builds capacity, and allows South African researchers a considerable part of the funds needed to carry out their work. As an example of policy implementation, the DST persuaded the Cabinet that there was a severe backlog of equipment for research; the Treasury allocated the funds needed, and the NRF is allocating the funds according to set policy, on the advice of its various adjudging panels. DST also implements "frontier science" through one of the NRF's other divisions,

dealing with bids for the optical telescope, the radio telescope, and other areas, where it is possible to give South Africa world-class competence. The NRF also fosters the development of university infrastructure, and rates scholars over long periods of time. Research proposals are not only judged on their content, and on the short-term merits of applicants, but also on their long-term (five to ten-year) records. This ensures that funds will be well used. There is a huge bursary programme, right up to post-doctoral fellowships, to grow national S&T capacity.

Another plus is the existence of 21 higher education institutions, universities, or universities of technology. They are all committed in their strategic plans to doing research and to growing in research capacity, even though they may vary greatly in performance and track record; the commitment and understanding of the needs at least is there. We have, in general, an education policy that provides support for researchers, in terms of supply-side subsidies, meant to build and maintain infrastructure. The Department of Education, advised by the Council on Higher Education and the Quality Committee that supports its work, decides on what kinds of subsidies should go to these universities, in terms of their research productivity, the needs for infrastructure, and the quality of research that they produce. The policy framework is generally a good one, even if there are many complaints, in practice, but this is inevitable in any system, good or bad. We also have many science councils and bodies, like the Water Research Commission, that operate, as you will shortly hear, in a slightly different manner. These are active in translational research. There are science councils in the natural sciences, the medical, human, and social sciences, minerals, geosciences, and so on. The country also mercifully has a very free press: one can expect to read criticisms of policies in the papers, and hear news of things that went wrong. There are a large number of civil society organisations that have particular interests and that lobby, in favour or against issues such as genetically modified foods or other aspects of biotechnology. We have awards at national level; we have mobility of our scholars. These are all the plusses in our science system.

However, there are more minus than plus points under my second topic, and much work is needed to address these. There are huge problems in school education, at primary, and especially secondary levels, in preparing the general population for participation in a knowledge-based economy. These are inheritances from the past, and they have not yet been addressed with any real effect, as evidenced by the various indicators. This is an enormous impediment to progress.

We have a very young Academy of Science (ASSAf, your co-host, today). It is only a decade old, and Government has only had a statute identifying ASSAf as the national science academy for the last five years. There are in fact two older "academies" that have each existed for almost a century; they are part of the history of the country, and still exist, so our officially recognised new academy has to make its weight felt, build a track record, and mobilise the kinds of people in every country who support and work for academies. Modern science academies are changing from a purely honorific role to focusing on providing science-based advice, independently of Government, based on merit and evidence, and on multidisciplinary approaches. These are the key hallmarks of modern science academy practice, reflected in the Inter-Academy Council, which was formed by the IAP, to provide science-based advice at international level, for all world governments. We have had fragmentation in this key domain in the past, with all kinds of advice for governments, sometimes by government departments, for themselves, knowing their own needs with predictable (but unconvincing) accuracy. This is certainly not safe or optimal advice to Government, even if implementation goes faster when (self-judged) policy is self-initiated. The Academy needs to grow and develop, and we are delighted with NASAC (The Network of African Science Academies), and with the African Science Academy Development Initiative of the United States' National Academies, which is reflected by Dr Barney Cohen's presence here today, representing the United States National Academies and the possibility that we can move forward with our sister academies in Africa. The health area research support system in South Africa seems presently to be somewhat confused, especially with the blurred delineation between the National Research Foundation, the Medical Research Council, and various other bodies; this is a problem in both structure and systematic support and development.

University-based researchers produce about 95% of peer-reviewed publications coming from South Africa. There is very little institute research, and very little full-time research. University-based researchers are pressurised by large teaching loads, excessive administrative burdens, severe under-funding, and under-prepared research students, as the system deals with the legacy of the past. Few of our researchers can work as people of the developed countries can, near full-time, under institute conditions. Under ideal conditions, one's own potential should be the only limiting factor in research productivity. The Academy has just completed a report as advice to the government, in that we have reviewed research publishing within the country and from the country. South Africa has more than 250 research journals that have been accredited by the Government, and there are many more that are not accredited. They mostly appear infrequently, are thin, with low visibility, and enduring an insecure existence. We (the Academy) have made ten recommendations that have the potential materially to improve the quality and visibility of the best South African research journals. At the practical level, researchers have library cuts, electronic communication bandwidth limitations, and extended distances from the active centres in developed countries. These factors are not conducive for successful research. Equipment and supplies are a constant problem, and immigration policies and practices prevent the recruitment of top scientists from elsewhere.

Some remedies are under way. There is a mix of selective school-level interventions. There is reform of the system through selective interventions in the so-called Dinaledi schools, initially about a hundred, increased to four hundred, where there are provisions to give a large cohort of learners a real capacity to move from rote learning to empiric investigation. The Academy, to support this, publishes a new science magazine entitled Quest. Its intended audience is wide, but it is aimed specifically at teachers and learners at senior levels of school education, giving them a good view of South Africa's top science, endeavours, stimulating pride and interest in what we can, and successfully do. The science-based advice system is gaining a more logical organisation. We are pleased that the DST recognises the Academy as playing an important part. Our symposium on evidence-based advice at the start of the year involved many different role-players. There was a profound insight gained during the last session, that an academy of science gives a country the ability to mobilise multi-disciplinary top talent from all sources, allows it to do studies and investigations, and make recommendations, independent of Government, in a professional manner. This helps to explain to all who are involved in the system the need for, and the role of, an academy like ours. (The proceedings of the symposium will shortly be published.) We need to address the health research base, and integrate it into the broader system. DST is addressing our problems by formal establishment of centres of excellence, inter-institutional networked research centres that are well supported. DST will shortly announce its first set of 55 research chairs, targeted to increase to 210 research chairs in the country by the end of the decade. Since there are currently only about 6000 actively publishing academics at South African universities and museums, this is a very significant and highly targeted intervention. Each of the new fully-funded, full-time research chair-holders will be financed not only for own salary, but also for a research group, and for necessary equipment. All this has come from the Cabinet, and from implementation of evolving policy. Universities have also come to the realisation that their scholars can no longer work under the conditions that they have endured in the past, and are forming institutes of research, with multiple funding sources, allowing top young people the best opportunities. As mentioned above, we are addressing the matter of how we publish, and how we become visible to the world, at large. We have a National Equipment Strategy being implemented, policy changes to attract key skills, changes to the immigration system to attract outside scholars, not to mention the encouraging developments that are currently taking place at the continental level.

In summary, in South Africa, we are lucky, in many ways, to have an infrastructural base that affords a valuable resource for the whole continent. We have serious problems that need addressing, and are being addressed. It boils down to a combination of looking after your own country, and working together on the continent, as a whole. This is the way to go to build the ideal of an African Renaissance.

Building African Networks of Centres of Excellence in Water Sciences and Technology

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The key issues and priorities for water resources in Africa may be listed as follows: •Water availability, influenced by climate variability and change (droughts and floods); high population growth and urbanisation rates; overexploitation of water resources; pollution of water resources; poor governance of water resources; inadequate human capacity, insufficient knowledge and data; lack of access to safe water and sanitation services; inadequate financial resources and institutional arrangements.

Science capacity is imperative for Africa's development, as has been identified by the World Summit on Sustainable Development. The report of the Commission of Africa states that a long-term programme of investment is needed, both to revitalise African universities, and to support the development of centres of excellence in science, engineering and technology, including African institutes of technology. This shows awareness at a political level. Awareness needs to be translated into action. The African Ministerial Council on S&T consolidates the science and technology programmes of the AU Commission and NEPAD. It sets continental priorities and policies for the development and application of S&T for Africa's socio-economic transformation. AMCOST goals are to enable Africa to harness and apply science, technology and related innovations, to eradicate poverty, and achieve sustainable development, and to ensure that Africa contributes to the global pool of scientific knowledge and technological innovations.

The first AMCOST meeting identified flagship programme areas, these being –biodiversity science and technology, biotechnology, information and communication technologies, energy technologies, materials science, space science and technologies, post-harvest food technologies, water sciences and technology, indigenous knowledge and technologies, desertification research, science and technology for manufacturing, and lastly, laser technology.

An expert workshop was held in Nairobi, 9th to 12th May 2005, at which there were 60 experts from 20 African countries and from France. NEPAD, the French Institute of Research for Development (IRD), UNEP and UNESCO were the organisers. NEPAD, UNEP, UNESCO and the French Ministry of Foreign Affairs provided the funding. Expert deliberations addressed trends in water sciences and technology, scientific and technological opportunities, criteria and indicators, specific processes and actions, regional and international cooperation modalities, governance structures, and financial mechanisms.

The recommendations that arose were as follows: the establishment of a Water Task Force that addressed criteria and guidelines; sharing of facilities and expertise; network sustainability; political endorsement; calls for submissions; and the verification of institutional capacities. Further recommendations were some elements of terms of reference for the identification and designation of networks of centres of excellence.

The Water Task Force met in Pretoria, 27th to 29th of July 2005. Nine experts from the five regions (plus an expert from France) discussed criteria and guidelines, mechanisms for cooperation and sustainability of the network, AMCOST/AMCOW endorsement, publication and dissemination of the information, verification of submissions, and arising recommendations.

The second AMCOST meeting dealt with an S&T Action Plan for Africa, consolidating S&T programmes of the AU Commission and NEPAD, and affording an instrument for the implementation of the decisions of the first AMCOST meeting. Identified areas for securing and sustaining water were the scientific assessment of Africa's water resources and systems, research and technologies to assess and monitor water-related disasters (with an emphasis on floods and drought), knowledge and technologies that improve water quality and quantity (including sanitation).

Assessment of water resources and systems encompasses methodologies and tools for conducting systematic assessment of the water resources (both surface and groundwater), and training African scientists and technicians on the methodologies and tools for conducting water assessment; launching and conducting water assessments at sub-regional and regional levels, developing a databank of Africa water resources and ecosystems, and disseminating scientific information on the nature of water resources and ecosystems.

Assessment and monitoring of water-related disasters cover identification and assessment of existing technologies for flood control, to determine their applicability in Africa, development of a databank and disseminating information on the technologies, and conducting research to modify, improve and develop flood control technologies. These would be linked to the desertification issue of drought.

Improvement of water quality and quantity deals with water quality assessment methodologies and techniques, research on and development of desalination technologies, drinking water treatment, and water eutrophication.

Governance mechanisms cover inter-ministerial committees (AMCOST and AMCOW), a technical advisory committee, experts in water science and technology, technical and advisory services, a peer-review system for competitive grants, and a network coordination office.

Financial mechanisms cover areas such as a special trust fund in the African Water Facility. Guidelines for the allocation of financial resources from the proposed trust fund would be developed and adopted by the governing council. There would be the matters of donor contributions, sale of products or patents, publications, etc, and public-private partnerships. The governing council would establish a special ministerial committee on funding the network. Such a committee would ensure that strategies for resource mobilisation and allocation are designed and implemented.

The South African Water Research Commission (WRC) is involved in a European Union (EU) funded project to promote the involvement of African water researchers in their Framework Programme (FP6 and FP7), including other bilateral scientific endeavours. The EU partners are the Natural Environment Research Council, the Centre for Ecology and Hydrology at Loughborough University, the Water Engineering and Development Centre (WEDEC), and Hydrophil (Austria). Focus is on information training and communication, details of which appear on a web address http://africanwater.net, as well as in brochures and on posters. The African Water Programmes are as follows.

[redacted]	[redacted]	[redacted]
1	Information, training and communications	Written material will support information, training, and dissemination activities, web site, brochures, posters, etc.
2	Working through existing networks	A database of African researchers and research organisations will be used to manage information on African researchers, and to be a tool in partner searches.
3	African Outreach	Activities in Africa, such as training sessions, dissemination, displays and conferences will be used for outreach and building exercise.
4	Africa meets the Commission	A delegation of African researchers will visit Brussels during the launch of FP7, to meet key EU programme officers and information providers

In conclusion, we are busy with the following tasks, namely, establishing an inter-ministerial dialogue between AMCOST and AMCOW; submission of centres to prepare and record their institutional capacity profiles; considering an inter-ministerial mechanism that will select appropriate centres, and formally designate them as Africa's centres of excellence in water sciences and technology, as well as consider and approve the governance and financing mechanisms proposed by the network of centres.

SOURCES OF INFORMATION

http://www.nature.com/nbt/journal/v24/n2/index.html

http://topics.developmentgateway.org/ict

http://www.netl.doe.gov/

http://www.lg-lasertechnologies.com/–Various UN Reports

IUCN

http://www.safrica.info/women/–http://www.cnn.com/ALLPOLITICS/1997/02/10/luckovic/–http://www.randwater.co.za/Education/Downloadable_Materials/dm_pictures.asp

Discussion on Session 1

Facilitator: Eiman Karar
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Karar: The challenges and issues have been identified by the speakers of this session, and we need to consider the way forward.

Question: What approach to creation of networks and centres of excellence is in mind? Are there guidelines as to how they would function as continental centres, as opposed to their local function? Considerations include sabbatical hospitality, training courses, workshops, the leadership role that has to be played, not overlooking the resources that will be required?

Reply (Pietersen): Not at this stage. This is substantial work that still requires to be done. We are at the stage of soliciting political support at ministerial level. Water is a cross-cutting issue. If we launch it as an AMCOST initiative, water ministers would object to lack of consultation with them in the process. We are looking at guidelines and criteria; it is not yet fleshed out. A biosciences initiative has been launched, and we are learning from this, in terms of the issues that can arise.

Question: My interest is in the EU project with the WRC and African researchers, as I am an African researcher. I am curious to know more about the project's intended function, and how may people, like me, would be able to participate?

Reply (Pietersen): Your presence at this meeting is indeed the first step. A key challenge is the construction of a database of African researchers. In terms of networking, there is a web site (detail not given) that provides current interaction, and you can lodge your details at this site, but we are also gathering the information that we have acquired from this meeting. We will have a series of workshops, in the aforementioned African Regions, where we will bring researchers together to introduce them to the programme. A delegation of African researchers will then approach the EU, and engage them on the various issues. Dialogue must be sustained.

Comment (Karar): The reason for this intervention is the concern on the part of the EU, in that whenever they make projects available for bids, there are no submissions from Africa. The message from African Researchers has been that the complex beaurocratic procedures, poor communication, and processes that take indeterminate lengths of time, encourages prospective applicants to turn their attention to their other priorities. African Water, through WEDEC (University of Loughborough) will retain the researcher database, allowing for the twinning of European researchers with African counterparts. There will be more effort in creating transparency to the submission process, in order that it may be fully understood. The NEPAD task force and other relevant structures will identify individuals that could be trained as to the EU system of proposal submissions. The WRC operates under similar lines, and a training programme on proposal submission (to the WRC) will be hosted at the WRC in Pretoria in February 2007.

Comment (Pietersen): This workshop programme also identifies water research priority. We will take this information, and use it to influence the EU, in terms of the research priorities that have been identified at this, and other meetings in Africa. This will replace the trend, where EU attempts to perceive, in their own perspectives, what the needs of African Research are.

Comment (Kfir): It is seen as an EU initiative, and there is money. It also an opportunity to generate a "who's who" in African water research, and even better that an African responsibility can be funded from an EU source. This is primary information, needed for any further planning steps. There was an attempt, some years ago, to generate a network of water researchers in Africa, centred in Kenya. It failed. I am closely associated with IWA. IWA offers highly-reduced membersship fees for developing countries. Yet, African presence in IWA is minimal. South Africa has WISA (Water Institute of Southern Africa – extension to the SADEC area). WISA's purpose is to get professionals, scientists, practitioners and government together at biannual meetings. Similar activities also take place in Latin America. Africa has no similar structure. Since the advent of our democracy, South Africa has tried to build its connections with the rest of Africa, from which it was previously isolated. We often meet researchers through UN and UNIP activities, often in foreign locations. I hope that through the Academy initiative, and NEPAD, that we address these shortomings. The South African WRC funds research; it does not conduct research, thus it sees itself as an organisational hub in terms of water research. This gets people together. Our successes offer blueprints for others in Africa to build similar relationships.

Question: What is the relationship between your DST and ASSAf?

Reply (Gevers): It is a "walking on eggs" issue, as a young academy, trying to promote differentiation of function in the systems, so that each organisation knows its role, and adheres to it. Stated emphatically, even through a statute in parliament, ASSAf is an independent academy (independent of government), but that it may receive and use government funds for its purposes, as most of the other international academies do. This independence is stressed in every report and document that it publishes. It is nevertheless a very cooperative academy, and wishes to work with partners, including the government. We have been offered accommodation in the new building for DST, and there was debate as to the wisdom of sharing a roof with a department on which we were (financially) dependent, and with whom we could well differ, in future. We have been allowed to brand ourselves as the science institutions wing of the building, and so far, it has been a great success, with rapid access to the people that we need to see. We are also located close to the NRF (National Research Foundation) and the CSIR (Council for Scientific and Industrial Research), and other relevant institutions. In broad terms, it is important that the government does not see ASSAf as a tool, or enemy, or obstructor, or in any other negative way. One must be independent. We have sought, in our first report, to clearly identify the government departments, the institutions in the country, including higher educational institutions, where we find shortfalls, and what should be done. We have highlighted problems with government policy, and made recommendations as to corrective measures. Our second study, on human nutrition and immunity, in respect of HIV and TB infections, again, we constantly expect to be at variance with government policy, but we wish to be constructive, and will state what we believe what the evidence implies, and what the best policies would therefore be. This is a sensitive point. We have to generate a credible track-record in an evolving system. The academy does not conduct its own research. It is an academy, which in a professional manner, brings together the best expertise from the system, and investigates evidence, and looks for the best solutions, where they are sought. If research is needed, then we would recommend that the research be done. Grant providers would then identify the people for such research. We would not do this ourselves.

Question (Olago): A problem with setting up networks is the (possibly negative) perception, by individuals, of what benefit there might be. What can be done to create and sustain interest in organisations of this kind? Lack of information, lack of tools (including special, purpose-designed and expensive software), lack of international visibility (publications); these resources are simply unavailable to many, necessary in order to reach the passage to the international arena. People resort to the line of least resistance, and attend to more parochial issues. Useful data never gets incorporated into central databases. There is failure of monitoring networks

within the continent. Good projects yield valuable information, but somehow this gets lost is the system, and is not available to others who could utilise it. How can we improve this process of information exchange amongst scientists? There is the free journal exchange system, on line, but there is a lack of Internet access, besides bandwidth problems. Perhaps a network centre could be a solution?

Reply (Gevers): In the USA, and in the biological sciences and in other science areas, they have the so-called Gordon Conferences, usually for two weeks, bringing together a group of intensely interested scholars, dealing with various topics, networking on the latest developments in their fields, getting to know one another. In developing a centre of excellence, it is imperative that one provides facilities for guests, in an attractive and informal way, where they can work together under the most comfortable "Cold Spring Harbour" type of environment. This is one example of how thought that has to be given to these matters. Then there is the problem of open access to information (including "e-research"), that there is thought given to the maximisation of its value. My concern is over loose talk, rather than thinking it through, looking at the options, and turning them into reality. University of Cape Town was involved in a programme, where special laboratories were provided for short courses in special techniques, playing a catalytic role. These matters have to be spelt out.

Comment (Pietersen): These issues have critical importance. WRC publishes "WaterSA", a periodical that covers scientific topics for the water sector. These are initiatives, along with all the other issues that have been raised, that have gone into a melting pot that has yet to crystallise.

Comment (Kfir): WaterSA is securely state-funded from within South Africa, but also has an impact outside its boundaries. One asks how one can extend such a structure into the rest of Africa. Raising the question that has already been asked, "what is there in it for me?", I believe that one cooperates with those you know. Personal contact is necessary, and a relationship is necessary for collaboration. A problem lies with funding. The WRC is a funding agency, and we can fund South African research. Money for the other African partners has to be found, before collaborative work can commence. The WRC induces different universities to work together. We know them. If you need expertise in Monte Carlo methods, we tell you whom in South Africa you should approach. It will work, if WRC funds the project from both sides, and providing the essential synergy to the proposal. South Africa is a member of the Global Water Research Coalition, which I term "the rich-people club". USA, UK, Australia and others are members. The only reason why they favour our membership is that we can contribute to the game. We spend research money, and work together on common problems, such as algal toxins, to a mutual benefit. Visibility and profile are important. We have good researchers in Africa, and one questions why the profile is not there.

Comment (Dia): I attended a meeting at Alicante about water management, and during this meeting, they discussed ways of improving scientific collaboration between African countries. Solutions are difficult. One option is to improve distance learning in management. We should find ways of implementation of this kind of cooperation, under the umbrella of African Academia.

Question (Tungaraza): I was first a government employee, meeting academics, who were trying to help government. Academics were perceived as the harbingers of incomprehensible and impractical ideas. I then joined academia, and have been there for five years. We had a recent meeting with government officials on environmental matters, and again, there was this rift. A government official complained that the meeting was treated as a classroom by some (a mentor-pupil relationship), rather than a workshop. Academics can communicate with ease with one another. How can we convince government that what we do is not just "an academic exercise" (construed in a useless and derogatory context)? Tanzania has a great problem in translating findings to practice, because of this communication gap.

Comment (Karar): Welcome to the club!

Comment (Cortesão): There are many challenges related to that problem. This is where academies can provide a link. IAP has discussed this issue, and has been successful at some attempts and experiences. Some academies of science have been more successful, other less so, in constructing bridges with policy makers. Knowledge is useless, unless it reaches and contributes to the decisions and policy-making processes. One way to address the problem is to invite participation from all parties throughout the process itself, all being represented at meetings, so that there is no sense of alienation on the part of anyone, at any time.

Kfir: We have no problem communication with our DST. They understand the role of science and technology. Water is cross-cutting, and the WRC has to deal with others, such as the Department of Agriculture, Provincial and Local Government, *vis-a-vis* water services, and deal with the Department of Water Affairs and Forestry. Their perspective of water research is that it must make their life more comfortable in terms of policy development, and informed decision. Sometimes we succeed; sometimes we fail. We developed a river health programme. Now they own it, and they execute it, and are proud of it, even forgetting the origins of the research, which is fine. Another programme was concerned with sewage treatment works that were malfunctioning. Newspapers highlighted the conflict between researchers and the service providers. The consequent tension became a problem in itself. Some academics, because of their demeanour, are best isolated from government officials. Problems arise if government lacks capacity to adopt the recommendations of research, or if a researcher in unable to communicate his/her message to a government official in an understandable way. The WRC approach is to first solicit opinion on funding of the research, then have interested parties from all sides on a research steering committee. We do not operate in isolation. Even this way, there are still problems.

Question (Mvundika): We heard of allocations of 0.8% of GDP. Zambian allocation is about 0.00%, and we fight for it to be raised. Politicians reply that they can only increase it to 0.2%. Calls for collaboration are brilliant, but what can we do to address this matter?

Reply (Pietersen): One percent is considered the norm, in terms of peer review. How they push these issues will be interesting. It is a continental topic that is under discussion, but the time-frames need to be resolved by each country, on its own.

Comment: Co-ownership in the processes, as has been discussed, has worked in our country, with fruitful partnerships with the relevant government body.

SESSION 2

Water Resource Management in Africa

Chairperson: Kevin Pietersen

Water Resource Management in Senegal

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I attended the IAP Meeting in January, held in Alicante, Spain. Action was called for water management, and African academies need to respond thereto. I am pleased to be able to attend this present workshop, for it addresses this brief.

Senegal is at the western-most part of the African continent, bounded by Mauritania (north), Mali (east), Guinea (Conakry), Guinea Bissau (south) and the Atlantic Ocean (west). Its area is about197 000 km^2. The main rivers are the Senegal, Gambia, Casamance, and Faleme. Climate is tropical, with a dry season from June to November, which creates water supply problems. Population is 12 million, with a growth rate of 2.9%. Dakar is the capital city, with a population of about three million. The currency is the FCFA, currently 1US$=555FCFA. Senegal is a member of UEMOA (WAEMU), CEDEAO (ECOWA, UA (AU), NEPAD (New Partnership for African Development) and CEN-SAD. The countries main resources are agriculture, marine products, mineral products (phosphate, fertiliser, phosphoric acid, cement) and cultural products.

I was General Director of Mining and Geology for six years, as well as being responsible for water management, including water research. Our institute has a department of geology and water management. We have several PhDs serving this field. Senegal is generally poor in rainfall, precipitation ranging from 200 to 800 mm/year.

In today's global economy, a country's economic success depends on how well it leverages technology to manage its natural resources. Senegal is poised to make significant strides in economic growth, through the sustainable development and management of georesources, like water. As with the other Sahelian countries, Senegal exploits its water resources significantly through drilling wells, building dams and constructing other hydraulic infrastructures. It's very difficult for African countries to bear the entire cost of construction, operation and maintenance of these hydraulic infrastructures. While it is necessary to call for a more sustained commitment in favour of dams, there is also a need to consider other alternatives, these being water requirement management and GIRE, rainwater collection techniques, and minor irrigation.

We have a constructed water catchment basins programme (small rural dams) for rural fresh water supply. Small dams are regarded as a means for providing the water needs of small communities. Water retention dams, initiated in almost all Saharo-Sahelian countries, can have capacities of a few thousand cubic meters, and can supply water for livestock, irrigation, domestic use, as well as for fish farming. There are plans to replace large-scale irrigation with these small dams. They harvest water, and thus improve the livelihood of the rural population. Any feasible means of water conservation is valuable in the rural areas. Rural communities, collecting runoff, sheet floods, or slipstreams have followed various water-capturing initiatives. About 150 billion cubic meters per annum of rainfall water is lost to the sea, because it exceeds the existing water exploitation capacity. Senegal has initiated a massive programme, entitled "bassins des retention et des lacs artificiels", to make water provisions for our arid zones.

I address the nature of the water resources of Senegal, and the strategy management thereof. There are two sedimentary geological domains; the large so-called Senegalo-Mauritanian basins that are mezo-Cenozoic, and another domain, to the south, being a pre-Cambian to Paleozoic complex basement. Water reserves are estimated at 7 billion cubic meters, and cover 80% of the territory. The meso-Cenozoic basins include several superimposed aquifers. They are very shallow at 0 to 20 m depth in Casamance (to the South) and 40 to 60 m depth between Kaolack and Tamba (quaternary basins). Water is subsurface, between Dakar et Thiès (infrabasaltic sand) with quaternary sands of Thiaroye, and Paleocene limestone of Sébikotane and Pout. There are deep aquifers: between 200 and 400 meters depth in the case of Maestrichean sands. 80% of water originates from groundwater. The basement complex is composed of pre-Cambrian rocks, with acid rock intrusions, within greenstone belts, and affords a highly mineralised aquifer of poor quality and usability. Listing aquifers, we have the central Maestrichean, and in the western part, the littoral aquifers. Here, we have the problem of sea water infiltration. We have the western pre-Cambrian granites. This raises the issue of water replenishment rates of these aquifers in an important hydrographical network. There are both local and transboundary rivers, such as the Senegal River (its source is in Guinea), and the Gambia River, all needing to be part of an integrated management system. There are also many smaller streams, affording exploitation in the form of constructed catchment basins. Furthermore, there is Lake Guiers. The city of Dakar currently relies on nearby Littoral Nord aquifers (35 000 m^3/day) for its water supply. These aquifers have a low replenishment rate, and have been exploited well beyond their sustainable yields. The growing water demand calls for the mobilisation of additional surface water resources over long distances (about 240 km) from the Senegal River and Lake Guiers system, with withdrawal rates of 0.5 m^3/second in year 2000, to an expected 6.0 m^3/second in year 2030. These needs fall within Senegal's water rights under the OMVS agreements (between Senegal, Mauritania, Mali), an accord that is responsible for an integrated system for water management and environmental control of the Senegal River basin. This is supported by JEFF funds.

We have a commitment to the millennium goals. There is the issue of increased water use in all sectors, while water availability remains unchanged. Senegal is committed to an increase in provision of water and sanitation, but we lack the necessary decision-making framework for this. Senegal set up an appropriate Framework for Water Resources Administration in 1993, to deal with the utilisation of water resources for sustainable growth. There have been major sector reforms, with strengthening of an institutional and legal framework, to ensure efficient implementation of urban and rural water supply.

Major aims of institutional reforms have been to ensure the autonomy of management, and a rational organisation of the sector. Objectives have been to encourage the development of human resources; to foster improvement in commercial management and cost effectiveness; to improve cost recovery and reach a financial equilibrium of urban water supply in the medium-term; and to establish a new tariff policy. Rural people are poor, and tariff policies should not constrain their access to clean water.

Management divides its responsibilities between rural and urban areas. There are two ministries, these being the Ministry of Agriculture, Rural Hydraulic and Food Security (including Agriculture), and the Ministry of Hygiene, Urban Hydraulic, and Sanitation. There are the various technical departments and agencies under these structures, such as SONES (Senegalese National for Water) and ONAS (Senegalese National Agency for Sanitation). There is the SDE (Senegalese Development of Water), responsible for transfer and supply to users. There are the many technical departments, as well as the university, which is also involved in management. There is also the Ministry of Environment, and the Ministry of infrastructure, also involved in water management of Senegal.

The responsibilities of the Ministry of Agriculture, Rural Hydraulic and Food Security (MARHFS), with its departments, through the Resources Planning and Management Department

Water Management in Cameroon

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This address covers water resources in Cameroon, and provides an overview of the challenges as regards current water management.

We have a lot of water and a lot of variability, from 10 m rainfall/year in the South to about 500 mm/year in the north of the country. Based on the year 2000 population, we have an average water availability of about 18 000 m^3/capita/year. Of this, only about 0.4% is actually withdrawn. We are part of the major river basins such as the Niger, Congo and Chad basins. If the population continues to increase at the current rate, we would expect a national average water availability of 8 000 m^3/capita/year in year 2025. In year 2050, it would be about 4 000 m^3/capita/year, with two provinces that will experience water scarcity. There is seasonal variability, as well as geographic variability. Our adversity is more often a matter of too much water.

Regarding water quality, most of the surface and shallow ground water near urban areas is polluted. Domestic wastes (all forms) from surrounding dwellings end up in water bodies in built up areas. In addition, agricultural run off from the adjoining lands adds sedimentation and agrochemical (pesticide) pollution. The population that is unserved with pipe-borne water must rely on springs for relatively cleaner water. Although good in clarity and colour, these springs can be heavily contaminated by microorganisms, including pathogens. Challenges related to water management are meeting basic needs, securing food supply, protecting ecosystems, provision of water for energy and industries, and for navigation.

Inadequate supply of water affects basic needs, health, food security and essential livelihoods of the population. Improved access to water can be a major contribution towards poverty alleviation. This is because half of the population is without access to adequate, safe water supply, and a quarter of the population is without access to adequate sanitation. Water-related diseases account for 65% of all recorded illness, and 52% of deaths. About 15% of children died in the year 2000 before the age of five, mainly due to water-related diseases. This is an increase from the level in 1991 of 12.6%. The health situation of children has therefore deteriorated during the last decade, instead of improving. The period 2000 to 2006 already indicates that Cameroon is seriously off track to meet the target of the African Water Vision, which has as aim to reduce the percentage population without access to water services, by 95%, by year 2025. Water costs are relatively high, and the lowest rate for a private consumption is 0.52 US$/$m^3$. There is a high connection charge, with a minimum of about 276 US$. Public water vendors charge 1FCFA/litre, which amounts to about 2 US$/$m^3$. This is 269% higher than the price paid by those with private connections. Hence, the poorest urban dwellers pay even more, in a country where about one third of the population is below the poverty line. Water supplied by the National Water Corporation water is very expensive. The lowest rate, which is about the same cost as in Canada, is 158 % higher than in Chad (at 105 fr/m^3),

Agriculture is the backbone of the economy, and accounts directly for a third of the GDP, employing about 60 % of the work force. Food production has kept pace with the increasing

population over the last decade, and there is enough food in the country, with surpluses for exports. However, about 25% of the total population is undernourished; that is, they do not consume sufficient calories. There are regional variations, with the situation being worse off in the northern parts of the country.

It is estimated that there are 240 000 ha of irrigable land in Cameroon. However, only about 39 000 ha (16 % of the potential) is currently under irrigation. To attain the Millennium Development Goal of halving the proportion of population who suffer from hunger by the year 2015, the African Water Vision calls for an increase in irrigated area by 50% by this date and by 100% by the year 2025. Small-scale irrigation is the preferred option, because it has been shown to be more effective. We must also consider pastoral water supply, especially in northern Cameroon, which is a major livestock producing area. The rainfall is lower than in the south of the country, though the amount could be considered adequate. The major problem is that of poor temporal distribution, where about 50% of annual rainfall falls within two months of the year. There is therefore a need for conservation, and low cost storage of water resources, as poverty is more pronounced in this part of the country.

As regards fisheries, and the issue of food security, Cameroon has about 360 km of coastline, and the inland water bodies are estimated to cover 4 million ha. Fish production however has been stagnant, providing only 60% of local demand, while imports are estimated to cost about 30 million US$, annually. The challenge is to increase production to meet local demand, as well as provide opportunities for export.

There are three main causes of ecosystem degradation. One is climatic, through recent decreasing and irregular rainfall, leading to droughts. Another is pollution, much from domestic sources (waste-solids and liquids). Most central sewage treatment plants have broken down, and water-courses are used to dump trash. Further, there is pollution from agricultural and industrial sources that have had little or no treatment, as well as improper use of pesticides in the practice of "poison fishing". Man-made interventions have also impacted on ecosystems negatively. An example is a 28 km dyke, constructed in the Maga in north Cameroon, to reduce flooding in the Benue plain and create conditions for growing rice. The impact of this intervention has been disastrous, adversely affecting the poorest section of the population. The consequential direct economic loss therefrom has been estimated at 2.5 million US$/year.

Water is an essential requirement for many industries. Inadequate water supply leads to industries opting for independent water supplies. Such systems are mainly from groundwater, frequently with over-pumping, with consequent marine water intrusion to the aquifer in coastal areas. There is enormous hydroelectric potential. However, only about 2% of this potential has been developed, and only 41% of the population has access to electricity. Hydropower accounts for 80% of the electricity consumed, while thermal sources provides about 20%. The national plan is to increase hydropower production to meet 90% of electricity demand. Insufficient energy is currently produced (dam capacity reduction due to silting) and power rationing in recent times has occurred in the dry season. This has lead to the construction of thermal generating plants.

Water transport is very important in some areas, especially the north of the country. Flow reduction in the dry season, silting, and invasion by aquatic weeds has been reducing the periods of navigability, with time.

Poor water resource management in Cameroon poses a severe constraint to sustainable development. This is because significant sections of the population suffer debilitating disease and economic hardship, mainly due to poor management, rather than actual water shortage. Despite the great importance of water, the government has not yet recognised this as a critical element of poverty reduction. Consequently, water has not been put at the centre of socio-economic policies.

Water management in Cameroon today follows the conventional sectoral approach, with responsibilities in the hands of many different ministries. The 1998 Water law exists, with many articles for sustainable management, but the laws not enforced (insufficient political

will, inadequate resources etc). There is poor coordination of water resources development and management. The National Water Commission, previewed in the water law to coordinate the sector, has never got off the drawing board.

Critical water management problems include inadequate legal and institutional frameworks for the protection and regulation of water resources, inadequate data for informed decision-making (very few functioning water monitoring stations, and little information on water use), dwindling flow of rivers and shrinking water bodies (Lake Chad), insufficient political will (non enforcement of existing laws, poorly funded sector, and dependence on external funding etc).

There is an insufficient number of motivated and skilled water professionals who can deal effectively with the complex issues of water scarcity, climate variability and joint management of international waters. In addition, there is inefficiency and wastage in the use of available water (a 40 % leakage loss in urban water supplies; and inefficient irrigation systems). Degradation of water resources occurs through pollution, and deforestation is reducing the available water supply.

The Government is becoming more aware that current poor water resources management in Cameroon is a severe constraint to poverty alleviation, and to sustainable development. There are plans under way to improve water management by adopting and implementing integrated water resources management (IWRM) principles, with the assistance of the Global Water Partnership.

To conclude, Cameroon currently has abundant available water resources, estimated to be 18 000 m^3 per capita per year, and the country is projected to have sufficient water, well into the foreseeable future. Nevertheless, water resource management is still a severe constraint to sustainable development, mainly due to poor management, rather than actual water shortage. Despite the important role of water in poverty-alleviation and socio-economic development, the government has not yet placed water at the centre of its development policy. Many problems exist in the management of water, but the fundamental one is the lack or insufficient political will/vision to create an enabling environment for sustainable water resources management to be implemented. The development and implementation of an IWRM plan will go a long way to improving water management in Cameroon.

DISCUSSION

Comment (Karar): It is clear that the concept of water resource management can mean different things to different people, and some form of common understanding is still needed.

Comment (Kfir): It would appear to centre on the issue of water quality, which is turn, impacts on the health of the population.

Water Resources Management in Uganda

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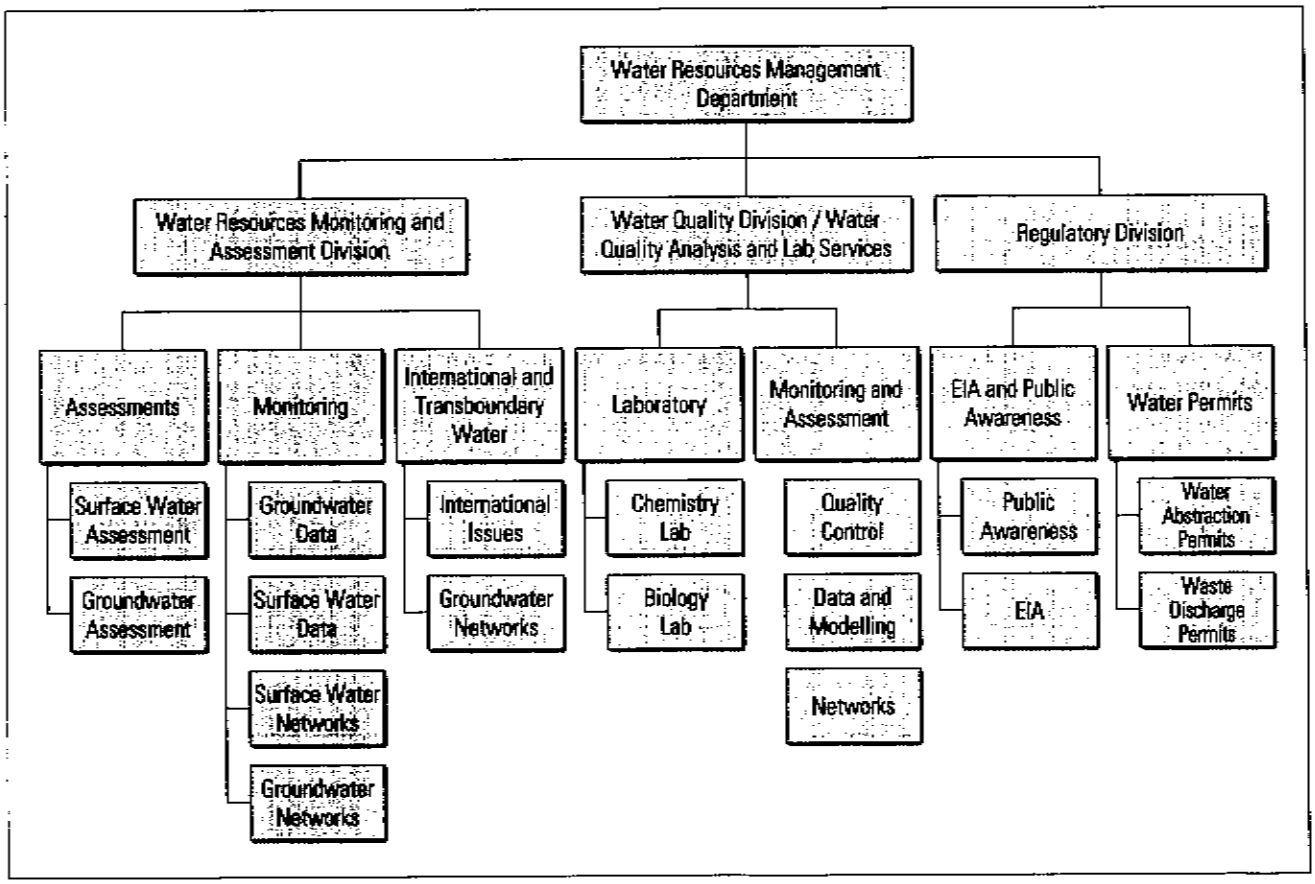
We have a lot of water, but predictions show that if we do not manage it properly by year 2025, we will become identified with the water-stressed nations. Our population is 26 million, growing at 3%/year, one of the fastest growing populations, and indeed, this is a challenge.

We have recently created a Ministry of Water and Environment. Ten years ago there was a Ministry of Natural Resources, which included energy, minerals and water. It then became the Ministry of Water, Land and Environment. So, water is further prioritised at a national level, with an integrated sector approach, with good budgetary support from the donors. The Water Resources Management Department falls under Water Development, headed by the Ministry of Water. There are three divisions, water quality, water regulation, and water resources.



There are different programmes being implemented within the structure. One is support of water resources management, and another is the Lake Victoria Environmental Management Project. We

share this lake with Kenya and Tanzania. We also have the Nile Basin Initiative, supported by the World Bank. The ten Nile Basin countries never used to interact, even at discussion level. This initiative has started dialogues, and problems are now being solved.

We have floods. One programme is to mitigate the floods in the central Lake Kyoga. This is along with the Lake Victoria Development Programme.

We also have a monitoring programme. There are three categories of monitoring; surface water monitoring, ground water monitoring and water quality. There is a programme to upgrade monitoring stations.

There are eight major drainage basins in Uganda, Lake Victoria perhaps being the best known. We are moving toward the catchment management approach, with regional/catchment water officers. The monitoring shows a fall in the levels of Lake Victoria with time. There is a network of fifteen groundwater-monitoring wells, with a limited coverage of about 20%. Problems include the scarcity of data. Some existing wells, used as monitoring stations, lack comprehensive drilling and construction data. There is also insecurity in northern and north-eastern Uganda, hindering groundwater network operations at these locations. Since most wells are located in the basement aquifers, that tend to be highly heterogeneous, and of limited lateral extent, the isolated nature of these aquifers requires more baseline monitoring boreholes, to ensure that the network is representative of the full range of Uganda's hydrogeological conditions. There is also a lack of purposely-designed monitoring boreholes, to provide good and reliable data.

As regards to water quality monitoring, the key water quality issues encountered during the reporting period include suspended sediment pollution, organic matter pollution, pathogenic contamination, high heavy metal content (iron) and eutrophication. These issues were found predominant in certain source types, while insignificant others. Chemical parameters for most rivers are good. We have assessed E. Coli content of our rivers, and it is acceptably low, over time.

We shall now deal with the issues in the water sector. A consultant, using the Water Resources Issues Assessment Method (WRIAM), carried out an assessment of water resources issues. The WRIAM method was developed as a part of a project concerning Integrated Water Resource Management in Burkina Faso. It is based on a standard definition of the important assessment criteria, as well as the means by which semi-quantitative values for each of these criteria can be assigned, with the aim of giving a precise and independent score for each issue. The WRIAM method operates with four types of issues:

- *Impacts on the resource*: These occur when human activities diminish the quantity of the resource significantly, or degrade the water quality, in relation to the different requirements stated by the users.
- *Demands or availability of the resource*: these are essential problems, when the availability or the quality of the resource does not correspond to the needs of the users.
- *Mobilisation of the resource:* Problems (issues) related to making the resource available to the users. Examples are security restrictions, possibilities of establishing productive boreholes, capture/collecting technology, and the total requirement, in relation to the mobilisable resource.
- *Risks and harmful effects of the resource, and social and economic impacts on the users*: This includes the negative effects imposed on the human community because of the presence of water, such as floods (loss of life, damage to infrastructure, loss of crops), water-borne diseases and epidemics, gender issues, accidents (e.g. drowning) in reservoirs and impoundments, and the economic problems related thereto e.g. purchase of water.

Ranking rates water quantity as the first issue, quality is the second. Another significant issue is seasonal variation. National ranking differed very little from the basin rankings. It shows the cause and effect relationships of erosion and water quality, impact on supply, suspended solids, eutrophication, and diminished availability. These are key issues. Management issues are also identified, but do not rank so high. Steps are being taken to address these matters.

The International Atomic IAEA is supporting the Nile Basin countries in addressing some of the water issues in the basin, through the application of isotope methods in management of Nile Basin water resources. Phase I (year 2003 to 2004) initially involved Kenya, Tanzania and Uganda, and was aimed at improving the water balance of Lake Victoria, through a better assessment of evapo-transpiration, precipitation and groundwater contribution. Phase II of the project will involve all the other Nile basin countries, and will be completed in December 2006. The technology has proved very useful, as it has helped in a better understanding of the dynamics of groundwater resources in Uganda, and has, in some cases, been able to provide information that cannot be obtained by other techniques. The technique is fast, cost-effective, and if employed with other methods, will go along way in improving the management of the country's water resources.

The water level of Lake Victoria has dropped drastically. One cause is drought, another is the demand for hydropower. Nalubaale permits have expired, and the Directorate will use this opportunity to alter the water abstraction permit to Eskom (electricity supply utility) limited, to apply corrective measures. Available hydropower has consequently decreased, and power load-shedding measures have to be taken. It is apparent that the operating rule, based on the Agreed Curve of 1954, is not easily tenable. The Directorate will formulate new rules, as a matter of urgency, so that they be sold to stakeholders downstream and upstream of Jinja.

Apart from the hydropower potential of the Nile, being harnessed by Uganda, Lake Victoria and River Nile controls the regime of other water bodies in Uganda, notably Kyoga, to an extent of 92%. The Directorate is developing a plan to introduce bulk water transfer. Maintenance of high water levels in Lake Victoria is considered as a priority interest, which must be vigorously pursued by the Directorate.

Hippos at Queen Elizabeth National Park started dying at an alarming rate, due to an unidentified cause, towards the end of the dry season in late July 2004. The areas, where such deaths were registered, include Katako on the northern shores of Lake Edward, River Kyambura, Kashaka, and of late, the Kazinga Channel (Press release UWA July 2004). According to the press release, hippos are known to have died in a similar manner at least 5 times in the last 70 years in cycles of 10 – 20 years, but not at such an alarming rate. Causes of death in the previous events have not been identified. Hippo populations has decreased from about 11000, prior to year 1970, to 3400 in year 2000, representing 69% decrease in 20 years. Unlikely possibilities are rinderpest and anthrax, but heavy metals, and other soil-borne chemicals or pathogens, possibly from leachate, likely to contain copper or cobalt, arising from neighbouring mining, are suspect.

There are conflicts (agricultural, over other needs) regarding water resource use in the Manafwa Catchment, demonstrating the need for effective management that is accepted by all stakeholders, and in which they have had full participation throughout the decision-making processes, leading to consensus.

Then there is the problem of flooding. Egypt has been of assistance in removal of downstream blockages that have caused this problem on the River Nile, especially in the Lake Kyoga Basin.

Groundwater mapping has been constrained by limited resources. Mapping has been undertaken by the government, but because of the work-load, the private sector has been engaged, but is also constrained by funding.

The water sector is perhaps one of the most vibrant in Uganda, in that it is a leader in many of the reforms and trends currently in progress. We have many consultants, looking for ways to do things in a better manner. We are moving from district management towards catchment management.

Interventions will be the creation of a proper enabling environment, developing a decentralised framework for integrated water resource management, water resources planning and allocation, presided over by a water policy committee. These, along with the legal framework, are all part of the reforms that we wish to pursue.

DWD have a strategic investment plan, which will be an outcome of a study that will categorise and prioritise the best ways forward. One outcome of the recommendations is that the Water

Resources Management Department should become a Directorate, to emphasise the importance of water management.

We have done a lot on network monitoring. We are now re-examining the reasons for monitoring, in that it should not only be data collection, but with a water issue in mind, when doing so. It is thus a change to issue-based monitoring. We constantly review methods of data processing, storage and retrieval, with significant improvements. Research is a contributor to better ways of managing the sector.

Forty percent of our funding comes from our development partners. We constantly look for more support. We have an ACP-EU facility to which we have submitted proposals. Fifteen have been approved, providing more money. There is JICA, in which the Japanese have provided generous support with drilling boreholes. There is the TIGER initiative from the European Space Agency, arising from the Johannesburg Summit (2002), and involves remote-sensing of data.

The water sector is vibrant and we are open and willing to learn new ideas.

DISCUSSION

Question (Karrar): Your ministry had originally water, land and environment, and then you took out land. What were the reasons for reversing a trend in integrated management?

Rugumayo: We have a ministry of housing, land, and urban development, and a ministry of water and environment. I think that it was a bit political. Water wanted to have a higher profile. Our minister is head of AMCOW, and needed the status.

Water-Related Environmental Problems in Agriculture in the Lake Victoria Basin

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I will deal with our problems through a case study. I will first give a background on the institutional changes that have taken place in our water sector. Everything was haphazard prior to 2002. Water issues cut across about 27 different acts, none of which was adequately coordinated. Industry, and most others, had *carte blanche* to do as they pleased, with environmental pollution, and no implementation of standards and regulations. The act is now consolidated. We promulgated the environmental management and coordination act in 1999, which forced compliance, through monitoring by water quality analyses. New institutions are currently being formed. We have the water resources management authority, dealing with water quantity and quality, and we have the various services boards, dealing with the supply of water, and maintenance of its quality. We have the water services trust fund, which deals with apportionment of money to various projects and programmes. Institutional structure is all on a catchment zone basis.

The case study deals only with the Kenyan side of the Lake Victoria. There are several rivers and streams from Tanzania and Uganda that drain into the lake. The problems in these locations are the same as elsewhere, in the Rift Valley systems, the river systems, right up to the coastal zone. The tabulated information shown, specifically the average sediment transport capacity index, indicates that the basins on the Kenyan side are importing massive quantities of sediment into Lake Victoria. We note the increase in sediment, population density trends, and how these link with certain land uses, from the 1800's to the present. There was little change until about 1930, when agricultural activities started to proliferate within the Lake Victoria Basin. With this has been the large increase of sediment entering the lake. The agriculture has not been following any integrated management system, concentrating on only maximising its activity. River abstraction has modified flow into the lakes. There have been conflicts west of Nairobi, arising from insufficient water being available to meet essential needs. As for industrial water pollutants, we still need to identify and quantify them. Water management programmes only look at simple chemical and bacteriological parameters. Herbicides and pesticides, tannery and brewery effluents, all end up in the water system, and a proper assessment of the problem has still to be made. Microbiological problems and eutrophication are common to the lakes and water systems, compounded by the proliferation of mining activities. Suspended solids remain an ongoing problem, modifying aquatic ecosystems, with an accumulative impact.

We have a lot of degradation of floodplains and wetlands, impairing their function. The goods and services that they are able to provide are consequently degraded. We have a high irrigation potential. Half of this lies within the Lake Victoria Basin, and is still largely unexploited. Lake Victoria water provides fresh water for domestic, agricultural, livestock and industrial use. Raw sewage enters the lake in large amounts, affecting the COD and BOD of the Lake, and adding to microbiological pollution. Toxic metals end up in the food-chain, including fish, and although not yet at human health-hazardous levels, may soon become serious. Stormwater run-off carries

animal, plant and human waste to the rivers and lakes. Growing numbers of domestic animals, poor husbandry, and poor land management abets further pollution of water resources.

How can we manage these surface waters? We have high (naturally occurring) fluoride levels in our water. We adopt the WHO water quality standards. If one accepts the 1 ppm fluoride maximum limit, then all of Kenya's water is non-compliant with potable standards. We need water treatment systems that target specific chemical problems of this nature, and perhaps formulate specific standards for local application, to compromise ideality with practicality. Eutrophication is a major problem within the Lake Victoria area. There is debate as to the origins of the nutrient load; is it via atmospheric routes or influent water flow? The surveys of these problems will involve twelve neighbouring countries, and should commence in 2007.

We witness serious ecosystem modifications, one being in the Nyando River Basin, being about 3000 km^2 in area. 46% has undergone severe soil erosion, and has lost all useable value. Forests and shrubs are replaced by bare soil, in areas with an annual rainfall of 1000 mm, or more.

We need an integrated approach to these problems. We have a joint project covering the three countries, Kenya, Uganda, and Tanzania. The success of this, in the view of many, is that it has been very low. There are difficulties in coordinating the activities of the participant countries, and getting them to work in an integrated manner. What has indeed brought impetus, was when collection and collation of information was outsourced. There was a limnological investigation. Now we are able to locate the problem hot-spots, and identify and target appropriate interventions.

Farming practices and land management still have an unrelated status as regards water. Irrigation remains an unused potential, people depending on rain-fed agriculture. Plans for extensive irrigation are being made. Agricultural practices ignore the need to contain pollutants. Trade issues drive people to make use of water resources beyond sustainable limits. The external market demand for Nile Perch has grown to the degree that Lake Victoria cannot even provide local inhabitants with fish to eat. We need to draw the agricultural and industrial sectors into the framework, as they are the greatest contributors to water pollution problems.

DISCUSSION

Question (Gevers): These are alarming developments. Is the Government aware of this, and the incredible importance of success in this venture?

Reply: Yes, and no. Our government is bent on water supply, ignoring water quality issues. We have very little attention paid to ground water resources; how much is there, and where? There is the simple and general assumption that there is more water than is needed. But surveys of water quality indicate, with little doubt, that they will not meet the target of increased availability, from 54 to 79%, by year 2015.

Water Resource Management in Tanzania: Policy and Trans-boundary Management Problems

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The trans-boundary management problems arise from our geographic location. As we can see from the previous speaker's presentation, our water management is placed in different ministries, from one nation to another. In my country, and in my time, it has been shifted three times. It was with minerals, then with livestock, and now it is an independent ministry.

I show the map of Tanzania, with the twenty administrative regions. Each had a regional water engineer, a regional water manager, the borders being based on what were political administration demarcations. Management problems arose through these divisions having no relation to water regions, catchments, river courses, etc. Water provision was initially the aim, especially for domestic use and agriculture. Domestic use was primarily in urban areas, and agriculture in the rural areas. After independence, in 1971, the government recognised water as an important rural business, and then initiated a twenty-year plan, that was directed at the rural areas, perceived to be where the most pressing problems lay. Although funded by donors, this exercise failed. The major reason for the failure was that the first twenty years of implementation did not involve the beneficiaries, hence it was not participatory. Local people had never been consulted as to their needs. The Water Act was amended, and embodied the concept of catchment/basin management. The country was re-demarcated into nine river basins, using geographical criteria and natural barriers. Terrain is extremely varied in a country of over 900 000 km^2 in area. Water does not move naturally from one of these basins to another, due to natural barriers. The Ministry of Water now has a different organisational structure, for better management. A water basin officer heads each basin.

Politically, there is a different route for reporting government issues. The water basin administration is represented at different levels. There is the Water Resources Division at the national level. Below, are the basin water boards, then the catchment water committees, districts being a subsection within the political administration. Then there are the water user associations (WUAs). These are put together for each basin, or sub-basin.

The responsibilities of the basin water officers are to monitor water availability, regulation of its use (with user collaboration), allocations and cost management, and lastly, pollution control and education.

Major users of water are identified as domestic, animals/wildlife/fisheries, agriculture, and hydroelectric power (HEP). When government talks generally on water issues, it prioritises values as firstly domestic, then HEP/agriculture, and then animal/wildlife (Serengetti, where any lack of water is perceived, wisely or otherwise, to be a part of the natural selection process, for survival). Politically, access to clean tap water by people is important, hence its priority.

Tanzania has an adequate fresh water availability that amounts to 2 300 m^3/capita/year, based on year 2002 estimates. By 2025, the availability is projected to be 1,500 m^3/capita/year. This decrease is attributable to climate change and rising demand through population growth. United Nations values indicate that 1 700 m^3/capita/year constitute a water stressed situation, and 1 000

m^3/capita/year as a water scarcity. This implies that Tanzania is predicted to face a water scarce situation by year 2025.

Over 70% of the national electricity is from hydropower. 97 MW comes from the Pangani Basin (~177 000 km^2), and 465 MW from the Rufiji Basin (~42 000 km^2). The total current developed potential, country-wide, is at about 560 MW. Although the national hydropower potential has been estimated at about 4500 MW, the current developed situation indicates lack of satisfactory water supply. Irrigation for agricultural activities competes with hydropower for the same water supply. However, the location of agricultural activities (a consumptive user of water) upstream from hydro-generating installations (non-consumptive water users) creates problems. Uganda talks of diminished hydropower output, due to water scarcity, and competition for its use. Natural distribution contributes to the problems (water is not always where you need it). Then, there are the problems with financial resources. We also have gradual deterioration in water quality, and watershed mismanagement, because the objectives of water authorities concentrate more on water quantity, rather than quality.

Major water sources are lakes (Victoria, Tanganyika, Nyassa, Rukwa, Natron, Eyasi, Manyara), and rivers (Kagera, Mara, Pangani, Ruvuma, Ruvu, Rufiji, Songwe). Groundwater is not extensive, and is generally disregarded in areas with abundant surface water, but it is important in the arid areas, where they are well prospected.

We have problems with water abstraction. Agriculture is regarded as consumptive abstraction, as it does not return water to the reserves, after using it (lost by evaporation and soak-away). Irrigated land is estimated as 224 865 ha. Of this, 76% are traditional smallholder irrigation schemes, which account for 90% of the water abstraction. Water use efficiency is given as 10 to 20%, due to a lack of skills in effective water use, but these numbers are under contention, and could be raised, as some schemes operate in tandem, the run-off of one scheme being the inflow of another. There is a projection of 405 000 ha of irrigation by year 2017. This is a massive target, in terms of water abstraction, and one asks what will the consequences might be?

There are problems in terms of water-quality parameters. These include colour and turbidity, high salinity (sea-infiltrated costal aquifers – we have a long coast-line), a naturally occurring fluoride content (up to 32 ppm; national acceptable limit is 4 ppm; this impacts on both agriculture, through contaminated crops, as well as through water potability), nutrient loads that create algal bloom problems in the larger water bodies, and other chemicals, some arising from mining, industries and agriculture. There is also the problem of microbial (pathogen) contamination of water.

Water mismanagement problems include improper (or non-existent) handling of industrial and municipal wastewater (on average, only 10% of urban dwellers are connected to managed sewer treatment systems) over abstraction/inefficient abstraction by consumptive users, and poor agricultural irrigation practices (traditional methods) in the basins. There is also the problem of exotic aquatic plant species invasion (e.g. water hyacinth in Lake Victoria – not seen there before 1980).

Management approaches now include a Rapid Water Resources Assessment (RWRA). This was started in 1994, focused on surface water resources, groundwater resources, information systems, irrigation, water quality and pollution, wetlands/coastal zone, fisheries, forestry, public health, and water law and institutions. Documented achievements have been the recommended priority interventions in four of the most stressed river basins, Pangani, Rufiji, Lake Victoria and Wami-Ruvu. Government later added the Internal (Central) Drainage Basin, I speculate, because of the political capital that was at stake.

A National Water Policy (NAWAPO) was adopted in 2002 and a new Water Act drafted, with new institutional structures that have been formulated at national, basin, catchment and local levels. There has been decentralisation of water supply management, decentralisation of multi-sectoral water resources management, and strengthening of river basin management.

The major aim is to have integrated water management, that embraces water sanitation and supply, irrigation and drainage, energy generation, environmental issues, and industrial and other uses.

Policy synopses include decentralisation of decision-making, this being in the hands of the basin administration. Resource management and regulatory functions have been separated (they unfortunately remain in the same ministry, and the "separation" may thus only be in words, and not in action), and the multi-sector has been integrated (again, there are also problems, especially with catchment forestry, having conflicting interests, including commercial issues, with water catchment management, as a whole).

Water resources utilisation should be maintained within sustainable limits. There should be control, to preserve safe yields of surface and groundwater, and assimilative capacities for discharge of pollutants. Water pricing should consider the scarcity value, and must include the issue of cost-sharing. The income from water-use levies and pollution discharge licences should be retained within the basins, and used to support the costs of managing the basin water resources.

Major problems with watershed mismanagement and water quality are linked to location. Six of the nine water basins are trans-boundary. These water resources require trans-boundary solutions, with internationally shared responsibilities. Lakes Victoria and Tanganyika are examples.

Then, there are the aforementioned problems with over-abstraction. Examples are increased irrigation in Rufiji basin. This was estimated at 100 ha in 1930, and 40 000 ha in 1999, for rice farming. This has created a water scarcity for hydro-electric power, and consequently, drastic power rationing in 1994, 2000 and 2006. As already said, the problem is worst when power generation is located downstream from agricultural activity.

The situation may be summarised as follows:

The two major users are agriculture and hydropower. Usage problems have been identified, and a policy has been drafted. Administration issues and hierarchy have been identified, and stakeholder's involvement has been considered. Conflicts of interest, however, still remain.

Major causes of management problems include divergent interests, such as with the agriculture sector, domestic water suppliers and hydropower; conflicting resource values in the water, such as with the Nile perch fishery industry in Lake Victoria; the need for involvement of different management sectors, such as the SADC Protocol (regional water policy), a protocol for sustainable Lake Victoria Development, management of Lake Nyasa, and NELSAP (Nile Equatorial Lakes Subsidiary Action Program).

DISCUSSION

Question: The Pangani basin and hydroelectric power generation – I understand that since commissioning, it has never been able to operate at full capacity?

Reply: Again, I believe this to be a transboundary problem, as this is partly influenced by water sources from Kenya. It is often difficult to access the reality of situations, and one then relies on hearsay. Some blame the problem on wrong technology. Upstream interests in agriculture and fisheries have also been alleged to have impacted on water supply, and water quality. Compounded by political issues, it is often difficult to get the real picture.

Water Resources in Zambia

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Zambia is a landlocked country, between latitudes 8 and 18 degrees south, and longitudes 22 and 34 degrees east. It shares its boundary with eight countries, and covers a total land area of about 753, 000 km^2. In terms of demography, total population is about 10 757 000, of which 65% is rural, 35% is urban, about half of which are peri-urban.

75% of Zambia's population is engaged in agriculture. Mining is a major industry. Government is now promoting diversification, with respect to agriculture and tourism.

Zambia, with annual surface run-off of 135mm/year, has abundant water resources. The country is drained by two main river systems. The first is the Zambezi and its Kafue and Luangwa tributaries, all flowing to the Indian Ocean. The second is the Chambeshi/Luapula River System, which joins the great Congo River, flowing to Atlantic Ocean.

The current state of our water resources is as follows. There is a total availability of 144 000 Mm^3/year (Mm^3 = millions of cubic metres). Of this, 57 500 Mm^3/year is ground water, and 86 500 Mm^3/year is surface water in streams, rivers, lakes, dams, reservoirs, including swamps and wetlands. Average rainfall in 1138 mm/year.

The country has a number of lakes and wetlands, which regulate the natural flows of rivers. Notable wetlands are the Barotse, Kafue and Bangweulu Plains. Lakes include Mweru, Tanganyika, Bangweulu and Kariba.

Water uses are agricultural (irrigation, livestock, fish-farming), domestic, mining and industry, water transport, and hydropower, last-named needing large volumes of water.

The current national water demand for domestic, irrigation, livestock and industrial uses could be satisfied, leaving a large balance for sustaining environmental and other future needs. Nevertheless, seasonal and spatial variations of water across the country have resulted in deficits in some areas, especially in southern Zambia. Competition for water will increase, and may lead to conflicts in water use, as the country continues to develop economically.

Responsibility of water resources management and development is vested in the Department of Water Affairs (DWA). The Water Board of Zambia (WB) regulates water resources allocation through administration of the Water Act of 1949. Both the DWA and WB are located in the Ministry of Energy and Water Development (MEWD).

There is the National Water Supply and Sanitation Council (NWASCO), which regulate the provision of water supply and sanitation services by utility companies. There is the Environmental Council of Zambia (ECZ), a lead organ for all environmental issues, including any water-related issues. The Forestry Department protects river banks against indiscriminate cutting of trees and cultivation, to preserve the riverine environment. The Mines Safety Department is responsible for control of mine operations, to militate against environmental degradation, and to protect water resources against pollution from mining activities.

There is the Energy Regulation Board that controls transportation and storage of petroleum products, and the location of storage facilities, to ensure protection of surface and groundwater resources from contamination. The Ministry of Health ensures that health and hygiene standards are maintained in the provision of water and sanitation services, in order to prevent outbreaks of diseases and environmental degradation.

The National Institute for Scientific and Industrial Research (NISIR), the largest research institution in Zambia, has been a major player in management of Zambia's water resources, through its various activities, including quality monitoring in the different river basins. NISIR's first environmental monitoring activities led to passing of the Environmental Protection and Pollution Control Act (EPPCA) of 1990, and the creation of the Environmental Council of Zambia. NISIR's activities in hydrological monitoring in the high-rainfall Luano Catchment have created the basis for Zambia's water resources management.

There are many challenges with respect to water resources management. The current Water Act was enacted in 1949, and has not been revised adequately to meet current needs. The Act, in its present form, does not control groundwater development (anyone can drill a borehole without permission, and are doing so in large numbers, to pre-empt any regulatory control on this activity, in future). It does not regulate activities on international (inland) waters. It is difficult to administer water rights on affected rivers and lakes, due to these insufficiencies.

There is a lack of permanent and formalised collaborative and cooperative mechanisms, to coordinate activities in the sector. This has been partly due to gaps in the relevant legislation. The consequence has been duplication of efforts and wrong prioritisation of projects.

The water sector lacks qualified human resources. Many specialised positions in government ministries and departments dealing in water affairs remain vacant. Other contributing factors have been unattractive conditions of service, and long procedures in recruitment of staff in the civil service. The scourge of HIV/AIDS has compounded the problem.

There is the problem of inadequate and delayed release of funds. This results in a lack of capital investment in the sector. The hydrological network has been reduced over years, from 250 hydrometric stations in 1986, to less than 100 by 2003, due to low priority accorded to water resources assessment by national planning and funding authorities. Data and information records are scattered between different institutions, and need to be processed in order to present useful findings for end-users.

Water reforms were commissioned in 1993 to deal with problems of the water sector in Zambia. Government began by formulation of the National Water Policy, which was adopted in 1994. A Water Supply and Sanitation Bill was enacted in 1997. Government has focussed on the reform of water resources management and development since the year 2001.

A Water Resources Action Programme has been established, and began work in 2001, to spearhead a reform of water resources management and development. A draft Water Resources Management (WRM) Bill has been under review since 2003, involving wide consultation with stakeholders. This bill will establish a new institution, the National Water Resources Management Authority (NWRMA). This authority will provide for the establishment and management of catchment and sub-catchment councils, and will recognise water users associations. It will provide for management, development, conservation, protection and preservation of water resources and associated ecosystems. It will also provide for international cooperation (currently non-existent), equitable and sustainable utilisation of shared water resources, and provide for implementation of various treaties, conventions and agreements that relate to environment, to which Zambia is a signatory. The Water Resources Action Programme, a bill, that was to have been enacted by the beginning of 2006, is still not a reality. (We have no cabinet, at present, because of impending elections). This Act will create the necessary legal, institutional and financial framework for appropriate water resources management and development in Zambia. When enacted, the NWRMA will take over existing management functions from the Water Board and Department

of Water Affairs. Additional management functions will have to be developed and supported both by new regulations, guidelines and standards, and by improved data on water use, water demands and water availability.

General conclusions are that we need to strengthen institutional capacities in water resources management in Zambia. This cannot be overemphasised. This is also relevant, considering the dilapidated state of hydrometeorological networks and quality monitoring systems.

DISCUSSION

Question (Karrar): Where does the money come from, in terms of institutional arrangements? Who plays the regulatory role?

Reply: The regulator will be the one that has yet to be enacted. Control is over surface, but not ground water. Both need to be controlled, however.

Comment (Pietersen): What I then understand is that you are splitting policy regulations?

Question (Tungaraza): Referring to the he bill, to be submitted for groundwater, do you intend to do groundwater mapping?

Reply: The new authority will have this responsibility, and borehole-drilling applications will be required through this institution. People are currently abusing the open window, prior to the legislation being enforced, and avoiding the fees that will later become due.

Integrated Water Resources Management in South Africa

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South Africa is a water-scarce country. Rainfall is spatially and temporally variable. Average rainfall is about 450 mm/year, less than half that of the world average of 860 mm/year. The combined flow of all rivers in the country amounts to 49 200 million m^3 per year, which is less than half the flow in the Zambezi. 78% of our population is black. 95% of this group have been classed as poor, and 25% are illiterate. There is inequitable access to water resources. Groundwater has a pivotal role, especially with rural water supplies. Only about 20% of groundwater occurs in major aquifer systems that are exploitable on a large-scale. This is due to the prevalence of a hard rock geology.

National Water Resource Strategy estimates of the still-undeveloped resource potential show that the yield from surface water can be increased by about 5 600 million m^3 per year. There is room for the necessary infrastructure. In addition, substantial quantities can be made available through the increased re-use of return flows, with specific potential at some coastal cities, where wastewater is currently discharged to the sea. Potential also exists for further groundwater development, although on a smaller scale. Desalination of seawater offers particular opportunities for coastal users. Although currently uneconomical, the trend is that desalination will become more competitive, through continued advances in technology. It could be that the application of importation and other unconventional options (e.g. iceberg importation and cloud seeding) may become economically competitive in the near future.

Where does the management of water resources arise? We consider the South African Constitution, and the Bill of Rights. Everyone has the right to have access to sufficient food and (raw) water (the issue of water potability is not raised). Everyone has the right to an environment that will not harm his or her health, or well-being. The environment must be preserved, for the benefit of present and future generations (a sustainability endorsement). Chapter 3 in the Constitution deals with cooperative government. The foreign speakers at today's meeting have addressed the problem of fragmented management. We have cooperation as an endorsement, but I confess that there is still a gap between principle and practice.

The central principles in the National Water Act, 1998 (NWA) are equity, efficiency, sustainability and representivity (Principle 7). The purposes are to meet basic human needs of present and future generations, to promote equitable access to water, to redress the results of past racial and gender discrimination, and to facilitate social and economic development. Key provisions of the NWA are that water is an indivisible national asset. National Government is the custodian of water resources, and exercises its powers, as a public trustee. Water should meet basic human needs, and should maintain environmental sustainability, guaranteed as a right. This (minimum balance of exploitable water) is called the "Reserve". Water resource management is decentralised to regional and local institutions.

The new IWRM parameters are listed as water resource protection (the Reserve), water pricing, water resource planning, and the water management institutions.

We address the issue of water resources protection. The aim of protecting water resources is to ensure their continuing availability for human use, by leaving enough water of appropriate quality in rivers and streams to maintain their ecological viability. There are two complementary approaches.

Resource-Directed Measures (RDM) focuses on the quality and the overall health of water resources. Resource quality includes water quantity and water quality, the character and condition of in-stream and riparian habitats, and the characteristics, condition and distribution of the aquatic biota. RDM measures include the following elements. Development of a National Classification System; determination of the class of specific water resources; establishment of resource quality objectives, and determination of the Reserve, for each significant water resource, in accordance with the class of that resource.

Source-directed controls are primarily designed to control water use activities at the point of impact, through tools such as standards and compliance conditions for water use authorisations.

The NWA provides for three types of water-use charges. The first is for funding water resource management: activities such as information gathering, monitoring and controlling water resources and their use, water resource protection (including waste discharge levies, and the protection of the Reserve), and water conservation. The second is for funding water resource development and use of waterworks: the costs of investigation, planning, design, construction, operation and maintenance of waterworks, pre-financing of development, a return on assets, and the costs of water distribution. These involve financial charges that relate to the costs of managing water resources and supply of water from schemes and systems. The third is achieving equitable and effective allocation of water: economic incentives to encourage more efficient use of water, water conservation, and a shift from lower to higher-value use. This is an economic charge, related to the value of water to particular users, and could include subsidies and support for people such as emerging farmers.

Water resource planning (a national strategy) has the following objectives. Firstly, it aims to establish a national framework for managing water resources. The NWRS is legally binding. It is intended to be an enduring description of the ways in which water resources shall be managed. Secondly, it establishes the framework for the preparation of catchment management strategies. Thirdly, it provides information – The Act requires that the Minister ensures that all aspects of water resources management, which will affect other Organs of State, water users, and the public in general, are brought to their attention. Lastly, it should identify development opportunities and constraints. The NWRS also identifies areas of the country in which limited water resources are a constraint on development, as well as areas in which water resources are available, to support social and economic development initiatives. This strategy will be revised every five years, in terms of the law.

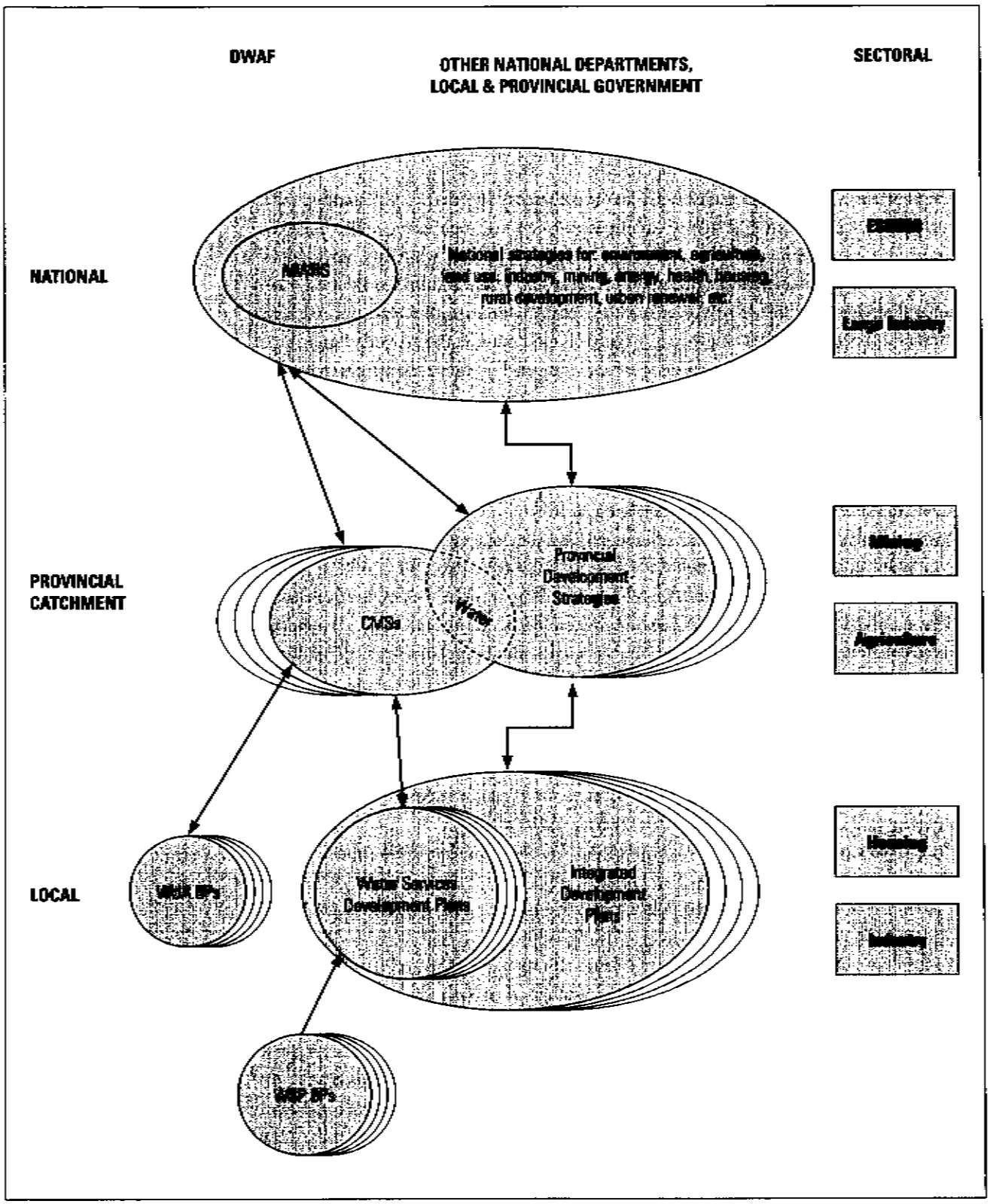
Figure 1 illustrates the DWAF structure, with the three management levels, labelled at the left-hand side.

Arrows denote routes of interaction. Much has yet to become reality, with the catchment management strategies not yet all in place.

We turn our attention to the water management institutions. On the first tier, there is the Ministry of Water Affairs and Forestry, with its Department, with the overall responsibility for effective water resource management. Responsibilities include strategic and national planning (mega-projects, such as hydropower). At the second tier is the Catchment Management Agency, with a catchment (basin) management strategy. There are 19 of these areas, each with its own governance agency, representative of the parties that are involved. The third tier consists of the water user associations (WUA), concerned with local-level water related activities. They are localised, and are active only when needed. Much needs to be learned from experience, as these plans evolve in practice.

We have the international water management institutions. Four of South Africa's main rivers are shared with other countries; Limpopo, Inkomati, Pongola (Maputo) and the Orange (Senqu) Rivers. Together, they drain 60% of South Africa's land area and contribute to about 40% of its total surface runoff (river flow). About 70% of the GDP, and a similar percentage of the population, are supported by these rivers, making judicious and responsible

Figure 1: The DWAF structure, with the three management levels



joint management of paramount importance to South Africa and the region, as a whole. We have water-sharing agreements with neighbouring coutries, these being Lesotho and Namibia (Orange-Senqu System), Botswana, Zimbabwe, and Moçambique (Limpopo River), Moçambique and Swaziland (Incomati System, s well as the Usutu-Pongola-Maputo System. There will be joint basin studies, to be finallised by year 2010. Once this is done, then transparency and trust is possible.

DISCUSSION

Comment (Kfir): Could you explain the link to the Water Service Act, and how the provision of water services link to the catchment plan.

Reply: These planning instruments include the Water Services Act (1997). The National Water Act was passed in 1998. The Water Services Act states that local municipalities are responsible for water supply and sanitation. They follow administrative boundaries, and we have the catchment management agencies that follow the hydrological boundaries. The catchment plan strategists need to interact with the water services development planners of local government; local government has to buy into the concept of local management institutions. There should be no dictatorial hierarchy.

Comment (Kfir): DWAF is a huge department, employing thousands. They had developer, managerial, and operational roles. The department will now devolve into the catchment management agencies, local government, etc. So operation will no longer be the responsibility of DWAF, except at the high level of water planning. They will have a strong policy and regulatory role. There is the Deputy Director General for regions, to assist them to move out of DWAF, at the operational level. It has not been easy. It impacts on the implementation of the Catchment Management Agency.

Reply: I overlooked mention of the other important institutions. We have eight regional offices of the DWAF; we will have 19 Catchment Management Agencies, we have the Catchment Management Fora (non-statutory, and localised), the Water Tribunal for disputes, the Water Research Commission (WRC), which is part of the chain. There is the Water Caucus, a civil society platform, and the National Water Advisory Council, not necessarily linked to the National Water Act.

Question: Considering water a right, and you have a significantly poor population, how do you assure that right? What policing mechanism do you have to collect fees from water users?

Reply: The Constitution refers to "raw" (untreated water) to the extent of 25 litres per person per day, within 200 metres. A citizen could sue the Minister, if they do not have this access.

Kfir: There is global debate on this matter. We provide free basic water (6 kl/household/month). Water pricing is scaled; more use means higher rate. The rich pay for the poor. Payment is not the problem, it is the lack of access thereto, in many cases. There are seven million without water supply, and 14 million without sanitation, especially with informal (unplanned) settlements in peri-urban areas, and the rural areas. Forestry is considered to be a flow-reduction activity (consumptive user). The problem is the same with sugar-cane plantations. This water does not return to the river, after use. Commercial foresters pay water levies, because of this.

Question(Dia): Do you have links with mining courts and water policy enforcement?

Reply: There is enforcement, and they have to comply. There is a licence for any type of use, and it will have conditions (such as an effluent specification) that must be met. Non-compliance attracts penalties. The waste-discharge payment system will internalise impacts, by encouraging cleaner technology, or they pay a price-equivalent, so that the

water resource manager receives the money to clean up. It is the regulator and the user that interact, with little other formal structure.

Dia: In Sengal, we have specific taxes on mining companies.

Pietersen: South Africa has similar systems. Industry has to provide guaranteed funds (trust, or whatever) for costs incurred during closure and site rehabilitation at the end of the economic life of the relevant activity. They pay for water received, and for their discharged effluent, as well.

SESSION 3

Water Research in Africa

Chairperson: Eiman Karar

Water Research in South Africa

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This presentation deals with an overview of the water research challenges that are at issue.

Our climate is characterised by high potential evaporation, and low average rainfall, as well as high variability in space and time. There are unpredictable impacts, with respect to climate variability and change. Groundwater resources are associated mainly with fractured rock aquifers, which are complex, and difficult to exploit. We require a knowledge base that needs to grow substantially, to permit effective implementation of water policy and legislation. Our demographics change constantly, as a result of population growth, rapid urbanisation and the impact of HIV/AIDS. There is rural and peri-urban poverty. There is an outstanding under-provision of basic water supply and sanitation to many rural communities, a shortage of skills and competencies among many water service authorities and providers, and a non-equitable access to water, as a production factor, arising from policies of the past. There is a sub-optimal efficiency and effectiveness in the productive use of water, and a high potential for degradation of water ecosystems and water quality, as a result of industrial and agricultural development, mining, and the rapid as well as uncoordinated settlement of peri-urban areas. There are health risks to humans and animals, arising from water contamination by both natural and anthropogenic hazardous constituents and pollutants.

The importance of water research and development can be encapsulated in the following statement. Water-centred knowledge forms a basis for the appropriate management of South Africa's water resources, and related water supply and sanitation services.

The structures and institutions that promote research in South Africa are the Water Research Commission (WRC), the Department of Water Affairs and Forestry (DWAF), and the Department of Science and Technology (DST). Other supporters of water research are the Science Councils, these being the Council for Scientific and Industrial Research (CSIR), the Agricultural Research Council (ARC), the Council for Geoscience, the Human Sciences Research Council (HSRC) and the Medical Research Council (MRC). The National Research Foundation (NRF) provides research-funding support to tertiary educational institutions, for the purpose of student training and capacity building. The NRF may also provide funding over a broader front (through structures, such as THRIP, and the Innovation Fund) for research projects that relate to national priority areas. There are the Water and Waste Utilities, such as Rand Water, Umgeni Water and ERWAT, and some of the industries, such as mining, power generation, petrochemical, textile, as well as commodity-based agriculture, that may fund research that is related to their own areas of concern. Omitted from the listing on the screen are the universities, who are the most significant executors of research.

The main organisation that funds water research in South Africa is the Water Research Commission (WRC), supporting approximately 50% to 60% of water-related research in South Africa. An Act of Parliament, the Water Research Act, established the WRC in 1971. The WRC does not undertake research, itself, but funds research, under contract, in compliance with an

early policy decision that the WRC should not duplicate effort and infrastructure through doing its own research. The mandate of the WRC is to promote co-ordination, co-operation and communication in the area of water research and development; to establish water research needs and priorities; to stimulate and fund water research, according to priority; to promote effective transfer of information and technology; and to enhance knowledge, and capacity building, within the water sector.

The Act covers a Water Research fund. There is a levy to fund research. As from 1 July 2006, it is 331 cents per hectare, where water-use is permissible under the control of an irrigation board, or other water management institution. It is 3.22 cents per cubic metre of metered water, supplied for purposes other than land irrigation (includes bulk supply for urban, industrial or domestic use). The WRC does not receive a parliamentary grant.

The strategic areas in the WRC research portfolio are water resource management, water-linked ecosystems, water use and waste management, agricultural use of water, and water-centred knowledge.

Water key strategic areas (KSAs) are identified as follows:

Water Use and Waste Management includes water services, water supply and treatment technologies, wastewater and effluent treatment and reuse technologies, industrial and mine-water management, sanitation, health and hygiene education. Water Utilisation in Agriculture includes food and fibre production, fuelwood and timber production, poverty reduction and wealth creation, resource protection and reclamation. Water resource management includes water resource assessment and development, impacts on water resources, water resource protection, and policy and institutional arrangements. Water-linked ecosystems include ecosystem processes, ecosystem management and utilisation, and ecosystem rehabilitation.

Research funds have been allocated in the following split, as given the last Annual Report. There is an equal split between the use and resource KSAs. Water resource management at 37% was the largest, water use and waste management was 31%, water-linked ecosystems at 17%, and agricultural water use was at 15%.

The Core Business Process of Funding follows the following steps. Sourcing of funds, WRC corporate business plan (guides regarding funding stream and percentage allocation per stream), WRC/KSA business plan (strategic allocation of funds per KSA, allocation of funds per thrust, and initial research portfolio), call for proposals (solicited and non-solicited), selection, contracting, fund management, knowledge dissemination/application, finalisation of research, and output/impact assessment.

We had a total number of 336 projects on our records during the year 2005-2006. Of these, 245 were active, 70 were new, 91 were completed, and there were 74 solicited active projects.

The WRC hold 32 clusters of patents. They are undergoing current licensing and commercialisation. The list includes PETRO™ (cluster of 8 patents), the Rhodes BioSURE™ (cluster of 36 patents), CUF Technology (cluster of 5 patents), secondary metabolites (cluster of 13 patents), acid mine drainage (ferrite process), and membrane fouling detection.

WRC products include technical/research reports, technology transfer documents, computer software, other types of publications and periodicals, including Water Wheel, Water SA, our Annual Report, and Knowledge Review.

In conclusion, our aims are to address knowledge gaps, which are determined through needs analyses. This involves participant stakeholders. We collate components, and determine the life cycle of the research issue (existing research, workshops and focal interviews etc.). We structure the research, so as to be strategic (pursuit of new knowledge that has prospects of implementation) and practical (conversion of existing knowledge into appropriate products/processes). We measure research quality and performance (including impact and effectiveness of the research). Finally, we promote institutional and individual capacity, to develop new knowledge-bases and institutions (including tools and methods) to implement IWRM.

DISCUSSION

Question (Tungaraza): How is water research coordinated? Is it a separate department in the ministry that deals with water? You say that most of the researchers are from academia?

Reply: You refer to the WRC? We are autonomous, and separate. We report through a board to the Minister of Water Affairs and Forestry.

Kfir: There are parastatal structures, public entities, and WRC is one, having to remain compliant with the responsibilities of a public entity. We get income from levies, but also occasionally from other government departments, occasionally from donors. We manage this money and coordinate research. We provide consultation throughout the sector, to identify needs, and generate a portfolio. Management is through funding allocation. We do not make decisions alone. We have to assess capacity for research. We had many who claimed expertise in wastewater treatment, but few that claimed to be sanitation experts. We had to foster a process in building expertise in sanitation at selected universities. Money has been spent in the past in agriculture on large-scale commercial farming. Solicited research has recently focused on subsistence farming, showing a shift in research priorities through perceived needs.

Water Research in Zambia

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I will give a historical background to water research in Zambia. After independence in 1964 the government realised that the planning and management of the nation's water potential required both basic and applied research. This was after realisation that conservation and use of water was of vital importance to any nation's agricultural and industrial development.

The Government therefore initiated the formation of a Water Resources Research Unit in 1970, within the domain of the National Institute for Industrial and Scientific Research.

The National Institute for Scientific and Industrial Research (NISIR) is the largest R&D institution in Zambia. It has many constituent units and centres. The Unit has been a major player in water resources management, through various research activities, such as quality monitoring in various river basins.

Research work in the Water Resources Research Unit is organised into three main areas. There is a water resources inventory, representative catchment studies, and environmental studies.

The water resources inventory (involving hydrogeologists and geologists) has a main objective of evaluation of existing water resources in terms of quantity and quality. This inventory of water resources is being carried out, using a basin-by-basin approach. Studies have thus far been done on the Chambeshi, Luangwa, Zambezi, and Kafue Basins. The environmental studies involve chemists, environmental scientists, and biologists.

Of the four basins, the Kafue has been the most studied by NISIR. The basin accommodates about 33% of the total population of Zambia, and is the most industrialised area (including mining, especially copper). It has the best communication facilities in the country. The basin has an area of about 154 000km^2 and comprises 20% of the total area of Zambia. Comprehensive data on this basin, with respect to both water quality and quantity exist.

The main objectives of the Representative Catchments Studies are to develop methods for qualitative estimates of water balance of drainage basins that are representative of the headwaters of Zambia, typified by high rainfall conditions. We need to evaluate changes in hydrological behaviour, consequent upon clearing of trees and settling of small-scale farmers, who are engaged in beef cattle rearing, together with subsistence agriculture. Catchments under study are well instrumented for measuring hydrological parameters, such as rainfall, runoff, groundwater levels and other meteorological parameters, such as temperature, humidity, sunshine, wind characteristics and pan evaporation.

The main objectives of the Environmental Studies are to evaluate the present status of pollution of water environment in the country, to carry out research on low cost wastewater treatment systems, to introduce new chemical, microbiological and hydrobiological methods in environmental monitoring, and to assess biological productivity of inland waters.

Environmental studies have shown that mining has had a large impact on the water quality of the Kafue River. Previously, there had been minimal control of effluent discharge, in terms of quantity and quality. Studies have indicated that water quality is worse at the downstream side, compared

with the upstream side of the river. Discharged mine effluents often contain high levels of copper and cobalt, these being the main components that are mined. Large suspended solid content, discharged by mines, has made some parts of the river almost disappear, through siltation.

Other players involved in water research are the University of Zambia, the Copperbelt University, the Department of Water Affairs, and the Environmental Council of Zambia. Work is often on a contract-funded basis. Research areas include pollution from industrial activities, especially mining; impact from disposal of liquid and solid waste; impact of unplanned settlements; and the impact of climate change and variability on water resources. The southern part of Zambia receives low rainfall, compared with the northern parts. The opposite happened during the last rainy season, demonstrating climate variability.

We have a problem of groundwater pollution in Lusaka, our capital. Mines were privatised after Kaunda ended his presidency. Most of these mines consequently closed down. Unemployed people then moved to the city, creating unplanned settlements. The provision of adequate water supply and sanitation to a rapidly growing population is an increasing problem in Lusaka. Over 55% of piped water for Lusaka is supplied by groundwater. The percentage of population depending on groundwater (pipe reticulation, and wells) is estimated to be over 80%. There has been an increase in number of potential sources of pollution, such as pit latrines, septic tanks, cemeteries, and unmanaged waste disposal sites. Unserviced new suburbs add to the problem. The groundwater table is close to the surface, and vulnerable to pollution. About 25% of the city's two million people are serviced by a sewer system. 20% are serviced by septic tanks. 55% rely on pit latrines in high-density unplanned townships, and also on shallow wells and boreholes for water, often located only a few metres from pit latrines.

Lusaka population has increased from 200 000 at independence, to about 2 million today. The national population has not increased as much as Lusaka's population. A study in 1978 revealed both biological and chemical pollution of water. It also showed that both biological and chemical content varied with season, and borehole locality. Exceptionally high values were recorded during rain season, and in areas reliant on pit latrines and septic tanks. Bacteriological analyses revealed a presence of coliforms in groundwater in the high-density residential areas.

The use of pit latrines in affected areas was identified as being responsible for bacteriological contamination, and high nitrate and sulphate levels, as well as high COD and BOD.

Groundwater research studies are being conducted under a project involving the use of isotope techniques for sustainable development and management of groundwater resources in Lusaka. The International Atomic Energy Agency is supporting this work. The objective has been to assess groundwater resources of Lusaka, with a view to developing sustainable groundwater management systems. There is need to identify potential pollution sources, and determine extent of groundwater pollution, to determine source, timing and magnitude of groundwater recharge rates and groundwater flow direction, and to determine the types, properties and behaviour of aquifers. Participating institutions have been the NISIR, the University of Zambia, the Department of Water Affairs, the Lusaka Water and Sewerage Company, the Environmental Council of Zambia, the Lusaka City Council, and the Ministry of Health.

A map indicates the borehole sampling points in Lusaka. Parameters under study include numerous chemical (including cation and anion assays) and bacteriological measurements, as well as isotope content such as tritium and oxygen-18. Isotope analyses are not yet complete. Data for the other analyses are presented. Total and faecal coliforms are abundant in the water drawn by the municipal supplier. This is only a recent trend, and arises from a township that has appeared nearby. Wells are also contaminated, way above acceptable limits, and people drink from them. Wells and pit latrines are next to one another.

The increase in human activities, associated with rapid urbanisation and poor planning in Lusaka, has made the aquifer a pollutant receptacle. Initiation of continuous water-quality monitoring can assist as an early-warning system with regard to threatening outbreaks of disease.

DISCUSSION

Question (Kfir): Is there a general assumption that ground water is fit to drink? Coliforms are easily destroyed with chlorine (at the user point).

Reply: The reticulated water is indeed treated by the supply company. The problem lies with the informal settlements, where they draw water from wells. They drink it as it is. Political issues compound decisions that have to be taken. People suffer from diseases associated with this problem, but do not realise the reason for their illness.

Comment (Kfir): The solution lies in hygiene education. When we have cholera epidemics, we supply the population with hypochlorite solution, to sanitise their drinking water, before use.... one teaspoonful to a bottle of water.

Comment (Tungaraza): I am aware of the use of antiseptics, even in Lusaka, for faecal coliform contamination. Water suppliers concentrate on bacterial problems, but often neglect the chemical issues, which may be significant.

Question (Karar): The research foundation; where does the funding come from? Do you have to identify and prioritise the research needs? Do you fulfil this mandate, or is it a constraint?

Reply: We are semi-autonomous, funded by government, but we get support from donors, like the International Atomic Energy Agency.

Kfir: What proportion of the research is done by your institution, in relation to that undertaken by the universities, and others?

Reply: We mostly do it. It is our mandate.

Water Research in Tanzania

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Research has been done in the past on an *ad hoc* basis, addressing problems at hand. Once done, attention then moves to another area. The ministry responsible for water owns a so-called Water Institute, intended for training technical personnel and doing research under the Ministry of Water, but in practice, the institute has been training technicians for various analytical duties under the Ministry. Most ministries have been structured with research departments. However, water has been moved from one ministry to another, a number of times, and now it stands alone, yet to establish its own research department. The available government document currently identifies nine challenges. These include sustainable financing of water resources, in terms of adequate funding for enforcement, abstraction monitoring, and human resources. Also, there is the need for effective water management institutions, and adequate legal, scientific and administrative skills for implementing the new water resources framework. There is a need for properly coordinated management; different sector agencies still use sectoral mandates and priorities, and this is historical, where forestry had their own act, dealing with natural resources, while fisheries used their own act, and land had their own act. With the new policy in year 2002, intention has been that all water-related issues would fall under the Water Policy. Departments nevertheless still act independently. There should be adequate technical and administrative capacity. Currently, there are ineffective water resources assessments, inefficient water allocation, inadequate enforcement, and insufficient water pollution control. There is a need for adequate and reliable infrastructure. Currently there is no development of new water sources, be they surface, groundwater, or inter-basin transfers. There is a need for authoritative water allocation procedures. Currently, we have over-licensing of abstractions at locations like Pangani and Rufiji, which have consequently become stressed, and they are important, both for agriculture and hydropower.

We need to address the problem of polluted water resources. Currently, water quality and pollution monitoring activities are inadequately funded. There is no effective enforcement and water pollution control. There is a need for effective trans-boundary water management. Six basins are trans-boundary in character. Poorer-skilled staff have to deal with aspects of lake and catchment management. There is thus a need for comprehensive knowledge of the available water resources. We have poor networks for data gathering. Groundwater monitoring is only carried out in a few selected areas. Water sampling and analysis programmes suffer from inadequate funding and inadequate analytical skills. Most of these problems require research. It is a problem of commitment to policy implementation.

The following are the major water problems. The water level of Lake Victoria is receding. There are problems with chemical pollution control and wastewater management. Only about 10% of the urban populations have access to sewerage facilities in Tanzania. There is a data-collection and access problem, with insufficient information of acceptable reliability.

The task for the government is to have a data-gathering network, involving other countries. This should include Rwanda, Burundi Kenya, Uganda, DRC, Zambia, Malawi & Moçambique, and

we wish to include other countries in the Nile Basin. There is shared water in these interboundary basins. There is a need for collaborative research and sharing of resources, such as laboratory skills and equipment.

Some achievements have been realised, mainly with respect to ecological studies that have been undertaken on the three lakes, Tanganyika, Victoria, and Nyasa. We have sociological studies on conflict resolutions, with respect to river waters and water users. There is knowledge dissemination on rainwater harvesting. Research underway involves recent ecological changes of Lake Victoria, and this has attracted various donor-driven research initiatives, namely VicRes (inter-university Council of East Africa), and LVEMP (Lake Victoria Environmental Management Programme).

How do we close the gap? We seek new avenues on land-use management in the water basins, atmospheric nutrient deposition (significant in Lake Tanganyika and Victoria), agrochemical/pesticide pollution problems from agricultural activities (and the practice of "poison fishing" in the Lakes, in competition with the commercial fisheries), and management of mining residues. Mines are processing vanadium, cobalt, gold, and there is mercury waste discharges from small-scale gold processors. The problems have political connotations that complicate their solution. Groundwater monitoring systems are also needed, especially with respect to limits of extractability, and recharge rate. What are the minimum-maximum limits to water withdrawal? One has to protect water capture zones against contamination. We lack piezometric systems that are required to monitor the relevant parameters.

There is no demarcation of activities, especially between consumptive and non-consumptive water usage, or polluting and non polluting activities. There is minimal collaboration between institutions, within and outside the country, for better use of specialised needs, such as laboratories, equipment, and staff. There are problems of interests, viz water quantity versus quality. Bodies that can provide support are the universities and research institutions, the water authorities, and the policy makers. They could form an organisation for central coordination.

Climate Change and Water Resources

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The Ministry of Water and Irrigation has been rolling out the operational functions under the new Water Act, 2002. The Ministry has remained as a policy division. The rest of its structure has been moved to other parastatal entities. This covers resource management, water distribution, and others. There has not been any research, *per se*, within this government structure, except for prospecting for new groundwater resources, as well as characterising existing resources in a more precise way, with view to improvement in supply. We have several institutes engaged in various research programmes. We have the Kenya Water Institute, but this devoted to technical training, as we have heard is the case Tanzania, and is without a research component. We have the Kenyan Marine and Fisheries Research Institute, vested with the responsibility of the inland waters, but the bias is towards marine resources, with most of the staff being biologists. Few employees are trained specifically in the area of water, namely hydrology, waste-water management, water and sanitation. Summarised, the government still does not really have a research programme. It only addresses immediate needs of supply and demand.

Africa's environment is closely linked with its climate. The African continent, one of the most vulnerable regions to climate change, is subject to frequent droughts and famine. The livelihoods of most Africans are largely dependent on utilisation of land-based resources, as well as on freshwater lacustrine and riverine systems as sources of potable water, fish, and transport. People are classed as vulnerable communities. Global warming is expected to bring higher temperatures, estimated to be between 0.2 and 0.5°C per decade in Africa. Climate studies, and modelling experiments, indicate that the anthropogenically-driven rise in global temperatures, and land-use changes, may affect climatic, hydrological and environmental parameters in an adverse manner. These are the two key research areas within the country.

The effect of global warming may well have threat and impact on our water resources. Associated therewith is the impact on these resources by humans. We can anticipate drastic declines in available water for consumptive use. Climate studies and modelling experiments indicate that global mean surface temperature is projected to increase between 1.5°C (2.7°F) and 5.8°C (10.8°F) by year 2100. This will affect the hydrological cycle. The plots shown show the gradual increase, especially since the 1980s, across all seasons. Climate change scenarios for Africa indicate future warming across the continent ranging from 0.2°C (0.36°F) per decade (low scenario) to more than 0.5°C (0.9°F) per decade (high scenario). This warming will be greatest over the interior of semi-arid margins of the Sahara and central southern Africa.

If we examine the modelling experiments, running through to year 2100, observed annual rainfall anomalies indicate that increases in precipitation are possible in east Africa, contrasted with a reduced precipitation in southern Africa during the next 100 years. Even if these projections really reflect future trends in the water that may be available, we have issue with the intensity of rainfall events that may occur, their frequency and time-spacing, and the impact that this would have on activities, such as agriculture. The major effects of climate change on African water systems

will be through changes in the hydrological cycle, the balance of temperature, and rainfall (IPCC 2001).

Non-climatic changes such as water policy and management practice may have significant effects. The Water Act may control excesses, and help to mitigate trends, through regulation and enforcement.

Many African countries, including Kenya (560 m^3/capita/year), experience current water stress, and it is projected that many more will shift from a water surplus status to a water scarce status by 2025, due to changes in population alone (IPCC 2001).

Some of the basic problems with water, as a resource in Africa, include a very high potential evaporation, which occurs throughout the year, and is in excess of 2000 mm/year over large tracts; very high aridity indices; generally low diversion of rainfall to runoff; an often very-concentrated seasonality of rainfall, and hence, of consequent runoff. We also have a strong response to the ENSO signal, and thus a generally high inter-annual coefficient of variability of rainfall. We have an amplification of the inter-annual coefficient of variability of rainfall by the hydrological cycle (Schulze 2001). Other problems that affect the quantity, quality and availability of freshwater include increasing population pressure (high population growth) and pollution of water resources, land use that leads to enhanced erosion/siltation, and possible ecological consequences of land-use change on the hydrological cycle.

We come to the so-named water towers. In Kenya, they are Mount Kenya and Kilimanjaro. All the major rivers in the world have their headwaters in mountains. More than half of humanity relies on the fresh water that accumulates in mountains – for drinking, domestic use, irrigation, hydropower, industry and transportation. Mountain areas constitute a relatively small proportion of river basins, yet they provide the greater part of the river flows, downstream. These "water towers" are crucial to the welfare of humankind. The potential for conflict over the use of mountain water grows, as demand increases. Careful management of mountain water resources must therefore become a global priority, in a world that is moving towards a water crisis.

Water towers have the following functions and issues associated with them. They have high precipitation levels, providing a positive water balance. They provide storage and distribution of water to the lowlands. They have a life-sustaining role. Water stored in mountain lakes and reservoirs has further economic value, given its hydroelectric power potential. Mountain fresh water sustains many natural habitats, both in the mountains and in the lowlands, thus contributing to the conservation of biodiversity. Mountains are highly fragile ecosystems, requiring careful management of the watersheds. (Poor land use gives rise to river siltation). There are conflicts over water availability and use (upstream abstraction, impacting on those who need water downstream). This is reflected in inadequate resource management. The impact of climate change and variability has to be factored into this whole equation.

The glacial meltwaters from the tropical glaciers of eastern Africa contribute significantly to the hydrological budget of rivers that emanate from the slopes of the mountains. The rivers on Mount Kenya, for example, currently meet 50% of the country's freshwater requirements, and supply the national grid with about 70% of its hydroelectric power. Today, the changes in land use around Mount Kenya (population, 8 million), deforestation, water abstraction for farm irrigation, and the gradual melting of the mountain glaciers are thought to be responsible for depleting the mountain's streams and rivers. Similar scenarios are observed for Kilimanjaro and the Ruwenzori mountains. Rate of glacier retreat is alarming, in spite of the consequential and welcome high water flows in dry season. Recent glacier recessions are documented for locations, such as the Lewis Glacier on Mount Kenya from 1880 AD. Sketch maps by Gregory in 1893 show clearly that a general, drastic reduction in glacier size has occurred since the late 1800s (Hastenrath and Kruss, 1992), being more enhanced in the late 20th century. The area of Kilimanjaro's ice cap has decreased by about 80% from the year 1912 to 2000 (from 12 km^2 to 2.6 km^2), and it is likely to disappear between 2015 and 2020, if the climatological trends of the past 88 years persist (Thompson et al., 2002). The

aesthetic value to tourists will be lost. By 1990, glaciers on the Rwenzori mountains had receded to about 40% of their extent recorded in 1955 (Kaser and Osmaston, 2002). Perennial rivers could become seasonal rivers. The problem of reduced flow is exacerbated by deforestation, water abstraction for irrigation, and other anthropogenic activities. These impacts are expected to become serious by about the year 2015. Both the population and the area of cultivation on Mount Kenya's lower slopes, and below, have more than tripled over the last 20 years, and abstractions of water from the mountain's rivers have dramatically increased. Currently, ten times the water volume, provided through existing regulations, is being used (H. Liniger and R. Weingartner, in Science in Africa, 2002). This is a problem of unenforcement. About 60% of the inhabitants of Ewaso Ngiro river basin, Mount Kenya, depend on river water for irrigation (Science in Africa, 2002). The loss of these frozen reservoirs threatens water resources for hydroelectric power production in the region, and for crop irrigation and municipal water supplies. Water-related development projects have been spurred on by increased stream discharge that has resulted from the melting ice caps. In effect, the government is cashing in on an aquatic bank account that was accumulated over thousands of years, but is not addressing its replenishment (L. Thompson, in the Monitor, 2003). We are losing our targets.

In conclusion, I list some of the challenges. We have to manage the increasing demands for fresh water. We have to safeguard biodiversity and natural habitats created by mountain fresh water. We have to recognise the interactions between the mountains and the lowlands (and the lowlands with the coastal zones – brackish coastal aquifers, through over-abstraction and consequent seawater infiltration, aggravated by reduced freshwater replenishment into these coastal aquifers). We have to assess the mountain water resources, and the impact of human activities. We have to invest in sustainable development of mountain regions, and lastly we must avoid conflicts.

DISCUSSION

Question (Kfir): Kenya is the location of a number of international bodies. To what extent to they support and supplement research in Kenya, for Kenya?

Reply: Everyone seems to focus on lake Victoria. There is a lot of support for this type of research under World Bank funding. We have new institutions, with their own projects, internationally funded. One was to increase the number of boreholes. They came in, and then went out, using the Ministry of water laboratories for conducting the necessary analyses. This information did not reach the wider arena. Universities in our region typically do this type of work. Yes, the organisations are there, but better coordination would increase the value of what is being done. We have many NGOs, doing a lot of small-scale work on water conservation issues. Findings are not usually made known. We need an information database, and clearing house, where prospective researchers can find out the status quo. Research funded organisations, from outside, must get ministry permits, and this provides some information on what is happening.

Question (Tungaraza): If an outsider visits South Africa, with intention of doing water research, how do you manage this situation?

Reply (Kfir): We have no control. We (WRC) fund about 60% of our own research. We tried to prepare an R&D Chapter as part of the UN Water Web Programme, and tried to find out who was doing what, outside our own funding system. We have IMWI (the International Management Water Institute), and I am a board member. It is located in Pretoria. We have problems, an example being a German university wishing to come and do research in South Africa, in a manner that contributes nothing to our own capacity. We will assist, provided that they are prepared to offer something of value in return. EU often requests some contribution from the country involved, and in these cases, we become involved. There is no clearing-house for this information. While the WRC may see itself as a water information hub, we are not provided with comprehensive access to information on these other activities (outside our mandate).

Water Research in Uganda

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Water research in Uganda is not well coordinated. Most of the research takes place at Makerere University, which also funds some of its research. The Uganda National Council for Science and Technology (UNCST) is the government body responsible for coordinating and funding research, and sees that it is integrated into national development. However, it is limited, due to both financial and institutional constraints. The Uganda National Academy of Sciences (UNAS) is one of the bodies that carries out research. There is other funding from the Directorate of Water Development, as well as from NGOs and the private sector. The percentage of funding that comes from the Directorate is about 10%, about 5% from the National Council, and about 85% is through the universities, Makerere, in particular. There are donors, Sweden, Norway and recently, the World Bank funded Nile Basin Initiative. I will discuss the various areas of research currently done at different levels, post-graduate (PhD, MSc and practitioner) and undergraduate.

There is a research project aimed at developing a decision support system for planning and operation of large dams along the Victoria Nile. The candidate is registered at the University of KZN. The objective is to optimise the productive and equitable use of water that is stored in Lake Victoria and Lake Kyoga, by creating and applying knowledge about management of trade-offs, and to promote synergies between different options for use, optimising hydropower production, food security and water productivity, and environmental sustainability, while minimising any negative and social impact. The outputs are a PhD thesis, providing improved knowledge decision support systems, to assist in better planning of reservoir and dam operation, and development of a practitioner "hand book".

Another study concerns modelling the impact of development projects on the water resources of the Upper White Nile River Basin. This candidate is registered at a British university. Research objectives are to develop a decision-support model for consumptive and non-consumptive use of water resources in a trans-boundary river basin, subjected to a matrix of development projects and climate change. The selected model should be able to simulate the impact of water use on water balance and sediment transport within the system.

A further study deals with Lake Victoria, and the use of optimal consumptive and non-consumptive scenarios analyses of the Lake Victoria waters, to develop economic and environmental indicators. This candidate is also registered with a British university. Dynamic programming techniques will be used, with emphasis on Uganda, while maximising benefits to East Africa, as a whole, through equitable sharing and sustainable use of the lake.

Yet another project deals with the investigation and analysis of the transient hydrological regimes of the Upper Nile, and implications for hydropower development. This is partly related to an earlier-mentioned study. The Nile Basin Initiative funds them both. The output will be a clearer view of the hydrology of the Upper Nile, including elaboration of the drivers of the Net Basin supply, and a better understanding of controversies surrounding the water levels of Lake Victoria.

We have a SIDA/SAREC-funded programme in the area of environmental engineering. There are various areas of this research. One is to analyse the pollution loading on shallow groundwaters, examining alternative water treatment technologies for domestic wastewater, water treatment methods, and to develop household low-cost purification systems. The last area is research into a holistic approach to sanitation. Ecological sanitation is the "in-thing", and is being widely promoted. The main barrier is user acceptance of ecosanitation, as a new technology.

There is research in hydrogeology, flood analysis, drought analysis, low flows analysis, rainfall analysis, sediment transport, water supply, and environmental sanitation. I have listed some of the papers that have been presented by the various authors, and they cover areas such as hydrogeology, groundwater investigations in Lake Victoria, groundwater flow in weathered fractured bedrock aquifers, urban management of groundwater sources in urban areas, and sustainable groundwater supply. This is linked to groundwater mapping studies. There is regional flood frequency analysis, dam break simulation studies, flood mitigation, and regional flood analysis by the L-Moment approach. There is low-flow and drought analysis, covering various parts of the country. There is rainfall analysis, including rainfall-harvesting strategies, the use of rainfall for agriculture, and rainfall reliability for crop production countrywide. Most of this work has been done in the Department of Civil Engineering, Makerere University.

Focus has also been practitioner-based in the area of environmental sanitation. We aim to improve designs for VIP latrines, generate support for improved sanitation training, and need to determine the social acceptability of eco-sanitation concepts.

In the area of water supply, we are trying to determine the sustainable solutions for rural water supplies. GIS is being applied as management tool.

In the area of sediment, we have sediment yield assessment, and river classification, with limited data sets. Another focus is a rationale for use of decision support systems for water resources management in Uganda.

Work has been done in the area of institutional development. Research areas include customer orientation, private sector management, self-help initiatives, tariff structures and a study on curriculum review, with a purpose of generating greater interest in an area. This has yielded positive results. There is course transfer, being a "tripod capacity-building approach". This refers to three institutions that have been involved in capacity building. The purpose has been to foster expertise transfer from the University of Loughborough, UK, to Uganda, and to examine ways in which such interaction may be sustained. There has also been a study on training of engineering students, through district-focused internship attachments. This resulted in an improved attitude on the part of the students towards their district responsibilities.

Final year research projects in the Civil Engineering Department at Makerere University includes flood analysis, drought analysis, hydro schemes and dams, hydraulics, surface hydrology, stormwater and urban drainage, as well as sanitation and water supply.

In conclusion, it is evident that there is a lot of interest in water research in Uganda. The major limitations have been the funding and motivation, of both the researchers and their supervisors. There is a need for more applied research, to match the local prevailing conditions in the country. Areas such as climate change and their impact on water resources have not yet been addressed.

Water Resources Research in Cameroon

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Kevin Pietersen's presentation on research in South Africa, when compared with the situation in Cameroon, makes me feel that I am visiting dreamland.

When preparing this talk, I visualised that we would need to communicate the main focus of research in Cameroon, identify problems and constraints, so that as a region, we can determine how to move forward. My presentation is structured with this in mind. Research in Cameroon is conducted by universities, and some research centres. There is a Ministry of Scientific Research and Innovation, under which we have the research institutes. The Institute of Mining and Geology accommodates the Centre for Hydrological Research, which has a mandate of assessing only surface water resources. The Institute for Hydrological Research is seriously under-funded, and is barely functional. The universities, however, are under a different ministry; the Ministry of Higher Education. Given that that the Ministry of Scientific Research and Innovation cannot effectively fund its own institutes, it is no surprise to learn that funding of university research from this source is inadequate, at best, or inexistent.

Concerning the critical water management problems, there is degradation of water resources through pollution and deforestation, as evidenced by eutrophication and siltation of dams. Data are inadequate for informed decision-making, since there are very few operational water monitoring stations, and little information on water use and demand. Some research indicates that river flows are dwindling, and some water bodies, such as Lake Chad are diminishing. This can be attributed to climate change, but human factors cannot be left out. In addition, there is an insufficient number of motivated and skilled water professionals, who can deal effectively with the complex issues of water scarcity, climate variability, and joint management of international waters. The problem is compounded by inefficiency and wastage in the use of available water, where there is up to 40 % loss in urban water supply systems, and the average efficiency of irrigation systems is estimated at about 30 %.

Poorly coordinated water management is reflected in the way research is conducted. There is no coherently focussed water research program. Research efforts are thus dispersed, mostly externally funded, and understandably follow the donors' agenda, which itself, is uncoordinated.

Cameroon had only one university up until 1993, but with a reasonably good infrastructure. Overcrowding with up to 60 000 students, loading this existing infrastructure, gave rise to a political decision to decentralise, and create six universities. The University of Dschang, for example, was a College of Agriculture, with about 700 students, and has grown today to accommodate about 12 000 students, with no significant expansion of infrastructure. With insufficient funding, the current preoccupation of these new universities is to develop basic infrastructure, with very little funds devoted to research. Research projects in the universities are thus mainly based on funds obtained from external sources, and work usually lasts only as long as the external funding exists. Research is mainly focused on applied research, to solve problems

that have been perceived to exist by the researchers. This usually involves adapting existing technologies, to suit local conditions or situations.

The most serious problem researchers have identified in the southern part of the country, with abundant water resources, is the degradation of water resources by pollution and deforestation. In the north, with limited water resources and spatial and temporal distribution problems, we again find degradation of the water resources, in addition to the need for efficient and effective use of water. Efficiency is paramount to the water sector, considering the rising cost of energy, and the upcoming implementation of abstraction fees for heavy water users.

Almost all centralised sewage systems that were built in the two major towns of Douala and Yaoundé are out of use, with untreated wastewater being discharged into the environment. The systems that were built were found to be too costly to operate and maintain, and were gradually abandoned, and left derelict. Untreated waste water from these sewage systems therefore flows into natural drainage channels and is often used downstream, for domestic purposes, and for irrigation during the dry season. In any case, these centralised systems served only a very small proportion of the population. The majority of the population, in both urban and rural areas, use pit latrines and septic tanks which pollute ground water sources, that are used by a significant portion of the population for domestic water supply.

Industrial wastes, likewise, are barely treated before disposal, because treatment costs are perceived to be very high. The need is thus for low-cost treatment systems for domestic and industrial waste waters. The current focus of researchers has been on the use of ponds, with aquatic plants, and the use of artificially constructed wetlands. The ability of various local plants to absorb various types of pollutants is being studied, so that systems can be adapted to the physico-chemical properties of the waste water requiring treatment. Studies are also under way to develop appropriate technology for the safe use of polluted but nutrient rich water in agriculture, as a short-term measure, without compromising the health of the population.

Cameroon has abundant water supplies, of about 18 000 m^3 per capita per year, and the major concern of policy makers is the provision of potable water to the population. Concepts such as efficient water use, and integrated water management, are therefore not considered priority issues.

Concerning research needs, problem areas include river basin management with limited data, adapting IWRM principles to the socio-cultural and economic environment, development of appropriate waste water treatment technologies, such as the use of artificial wetlands for treatment of different types of waste water, and specific problem pollutants therein. There is also need to examine indigenous technologies, with a view to their improvement. In addition, water management needs to take account of climate change, as well as devoting more attention to water assessment and monitoring.

The following constraints have been identified as obstacles to effective water research in Cameroon:

- Research findings end up on bookshelves, with low rates of information transfer to those who need to use it
- Teaching and research programs are not coordinated with the needs of the end users
- There are inadequate resources for water management research, insufficient infrastructure, and an insufficient number of trained researchers. Consequently, most research degree studies are conducted at foreign universities, often on topics seen to be irrelevant to the priority water problems of Cameroon.
- To compound the problems, there is a brain drain, with trained researchers leaving the research environment for more financially rewarding positions both within and without the country.

Water Research in Senegal

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Our problems in Senegal are that water research lies within the domain of applied geology. Each year, we try to organise meetings to identify key problems that relate to the management and use of our water resources. We have about four topics. We wish to understand and predict the impact of land use and desertification on water resources. We wish to develop and implement a large-scale water resources simulation/information system, incorporating satellite remote-sensing technology. We need to evaluate the variability of water resources that are impacted by aquifer contamination. There is contamination of surface water by agriculture, and mining activities, and sea water intrusion into coastal aquifers. Finally, there is flow risk assessment.

The universities conduct our research. The new approach is that research is purely a disciplinary approach. For that, universities invite decision-makers, to assist in identify key problems that require a solution. We put disciplinary teams together. Our university serves the West African countries. The Department of Geology serves both geology and water resources. We have two leaders, a hydrogeologist and a hydrochemical geologist. Our curriculum includes hydrogeology, hydrology, geochemistry and environment. The university has a commitment to do all research on water management, with the support of the Ministry of Agriculture, the Ministry of Environment, and the Ministry of Scientific Research. The National Academy plays a significant role, as it has to coordinate. Each year, we invite younger researchers to become involved in this research. I present one of the university programmes. We created the Earth Sciences Institute in 1980. Its expertise, hydrogeology, geochemistry and water pollution, concentrates on water resources and water quality issues in the Craton and coastal areas. Another topic is remote sensing, GIS, environmental impacts, natural hazards and risks, and ground geophysical surveys. The Departments of Earth Science, and Geology, are separate. Geology is in the Faculty of Science, and Techniques. The Institute of Earth Science is only a body that trains engineers in applied geology, and information technology. It includes the use of geophysics, satellite remote sensing technologies, and also modelling of aquifers. Basic research is done by the Department of Geology. A lot of effort is devoted to sedimentary aquifers and complex basement aquifers.

The problem of funding arises every year. Project proposals that can attract international support have the best prospects, and one of these is "TREES". The TIGER project is the application of remote sensing for water resources and management, and we have selected two subjects for this project. Participants are the Department of Geology, a research-and-educational input from the Institute of Earth Science, and the managers of the technical departments of the Ministry of Environment, Agriculture, and others. Included is the National Agency for management of agriculture and environment. SAED is the National Society for the development of the delta of the Senegal River. Scientific coordination is with IST. You have OMVS, DAED, and ISRA. There is the Institute of Environment, within the Department of Geology, The Laboratory for Atmospheric Physics, the Laboratory for Physics, and the Centre for Environmental Monitoring, under the Ministry of the Environment. These are collectively responsible for data acquisition, processing,

archiving and dissemination. Another large body is the Department of Planning and Management of Water. This is under the Ministry of Agriculture and Water Resources. This Department is responsible for project operationalisation, on all water projects. OMVS (International Organisation for the Development of the Senegal River, with Mali, and Mauritania) has a large project, with support from JEFF funds, for monitoring and management of water resources and environment in the Senegal River Basin. SAED is a national company, for agriculture and development of the Senegal River Delta. ISRA is a large development, under the Ministry of Agriculture for agricultural research. The entire project is names TREES. TREES is part of the larger project TIGER, initiated by ASA. The main themes are water resources and hydrogeology, concerning lakes, estuaries and coastal zones, floods and droughts, extraction and recharge of groundwater resources, erosion related to soil degradation and water flow.

The objective TREES has been to use remote sensing, to improve data. Project titles include "Remote Sensing characterisation of watersheds for surface water resources management in Senegal". Another is "Use of radar ERS SAR and ENVISAT ASAR data, for bathymetric map updating of shallow coastal waters in Senegal".

What is the current role of the National Academy? We wish to establish a National foundation for Science. For this we have entered into an agreement with the US National Academy, the UK Academy, and the Canadian Internationale Development Agency. We want to raise money to support scientific teams from our university and other research entities, for PhD, or MSc projects. Our intention is that we will call for project proposals, on an annual basis. Our aim is to bring young researchers into the field. We look to the ASSAf, to guide us as to means of coltaboration and support.

DISCUSSION

Question (Kfir): Who funds TIGER? Concerning this relationship with US, UK, Canada, and others, will funding be external or local? I understood at NEPAD meetings that Francophone Africa is already being served by French involvement?

Reply: You are correct. We worked closely with French Universities until 1980. I was a Fullbright Fellow at an American university, an MSc at Michigan State University, and this established collaboration. I also collaborate with Germany (Göttingen University) and others. At present, my new PhD student is working outside the Francophone area, the USA and UK. Philosophy has changed. TIGER is under ESA (European Space Agency). The submission was international, and our team received funding for this project. We also receive funding from the US Academy, as there is large project for water resources, and we made a submission to Michigan State University, and we expect to get the research funding. The Atomic Agency has funded a laboratory in Dakar. We have a remote sensing laboratory that collaborates with the European Agency.

SESSION 4

Innovative Applications to Address Water Resource Management Issues in Africa

Climate Change and Variability

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Our Department has been involved with the WRC on a number of projects. We train meteorologists for, amongst others, the South African Weather Service, and are the only institution in the RSA that offers a BSc degree in meteorology. We are currently involved in a collaborative project with Uganda, developing predictive models for weather forecasting in that area.

I will talk of the weather systems that are responsible for the climate in our sub-region. We will examine historical climate records, to provide perspective with respect to the present, and then examine climate change, without raising any issue of whether it may be considered to be good or bad.

The plot shown is of lower atmosphere temperatures, and carbon dioxide concentrations, for the last 400 000 years. These have been derived from ice cores from the South Pole, and other places. There have been significant variations in these parameters, and they are linked to glacial periods, about 100 000 years long. There are also shorter interglacial periods of warmer weather between these glacial periods. After reaching a temperature peak in the short interglacial periods, there is normally a rapid temperature fall, in a regular cycle. The approximated 100 000 years glacial periods might be attributed to changes in the elliptic orbit of the earth around the sun, named Milankovitch Cycles. At this moment, we are on one of those peaks, in a warmer period. The temperature profile that follows the current peak is not consistent with what happened before over the 400 000 year record. The current peak appears to sustain a plateau, instead of dropping to colder conditions, as happened before. Claims are made that anthropogenic greenhouse gasses are responsible for the current warming. CO_2 traces, indeed, track temperature profiles, but CO_2 concentration does not necessarily follow temperature, in all instances. For example, if we go back 460 million years, CO_2 concentrations were ten- to twenty-fold higher, and we had similar atmospheric temperatures as today. The situation is apparently more complex, and the debate about the involvement of CO_2 raises more questions than it provides answers. The most important greenhouse gasses are CO_2, methane, and perhaps more importantly, water vapour. The interaction of CO_2 with water vapour requires more understanding. Water vapour produces clouds that might cool the earth if they are thick enough. A world map of the last glacial maximum about 18 000 years ago shows large areas covered by ice and deserts, with forests being confined to the tropics. Under today's warmer conditions, we see more vegetation, and less glacial areas. Relatively, we are in a warm period, in comparison with where we came from. We now examine the weather systems over Africa in Figure 1.

Figure 1: The meridional cell circulation diagram

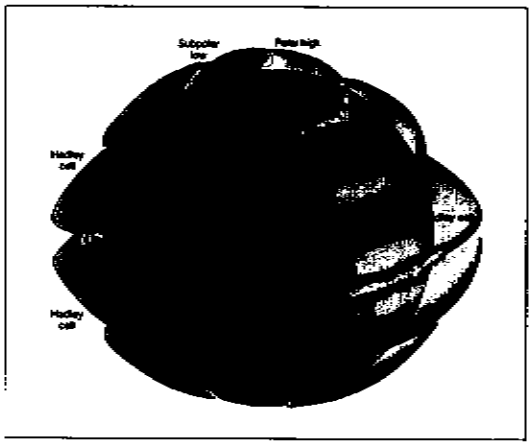

Figure 1 explains the meridional cell circulation diagram. As a result of more concentrated solar energy, one finds warmer conditions at the equator. At about 30 degrees south, we have atmospheric subsidence, which suppresses rainfall. Or is it so, we ask? If we did not have continents on this earth, we would not have disturbed this cell structure. Land masses

create thermal disturbances in the dry subtropics. Southern Africa lies on this dry, atmospheric subsidence latitude, and is thus expected to be dry. This is the norm, rather than the exception. Rainfall is the deviation. People fail to plan, bearing this in mind. Atmospheric subsidence will also tend to inhibit cloud formation. Presence of a continent will provide a heat source, which leads to convective lifting of air over that area, and this is the reason why we do, indeed, get rain in a normally dry region. Surface heat creates rising air, which in turn creates low-pressure systems This continental low results in circulation cells that will draw moisture from the tropics towards southern Africa. One often sees cloud bands extending from the tropics over Botswana and Angola towards the eastern parts of South Africa, bringing moisture from the north to the east. As a result the conditions in the west remain "normal" (dry), while we receive rain in the east. One gets the Atlantic high and the Indian high, flanking the low pressure. Following passing cold fronts, the Atlantic high occasionally ridges towards the south of Africa, generating more rain over the eastern parts of South Africa.

Circulation of mid-latitude cyclones (known as cold fronts) can link up with the circulation of continental systems over southern Africa. This often serves as mechanism to draw energy and clouds southwards from the equatorial regions. The changes in these systems that create our rainfall need to be examined and understood, in order to be able to interpret climate change.

We examine South African summer rainfall patterns, particularly our austral summer rainfall, and we can see that we have wet conditions in the east, and dry in the west. In winter, the mid-latitude systems return to "normal" with high pressures dominating, owing to the cooling of the land-mass.

We examine more recent climate records to explain the reasons for our concern about climate change. Since 1860, until today, we had 0.7°C average rise in surface temperature, over the globe. This is a matter of concern. There was a short period of cooling during 1940 to 1980, after which there was a rapid temperature rise, with the highest temperatures on record (over the past 1000 years) appearing over the past few years.

What is the best approach to this problem? The primary tool is observation. History, as shown in the graphs that have been presented, indicates that we are already in a process of climate change. This can be split in to the natural component (passive) and that attributable to anthropogenic (active) causes. The IPPC Initiative is concerned with predictive methods for future climate change scenarios, and their impact assessment. Several model simulations have been used for climate forecasts. The slide shown gives an idea of the complexity of the problems, and the numerous assumptions that have to be taken. Model simulations examine a matrix of grid boxes over the topography of the world, with resolutions of about 200 to 300 km. The current models are not ideal, since they predict an ongoing increase in surface temperatures, but fail to produce persistent trends in rainfall over central and southern Africa. Why did the IPCC use so many models? The reason is that one can compare projections to identify consistent signals – since models differ in the way they simulate the atmosphere. An average of all model results could give a more reasonable answer. They used these models to force future projections for CO_2. CO_2 stress scenarios, themselves, vary, the popular and so-called "A2" and "B2" being compared. A2 predicts doubling of CO_2 over the next century, while B2 shows a less severe trend. Surface temperature graphs from the third assessment report of the IPCC show trends according to the various models. Tracking reality in the past has been generally good, especially for temperatures, but projections to the future become divergent, creating uncertainty, especially for rainfall. The models do, however, all predict warmer conditions, in future. Global average rainfall data reflect chaos, models not even tracking past records with any reliability. Future rainfall increase is predicted on the global scale, and would be expected by the warming, which will increase evaporation rates. Regional rainfall predictions are, however, harder to make.

Southern African analyses (Rupsteenoja classifications), comparing temperature/rainfall results from the various models, show future projected variations in temperatures and rainfall. Deviations

for rainfall are scattered, both above and below normal. Temperatures show general rise with time; years 2020, and 2050, but rainfall values are inconsistent over southern Africa.

We turn out attention to rainfall observations from 1960 to 2002 to investigate trends. Since anthropogenic greenhouse warming is a reality since 1860, changes in the climate might already take place. There is evidence that global temperatures are rising. The map shows annual rainfall trends over 42 years. No statistically significant change over the whole country could be found for rainfall annual totals. This could be taken as good news since, if well managed, water resources are consistent. Monthly rainfall is changing, in that summer rainfall has been decreasing in the late summer (April-May months) over the summer rainfall region, along with wetter conditions in the late winter (July and September) over the western parts of the country. This can be seen as a temporal shift in the seasons. In terms of water resource management, the good news is that we still seem to receive the same amounts of water over a year, but in a changing temporal intra-annual pattern of precipitation.

Published temperature-trends in the IPCC Report, years 1976 to 2000, for Africa, show significant warming, especially over Zambia, Zimbabwe and Malawi. There are mixed signals for South Africa, and there are areas of insufficient data over Africa. Much of the warming over the past 20 years took place over the central to eastern regions of southern Africa. If we examine rainfall, there is also a trend towards drought over this region. Wetter conditions were recorded over Moçambique and the northern parts of east Africa. A recent model simulation that was carried out at the University of Pretoria, projecting climate for years 2070 to 2100, show changes similar to what have been observed. Studies of the weather systems, believed to cause these changes, are under investigation. It is suspected that the extension of the Indian high over east Africa might strengthen, which increases moisture flux over northern Moçambique, and causes drought over eastern southern Africa. These trends are difficult to track, because of a shortage of recorded data.

DISCUSSION

Question (Verhagen): You made no mention of ENSO. Do you note any climate-forseen phenomena related to ENSO?

Reply: Yes, there is, but I focused more on Africa. El Nino periods are lengthening, with shorter La Nina periods between. The water of the Pacific Ocean may be heating, and this may continue, in future. Katrina, and the warm water of the Gulf Stream, also shows this trend in warming of the oceans.

Question(Kfir): You talk of seasonal shift in rainfall. But seasons are not only a rainfall issue. Do we also see temperature shifts as well?

Reply: There isn't much information available on this.

Question (Olago): We have a lot of rainfall in Eastern Africa. What would the impacts of the Indian Ocean, and the associated dipole, have on this?

Reply: There is a consistent increase in the temperature of the Indian Ocean. I suggest that the temperatures will continue to increase over that region, producing more moisture, and if the Indian High strengthens, it will transport the moisture to the continent.

Technology as an Aid to Water Supply in South Africa

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I will provide a background to South African technology, as an aid to water supply.

We have drivers of technology development. Climatic conditions comprise one factor. The other is the human factor. It is all about distributions.

South Africa is a dry country. Rainfall average is 450 mm/year. World average is 860 mm/year. Our rainfall is 50 mm/year in the west, to 1250 mm/year in the east. 65% of the country has less than 500 mm/year. 21% of the country has less than 200 mm/year. Evaporation is 1100 mm/year in the east, to over 3000 mm/year in the west. We have 4 to 8-year drought periods. There is a lack of exploitable aquifers (<15% groundwater). Water is often not near economic growth areas (eg Johannesburg-Reef area – where the gold is). Western regions are dry, while eastern areas are wet. Evaporation rate is high in the west, and much lower in the east.

We examine population distribution, with respect to geography, income, and skills/education. The rural population amounts to 45%. People are scattered, with distant access to water. They like to build on top of hills, adding to servicing problems. We rely on springs and boreholes for water supply to these areas, and the Department of Water Affairs provides them. Piped water supply is thus both difficult and expensive, under these circumstances. Cheaper alternatives have thus to be considered.

There is a large disparity between rich and poor (second largest after Brazil). Poor people cannot afford potable water, and use (free) untreated river water, rather than pay. There is a large disparity in skills levels and education, these being concentrated in urban areas, and depleted in rural areas. Rural water treatment plants are consequently left in an unmaintained state, and improperly operated. Rural people are inadequately educated to understand the health hazards associated with drinking river water, and this results in sickness and morbidity, and a consequent health problem.

A number of possible solutions to these problems have been investigated and implemented. One of the solutions to these problems is seen in a good legislative framework. New legislation has been drafted to ensure water supply to all people, while ensuring environmental protection. Controversial as dams may be, we have constructed several large ones, to control the flow of unused water to the sea. There are 539 registered dams. In addition, there are inter-basin transfer schemes that move water from wetter areas to the drier and more needy regions. There are 18 of these, the Lesotho Highlands Scheme being the largest, with a 120 km transfer tunnel that carries water to the Ash River, and the Vaal River Catchment, to supply Johannesburg and its vicinity.

Another important step was the founding, by act of parliament, of the Water Research Commission (WRC) in 1971. There was foresight in that a previous investigation showed that water was the most limiting factor to growth.

Another option has been the re-use of waste water. There is a legal requirement to return all used water to the rivers for further use, downstream. The first plant for direct purification of treated sewage effluent to drinking water was commissioned in 1969 at Windhoek, Namibia, and

a demonstration plant was operated for some time on the Cape Flats at the end of the 1980's. Large power stations have converted from evaporative cooling to air-cooled steam condensing systems. Industries are recycling their wastewaters, or are using purified sewage.

Another solution to our dry conditions is rainfall stimulation from clouds. There has been ten years of research, funded by the Water Research Commission, using two aircraft, burning salt mixtures that generate smoke particles that seed the clouds from below. Harvesting yields a statistical average of 30% more rain from these clouds. It has been used on a trial basis to the north, and is being exploited internationally. It is considered superior to seeding with silver iodide from above the clouds, and is more environmentally friendly. It won an international award, supporting the understanding of climate change.

I deal with innovative treatment technologies and water demand management. There is demand management, through use of flow restrictors, pressure control, pre-payment meters, and leak detection. Dissolved air flotation is in use for cleaning drinking water (good for eutrophic waters). We have models for detection and management of ground water. We also have innovative and appropriate water treatment processes, immersible filter units, self-backwashing filters, robust stand-alone membrane units, water desalination by reverse osmosis, with membrane-fouling monitoring and protection, water sanitisation with ozone, fog harvesting, valveless filters, solar stills, point-of-use water treatment units, and our playground merry-go-round borehole pump. There are enzyme-immobilised biochemical assay systems for endocrine disrupting compound detection in water, at trace concentrations.

We have a levy for training, being 1% of worker salaries to a Skills Levy Fund.

We continue to adapt advanced technologies, so that they are appropriately robust and require minimal supervision. We aim to implement teams of skilled "roving technicians" available to deal with problems.

My concluding remarks are, that in spite of formidable challenges, we have, over the last ten years, succeeded in giving 10 of the 14 million people access to safe, potable water; something that they did not have before. This has been achieved though good governance and exploiting innovative and appropriate technologies.

DISCUSSION

Question (Tungaraza): If you are recycling treated sewage water for drinking, what control do you exercise over industry, and the (hazardous, chemical) components that they may be responsible for in this water?

Reply: There are specifications and limits, to which they are obliged to adhere. Industries may either discharge to river, or to sewage works. In either case, they comply with appropriate conditions, and pay, per pollutant, that must be treated, if it is discharged through a municipal treatment plant. There is a government standard for any discharge to the river, to ensure protection of the rivers, and the industry must meet this standard.

Question (Dia): Dams may have their value in a developing country, but there are the negative impacts.

Reply: One has two choices. Either one has a dam with water, or no water, at all. It is a question of balancing environmental impact with human requirement. This is the reason for having environmental impact assessment studies, with the interested and affected parties all arguing and contesting their respective cases, and submitting their points of view, decisions being taken through an integrated analysis of all these issues at stake.

Wastewater Treatment Technologies

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One of my duties is to turn our water liabilities into revenue streams. Mining operations can generate a lot of wastewater, and this requires responsible management.

Wastewater treatment objectives will drive the selection of an appropriate technology. Wastewater treatment objectives are determined by South African environmental legislation. There are discharge standards for domestic and industrial wastewater. Treated domestic wastewater may have to comply with either general standards, or specific standards, depending on the catchment area of discharge. There is emphasis on solids removal (by settlement and floatation technology), COD/BOD removal (aerobic, or anaerobic processes, as is appropriate), nutrient removal (to prevent eutrophication), sludge management (dewatering, stabilisation, and processing for re-use or disposal), disinfection, and water re-use, including availability as potable water.

When dealing with industrial wastewater, one must consider organic carbon and nutrients, common to the petrochemical, food and beverage, and paper industries. They are amongst the heaviest polluters. Total dissolved solids (TDS) include inorganic ions (mining and metallurgical operations), and solids, which is applicable to all cases. There are prescribed limits, and meeting them can be costly, but we make progress. Sulphate removal is a serious challenge, and there is a lot of development in this field. Metal recovery for compliance to discharge standards is important. Brine handling is important, as membrane systems that are used to remove discharged water TDS will inevitably create a concentrated waste brine stream (the retentate) which requires responsible management. Options include dewatering, crystallisation, and recovery of valuable constituents. There is water disinfection, for potable re-use, (amongst the other re-use options) where requisite standards should be met.

The slide shows a lay-out of a typical waste water treatment plant. It consists of retention/ equalisation chambers, inlet works, then the biological treatment, and then a tertiary treatment that cleans and polishes the water. There is the treatment of the sludge stream, including dewatering and drying, and processing for beneficial re-use. There is the BNR process and many alternatives, and these include steps that remove biological nutrients (4-stage Bardenpho, UCT, MUCT and MLR). This is the choice of large metros in South Africa. Trickling filters are still applicable, often in combination with other processes. Rotating biological contactors are ideal for small-scale treatment. Fluidised beds are not used very much for domestic waste, as this technology is more suited to industrial waste. The oxidation dish race-track reactor has been popular, and is still in use in small towns. Sequencing batch reactors are a growing new technology that requires less physical space. Lastly, there are moving bed bioreactors and moving membrane bioreactors (MBR and MBBR). Membrane elements double as filter elements as well, allowing greater mixed liquor loads, without any compromise of oxygen transfer. Thus, these plants also have the advantage of small footprint, relative to process capacity, and suit circumstances where there are space constraints.

In sludge handling, the first step is thickening (sedimentation or floatation) and stabilisation (anaerobic digestion, or chemical methods), sludge volume reduction (centrifuges, belt presses) and then drying (biogas, diesel oil, or other heat source). Dry sludge pellets are produced on the Cape Flats for agricultural use. There is a lot of research on sludge characterisation, and heavy metal content. Unfortunately, heavy metal content (at these installations) is high.

Industrial wastewater treatment uses the same process principles. As has been mentioned, petrochemical, food and beverage industries, and the paper mills, are the biggest contributors to COD/BOD. Inventive technologies have been developed for these problems. Inorganic ion removal can be by precipitation (softening, and the barium sulphate/sulphide process), ion exchange, biological sulphate removal (Thiopac, MBR, MBBR, CSIROSURE, BioSURE). Passive systems, such as wetlands, can also be used, especially for mine water. Membrane technology is popular, despite cost. There are electrochemical methods, used by SASOL, and lastly, thermal processes, that have yet to see general use.

I show you an example of a USB reactor. It is an anaerobic process, using granular sludge, and relies on settler modules at the upper levels. The solids are separated there, allowing treated water to leave, as a clear effluent. The biogas is also harvested, some of which can be used to heat the unit. There is also a double-stage modular system, which can reduce BOD by up to 90% and COD up to 80-85%. The upper module captures untrapped COD/BOD from the lower module. Mixing is passive, with no pumping requirements.

I show you a unit at South African Breweries, Cape Town, where all the reactors are closed. This compact unit treats 5 megalitres of effluent a day.

We have a twenty megalitre two-stage membrane unit at Witbank, treating mine water, for reclamation. Ultrafiltration precedes reverse osmosis, and then disinfection, for return of this water to the municipal potable supply system.

DISCUSSION

Question (Fonteh): We have our problem with unplanned settlements in peri-urban areas. What do you think would be the technical options?

Reply: Technology choice is dependent upon the population size. Big towns require established and mature BNR processes, as domestic sewage is well characterised, and we have had a lot of experience in deign, construction, and operation. It is not appropriate for small towns and rural areas, however. I have already indicated some of the options that have been found to be successful in small towns and villages.

Kfir: we have developed sanitation, as a separate expertise, and some of these problems lie in this area of discussion. We will shortly have a presentation on this matter.

Question (Tungaraza): I am interested in the term "UCT Process", and that it involved a university. What was the mechanism of interaction between this institution and the operations level, where such ideas have to be tested and implemented?

Kfir: The WRC most often funds these programmes. There is interactive communication between all participant parties, through a steering committee, during the entire project progress.

Water Resource Protection in South Africa

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Policy-makers and resource managers are facing a worldwide crisis in water resource management, but the situation is more urgent for developing countries struggling to overcome the grip of poverty. In response to these challenges, South Africa developed a ground-breaking approach to managing its water resources. The National Water Act of 1998 (Act 36 of 1998) contains three key innovations: the abolishment of private ownership, permitted under the system of riparian rights; the establishment of catchment management agencies (CMAs) as the basic unit for water resource management; and the Reserve. The Reserve is one of three resource directed measures (RDM) components designed to ensure the comprehensive protection of water resources. It is worth noting the fact that the Reserve can only be determined once significant water resources are being classified by means of a classification system, according to the NWA. Provisions have been put in place, though, to determine preliminary Reserves (in the interim) in anticipation of the completion of a formal classification system.

The outline of the presentation can be summarised as covering the legal framework for water resource protection, mandate(s) to give effect to water resource protection, water law principles concerning water resource protection, the role of resource directed measures (RDM), current initiatives on water resource protection, and some concluding remarks.

South Africa's legal framework is based on a global initiative (Chapter 18 of Agenda 21, 14 June 1992), giving the Water Law Principles (November 1996), a fully-recognised status in the South African Constitution (Act No 108 of 1996). The White Paper on National Water Policy of South Africa was established (April 1997), followed by the National Water Act (NWA)(Act No 36 of 1998). My talk deals with Chapter 3 of the NWA, which is Water Resources Protection; the mandate from our minister. This spans across several sectors, as well as government departments. The various government departments have equally strong mandates, and their roles and responsibilities are not always clearly defined. There are overlaps. The departments are: DWAF (Department of Water Affairs and Forestry) – primarily water resource management; DEAT (Department of Environmental Affairs and Tourism) – biodiversity conservation; NDA/LA (Department of Agriculture and Land Affairs) – land management; DPLG (Department of Provincial and Local Government) – development planning across government.

Initiatives usually reflect needs that are specific to one department or sector. Collaboration between departments or sectors can become complex. Cooperative governance is essential, in order to facilitate effective implementation. There is an Interrelations Governmental Framework Bill, obliging government departments to work together. By definition, the DWAF holds a strong mandate, with respect to water resource protection (Chapter 3 of NWA).

I select five of the 28 water law principles that are pertinent to my subject today. Principle 2 states that all water is linked. Principle 5 recognises the unity of the water cycle, the interdependence of its elements, and that the catchment is the basic hydrological unit. Principle 6 recognises that there is a (natural) uneven distribution of water over the country. Principle 7 relates to the water

management objectives (economic growth, social equity and ecological sustainability). Principle 26 links the regulation of water services to broader local government.

Stakeholders often perceive protection elements as being in conflict with socio-economic needs. This leads to much debate as to the meaning and purpose of water resource protection.

We now deal with resource directed measures (RDM – Chapter 3 of the NWA). All water, in its entirety, is under consideration, be it ground or surface, both in terms of quantity and quality. RDM considers an integrated approach to water resource protection and management, by ensuring long-term sustainable use of water resources, and balancing the need for long-term protection against the need for economic growth, and social development.

RDM consists of the Reserve (defined below). There is a classification of water resources, and identification of resource quality objectives. Protection measures are in various stages of development, addressing both resource quantity and quality. All water resources require characterisation (estuaries, wetlands, lakes, groundwater). The WRC is offering us research support in this endeavour.

RDM can be contextualised in the following way. The NWA requires the minister to classify water resources by means of a system that has been gazetted. Public comment is invited. A classification is then drafted, again, involving debate. Reserves have to be determined, and the resource quality objectives have to be established. These are the management rules for achieving the desired state of water resources management. This is the ideal. Currently, this ideal is not being reached, as the classification system has not yet been completed. The NWA does provide for preliminary determination of the Reserve. The Minister is obliged to give effect to these preliminary measures. The Reserves, at this stage, have only legal status, being without a gazetted classification system. The technical work behind all this is fortunately sound.

We have followed various approaches from year 1999 until now, to reach management objectives, and resource determination. We have tried to reach the ideal situation, where we are able to first determine the classes of water, before determining the Reserve. When we set Reserve scenarios, this is done in consultation with our key stakeholders. By the time that we set management objectives, it is not the decision of an individual, such as the Minister, alone. The decision is transparent, with all the associated risks that are relevant.

A national water resources classification system is based on the following parameters. There are the biophysical aspects, the socio-economic status, the delineation of water resource units, functional relationships between resource units, the development of alternate scenarios and their possible implications, and evaluation and recommendations taken with stakeholders.

The authority then makes a decision as to class.

Ecological classifications of water are as follows: Natural (good quality), A; moderately used or impacted, AB, B, BC, C; heavily use or impacted, CD D; unacceptably degraded, EF, F. If we contextualise the classification, we deal with the current state, and the future state that is desired. There are steps in this process. We need to determine the level of protection, and determine the degree of use, so as not to compromise the future state. This turns theory of sustainable development into practice. We have our nineteen catchment regions, which require classification, and countries such as Lesotho and Swaziland, where international consultation on this process becomes essential. Fifty to 60% of our water is shared with neighbouring countries, and the Act recognises the importance of dialogue with these external parties.

If all available water is depicted as a bucketful of water, then the lower half would be the Reserve (minimum balance) that must be kept for human and ecological need. This is the basis of the determination of a minimum requirement of raw water of 25 litres/day/person. In practice, where water is more abundant, this minimum allocation can be raised. Policy is clear, and without precedent, but implementation needs also to have flexibility. In determining the Reserve, in a local context, care must be taken, at the same time, not to compromise our international obligations. This has special relevance, with respect to interbasin transfers.

Referring to the water in the top half of the bucket (above the Reserve, in the lower half), the NWA requires all other water users to apply for licences, and this is the responsibility of the Catchment Management Agency. The Reserve is the only entitlement to water, in terms of the NWA. Water rights are being replaced with water entitlements.

These are some of the initiatives. DWAF is being restructured, to enhance the effective implementation of protection provisions of the NWA. Protection measures are being put in place for determining EWR, and setting RQOs. Financial measures are being put in place, and the pricing strategy is being revised (polluter pays principle, and waste discharge charging systems). Water Use Authorisation deals with compliance, intervention and enforcement. There are source-directed controls, where there is regulation of industrial impact. Working for Water involves clearance of alien vegetation, and recognises water resources in terms of an entire aquatic ecosystem. Working for Wetlands involves a sector-wide collaboration. There is water resource monitoring, as part of the River Health Program and conservation of river biodiversity, which reports on improvements and progress in river conservation. There is inland water biodiversity, with cross-sector policy objectives. There is groundwater protection zoning, with identification of policy gaps and necessary intervention. National strategy for groundwater management still has shortcomings, that require addressing in the National Water Resource Strategy.

I finally address the challenges in the implementation of the NWA, with regard to resource protection. Integrated approaches are needed. Strategies to be technically sound (scientific and legal). It is crucial to have a more vigorous approach to implementation.

Further challenges are to redress the past inequities in water allocation, and ensuring equity between generations, ensuring "some for all, forever, together". Equity and sustainability must both be addressed, despite this being unpopular at the political level, at times (before elections). We need the administrative capacity to implement protection provisions of the NWA. We need to link water resource protection and water services provisions; this is critical. We need to combat the perception that water resources protection is a tactic to delay other "overriding" service delivery priorities. Integrated management is for the good of all, and at the expense of none.

W(h)ither isotope hydrology in South Africa?

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HISTORICAL INTRODUCTION

As implied by the ambivalent spelling in the title of this talk, I am concerned about the "withering" in interest towards isotope hydrology in South Africa, as well as the destiny of this discipline.

Isotope hydrology in South Africa was pioneered in the early sixties by the Environmental Isotope Group (EIG) at the University of the Witwatersrand (Wits) and the Quaternary Dating Research Unit (Quadru) at the Council for Scientific and Industrial Research (CSIR). Physicists and chemists drove the field, at that time. Hydrologists were either unfamiliar with applying environmental isotope techniques, or sceptical as to their usefulness. A steady stream of applications to real-world problems was produced by the two groups, from the latter 1960's and into the 80's, not only in South Africa, but increasingly in the neighbouring states, such as Botswana and Namibia, as well.

This success began to attract the interest and support of organisations such as the International Atomic Energy Agency (IAEA), government agencies (Departments of Water Affairs), as well as the private sector (geotechnical consultancies). By the latter 1980's, the (geo)hydrological community, worldwide, increasingly embraced the by-then well-established field of isotope hydrology. South Africa by then had developed an international reputation in this field.

Teaching the discipline was part of a geohydrology course at the University of the Witwatersrand (WITS). In addition, a very successful short course was developed from this WITS course, and was run some forty times by the Ground Water Division of the Geological Society of South Africa (GSSA).

At that time, the University of Cape Town (UCT) and the Council for Geoscience (CGS) had developed analytical capabilities that found applications in isotope hydrology. Increasingly, the WITS and CSIR research groups had to become self-sustaining, with minimal official baseline support. In the latter 1990's, and early years of the millenium, South African expertise and analytical capacity contributed to a series of investigations in numerous African countries.

The WITS laboratory was appointed a Regional Centre by the IAEA in 1999, on the grounds of its high reputation, and given a major infusion of state-of-the-art equipment, which was associated with a southern and Eastern African regional research programme on sustainable water resources (RAF/8/029).

WHAT IS ENVIRONMENTAL ISOTOPE HYDROLOGY?

The isotopes of the various (mostly light) elements that comprise environmental matter (specifically water, and its dissolved constituents) undergo fractionation, i.e. small changes to their abundance ratios. These changes arise through processes such as phase change, diffusion,

chemical reactions and radioactive decay and can be traced through hydrological systems, providing information on the source of water, and its fate along its pathway through the system. In groundwater, the so-called stable isotope ratios $^{18}O/^{16}O$, $^{2}H/^{1}H$, and of dissolved carbon $^{13}C/^{12}C$, are more-or-less set during recharge, and characterise a source. Cosmogenic (naturally synthesised) radioactive isotope concentrations of ^{3}H and ^{14}C, at recharge, decline, due to radioactive decay during sub-surface transport, enabling this water to be "dated", or a mean residence time determined. Other isotopic species may also be employed as tracers in hydrology.

Some fields of application of environmental isotope hydrology are: Water resources assessment; surface water/ground water interrelations; pollutant transport/salinisation studies; urban hydrology; safety/leakage, sustainability, and pre-construction studies of dams; environmental protection/vulnerability assessment; monitoring artificial recharge; construction/verification of conceptual models; parameterisation of mathematical models; river basin studies (Thukela, South Africa and Nile, North Africa); palaeohydrology and climate studies; and geothermal studies.

EXAMPLES FROM A REGIONAL STUDY

To give a "feel" for the power of environmental isotope hydrology, I will share some information on the IAEA Regional Model Project RAF/8/029. This project, which ran from 1999 to 2002, addressed the sustainable development of groundwater resources in Southern and Eastern Africa. Countries involved were Kenya, Madagascar, Namibia, South Africa, Tanzania, Uganda, and Zimbabwe. Our group at Wits was the central analytical facility, besides providing considerable scientific input. The project list comprised:

- *Kenya* – Surface water/ground water interrelations in the Merti aquifer. *Madagascar* – Mineralisation processes in crystalline and sedimentary aquifers of southern Madagascar;
- *Namibia* – Reappraisal of the hydrology and resource assessment of the south-eastern artesian basin;
- *South Africa* – Resource assessment of water supply to 26 villages in Northern (Limpopo) Province;
- *Tanzania* – Recharge to and pollution of the high-yielding Makutupora basin aquifer;
- *Uganda* – Water balance and pollution potential of ground water supply to Wobulenzi town;
- *Zimbabwe* – sources of recharge to and mineralisation processes of the Save River valley alluvial aquifer.

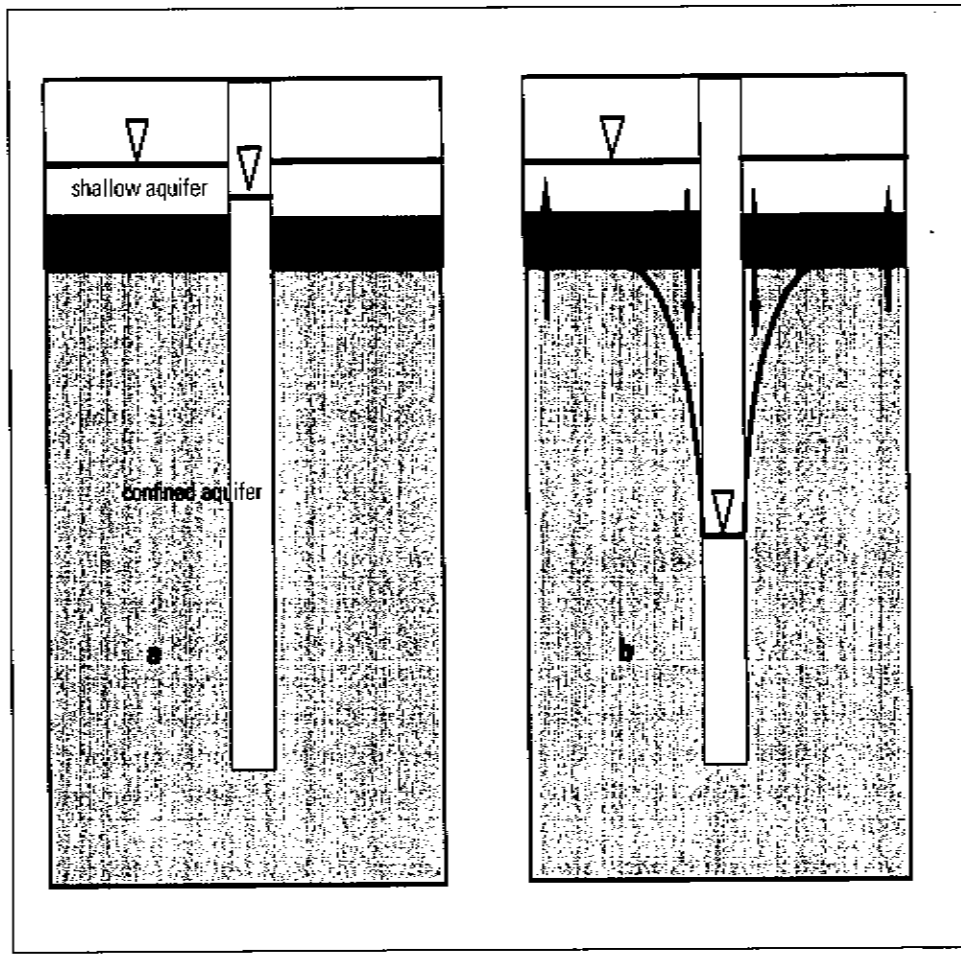
The three case studies that I will present, briefly, were a follow-up on these investigations, and yielded valuable information that was incidental (not primary) to the original goals of these projects:

- an investigation of nitrate pollution in a major water supply in Tanzania
- a unique case of groundwater feeding an ephemeral river in an arid/semi-arid region of Namibia
- identifying of a major groundwater resource in Limpopo Province, South Africa.

MAKUTUPORA BASIN, TANZANIA

Groundwater was being abstracted at a rate of about 24 000 m^3/day from a well field supplying the capital of Dodoma, in the Makutupora Basin in central Tanzania. Individual borehole deliveries were up to 500 m^3/hr. Abstraction was increased to about 30 000 m^3/day in the early 1990's. Technical problems, a few years later, lead to a reduction in the abstraction rate. Nitrate concentrations rose from about 10-20 mg/litre to about the WHO limit of 45 mg/litre, and over

Figure 1. a) Schematic representation of the Merti shallow and deeper confined aquifers b) the situation with heavy pumping, causing drawdown around the abstraction borehole allowing (contaminated) shallow water to enter and mix with water from the deep aquifer.



100 mg/litre, in some of the boreholes. Nitrate concentrations dropped to earlier values, by the late nineties. Changes in land use were blamed for the nitrate pollution, prompting relocation of villages, and closing of an agricultural scheme.

Figure 1(a) schematically shows a borehole cased through a shallow aquifer, separated by clay layer from a confined groundwater supply from which the water was being abstracted at a high rate. The tritium isotope data indicate that the deep aquifer had a residence time of at least 200 years, with recharge at the nearby Chenene Hills.

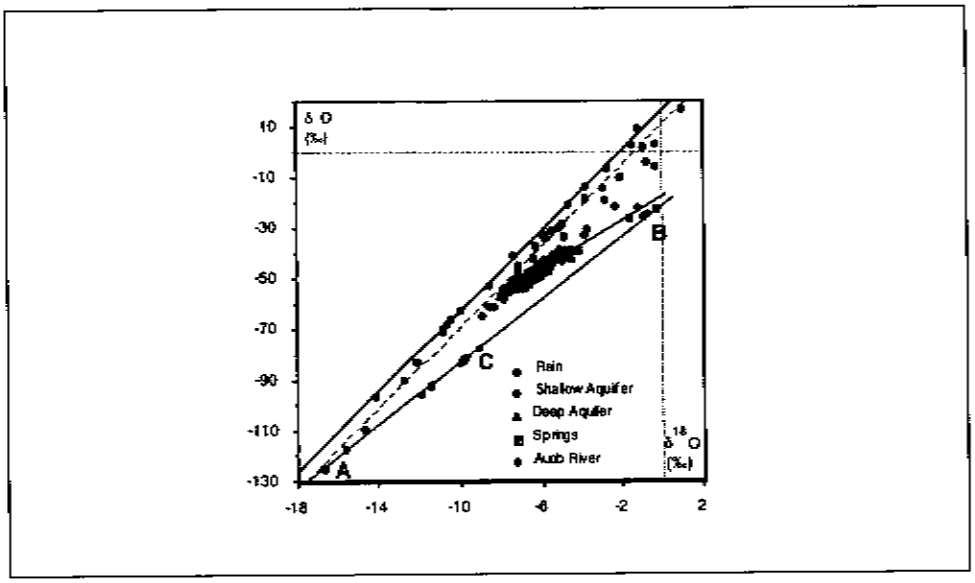
The radiocarbon data showed an even longer time-span of several thousand years, so short-term concentration changes could not have occurred in the confined aquifer, and this would have needed enormous amounts of nitrates. An alternative model is shown in Figure 1(b). Pumping creates a cone of low pressure around the upper section of the borehole, with upward flow outside this cone. This cone, caused by excessive abstraction, draws in the polluted water from the shallow aquifer. This input decreased with lowered pump rates.

The isotope study demonstrated that the solution to this problem was to reduce pumping rates, and to increase the number of boreholes in the field.

FLOOD IN THE AUOB RIVER, NAMIBIA

The second example relates to groundwater contributions observed during a rare flood of the ephemeral Auob River in the arid/semi-arid south-eastern Kalahari of Namibia. The flood resulted from an exceptional rainy season during 1999-2000 that saw widespread flooding in

Figure 2. Table isotope diagram for rainfall, groundwater and river water at Stampriet. Rainfall values span a wide range along a regression slope of 8. Groundwater shows a more limited range along a slope of 5.5. When the regression line for Auob flood water AC, with slope 6.2 is extrapolated, it intersects the most enriched values of groundwater at B.



southern Africa. Stable isotope values of daily samples of the Auob flood water at Stampriet, taken between 29.02.2000 and 10.03.2000, plot on a regression: $^{2}H=6.2\ ^{18}O-20.1$ (Figure 2).

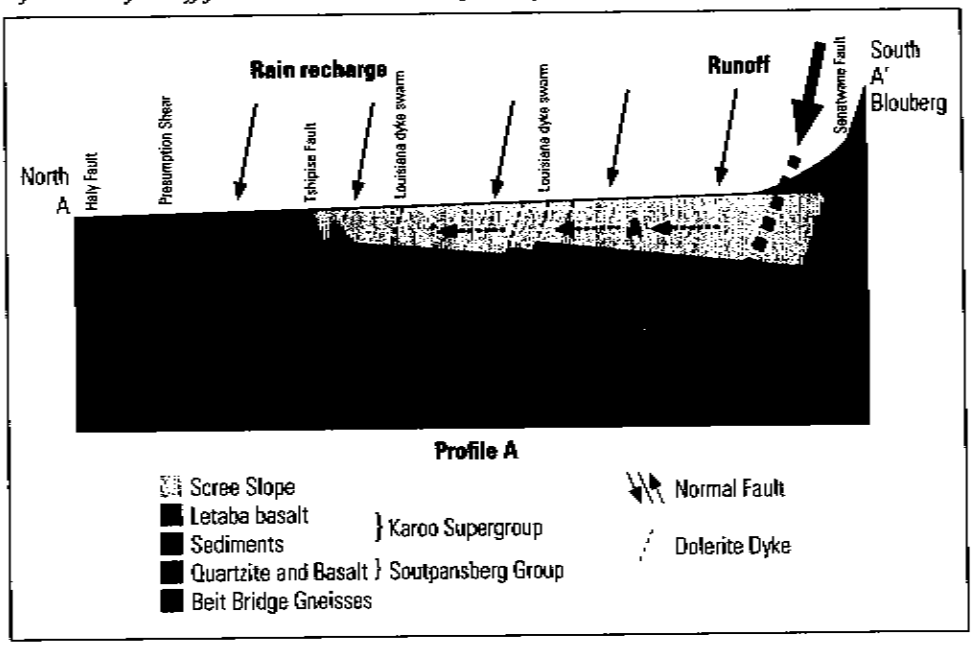
The slope of the regression line AC (6.2) is too high to result from river surface evaporation. The correlation coefficient of 0.999 suggests mixing between two well-defined sources. At low flow, the stable isotope values (at C) resembled those of groundwater. With a further, major downpour, the peak of the flood gave values close to rainfall, to return as the flood subsided. If we extrapolate AC to the intersection with the regression for shallow groundwater at B as the one source, and take the intersection with the rainwater regression A as the other we conclude that at C up to 45% of the water carried by this ephemeral river in an arid environment – even if temporarily – was actually groundwater. This is a unique situation, probably never reported elsewhere.

A RESOURCE DISCOVERED, LIMPOPO PROVINCE, SOUTH AFRICA

The study in the Limpopo Province was a continuation of a South African national project under IAEA regional programme RAF/8/029, in cooperation with DWAF and the WRC. Figure 3 shows a schematic geological section of the Taaibosch Karoo graben, with metamorphics in the north, and mountains with older sediments in the south.

The original hydrogeological model was of groundwater in the superficial basalt A, recharged by rain and mountain runoff in the south flowing northwards and draining into a regional fault zone B. The isotope study showed that recharge to the basalt was only a fraction of what had been assumed in the model. The underlying sandstone was not exploited as it was deemed to be a poor aquifer. However, the isotopic and chemical signature found in some boreholes along the Thsipise fault resembled closely that of groundwater at the foot of the mountains 20-25 km to the south. This led to exploratory drilling into the deeper sandstone. High yields of good quality groundwater were encountered. Although isotopic data showed a residence time higher than in the basalt, further work indicated that the sandstone was an actively-recharged and more consistently high-yielding aquifer than the basalt. It is now being further investigated as a regional water supply. Some of the exploratory boreholes are already being exploited for emergency relief to a nearby town.

Figure 3. A schematic geologic section of the study area. The original model assumed flow in the basalt A only (stippled arrows) and drainage through the Tshipise fault B. The isotope-based model (bold arrows) points to recharge to the more productive underlying sandstone C mainly through infiltration of runoff from the mountain, with upwelling along fault zones



THE PRESENT SITUATION IN THE FIELD OF ISOTOPE HYDROLOGY

The CSIR, in the last two years, has curtailed its formal programme in isotope hydrology, and the CGS closed down its entire light isotope section. The WITS laboratory and staff have been handed over to the national accelerator facility of iThemba LABS, Gauteng. The present situation is cause for concern, because there has been a considerable reduction in national analytical capacity, and the field of isotope hydrology is moving away of from its academic, earth science associations in South Africa. Additionally, there is no new generation of trained scientists who can be champions for the field.

There is no remaining programme for education, training, and information, in order to ensure continuity of awareness of isotope hydrology techniques amongst hydrologists and competent practitioners in the field.

Organisations such as the IAEA and UNESCO's International Hydrological Programme (IHP), on the other hand, emphasise the need for, and give support to, academic education and training in the field of isotope hydrology. There is a need for the hydrological community of all sectors in South Africa to take stock of its needs for, and capacity in isotope hydrology, as an essential component of water resources development, management and conservation.

Of at least equal importance, it has to muster support for, and assist in developing academic programmes in this field, in terms of research and manpower capacity building. These issues are of importance also in terms of regional development. South Africa represents the bulk of the analytical potential and expertise south of the Sahara, and should be able to assist in manpower capacity building in the region. The presenter was invited to join a small working group on an IHP/UNESCO initiative entitled: Ground Water for Emergency Situations (GWES). This propagates the use of groundwater as a pivotal resource for disaster preparedness, and sees isotope hydrology as an essential component in identifying, evaluating and managing such resources. South Africa should play an active role in this initiative, both in the national and regional interest.

We also have the International Program for Isotopes in the Hydrological Cycle. This program is run in co-operation with other UN organisations (WMO, UNESCO) and scientific institutes in some of the IAEA Member States.

The goals of this initiative are two-fold. The first is to fully integrate isotope hydrology in water sciences at universities world-wide. The second is to establish (through the UNESCO/IHP) national committees on isotope hydrology, to facilitate the application of isotope hydrology in the water and climate sectors of member states.

The initiative was presented and endorsed by the Fifth Joint UNESCO/WMO International Conference on Hydrology, held in February 1999, on the scope and objectives of this initiative.

SOUTH AFRICA NEEDS TO RESPOND

South Africa has not sufficiently availed itself of these initiatives, to stimulate and support education, research and development in isotope hydrology for its national and also regional requirements. Following a growing awareness in the 90's, there is at present a more limited appreciation of the use of isotope hydrology in South Africa. Laboratories receive requests for analyses on an *ad hoc* basis, originating mainly from minor private sector contracts, with little or no possibility for scientific input. Initiatives for research and development, up to fairly recently, have come largely from individuals and research groups. The few remaining experienced – mainly retired – individuals, who have international recognition and contacts, can and should be utilised by national and government entities (DWAF, WRC, NRF) to revitalise this erstwhile vibrant and productive field.

The country needs a new generation of isotope hydrologists, who could take charge of existing isotope hydrology facilities, and hydrogeologists, with a good grasp of isotope hydrology. The Water Research Commission, in cooperation with the Academy of Science of South Africa, can provide the framework, through which initiatives in this regard can be launched and supported. Education and training, at university and technicon level can use the existing (and ageing) expert manpower to the full, to set up and launch isotope hydrology courses in earth science and engineering faculties. These will initially require external support, until taken up in the mainstream curricula. Scholarships should be available for post-graduate studies and research in the field of isotope hydrology.

There should also be coordination, stimulating closer cooperation amongst existing analytical centres and between them and academic institutions. Excellent vehicles would be major national, multi-disciplinary research programmes. As for development, stock needs to be taken of existing facilities, and their equipment and manpower needs assessed, and a plan devised by which the optimal configuration or cluster of facilities, groups and education/training is put in place, to service not only the needs of the RSA, but those of developing African states.

A large proportion of isotope hydrology endeavour in Africa has in the past been coming from outside the continent. It is important that an indigenous African network for cooperation in the field of isotope hydrology should be established, to build a tradition of Africa finding solutions to its own problems. This should include support for, and cooperation with, sub-critical analytical facilities in some states. We should stimulate information, publicity, and seminars, to create public awareness in the private, professional and government sectors. We need a national committee on isotope hydrology. This could be a first step, as visualised under the IHP initiative.

Madam Chair, I thank you, and through you the WRC, for the opportunity to express my concerns at this forum

DISCUSSION

Question (Tungaraza): I know the location of your studies in Tanzania. These problems are rooted in (a lack of) coordination. The manner in which boreholes were installed, with the screens at various levels, took only the question of maximised yield into account, regardless

of water quality. One would have hoped that there was wisdom gained from this error, but this activity continues elsewhere, even in Dares Salaam, where there are 300 boreholes, and a student is even researching the situation for a PhD! It is the engineers that drill the holes, and the government does not use the reports that are available to them.

Mine Water Pollution

Nikisi Lesufi, Environmental Adviser, Chamber of Mines of South Africa
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An overview of this presentation is as follows. I will deal with mining in its historical context, its economic legacy, its social legacy, and its environmental legacy. I will then examine mining in its current context, and factors that determine mining water quality impacts. Associated therewith are the site-specific issues, corporate policies, and regulatory framework.

We need to examine mining in its historical context. The positive legacy is that mining played a critical role in South Africa's economic development. Johannesburg rose from a mining camp, to a major African city. The negative legacies have been social issues. These include labour relations, with social and occupational health issues. Another negative legacy is mining's environmental footprint, with land and soil sterilisation, biodiversity degradation and water impacts. There have also been the regulatory and corporate inadequacies.

In current context, we now have regulatory (and legally enforceable) drivers (MPRDA – Mineral Resources Development Act), approved EMP (Environmental Management Programme), adequate financial provision that will include final closure plans, post closure issues. The National Water Act, water use licence authorisation, GN 704, M series operation guidelines, best practice guidelines, other legislations (NEMA, OHSA and more), corporate policies, and public pressure.

The following factors determine mine water quality impacts. There are the site characteristics, amount and type of material being moved, the depth of the deposit, the chemical composition of the ore and surrounding rocks, and the extraction process, together with the environmental management practices and business philosophy.

Impacts can include effluent discharges and acid drainage, groundwater alteration or contamination, the presence of hazardous wastes and chemical residues, and the handling of hazardous chemicals, safety practices, workplace exposure, including nuclear radiation.

Water pollution sources can include drainage from surface and underground mines, and wastewater and beneficiation. Acid mine drainage (AMD) arises from the interaction of acids and metals. AMD occurs in underground and at surface workings, and in tailings dams. There are consequent negative impacts on the ecology of water bodies and there is bio-accumulation, which can ascend the food chain. AMD also impacts upon underground water resources.

Acid mine drainage occurs when sulphide minerals in rock are oxidised, usually as a result of their exposure to moisture and oxygen, as a result of the mining process. Products are sulphates, mobilised metals, and acidity, which can have variable environmental consequences. It is therefore of utmost importance to the mining industry to know the characteristics/capacity of waste rock, overburden, pit walls, pit floor and tailings, and their propensity to generate acid mine drainage. Then, there is the issue of tailings and slimes disposal. Leachate arises from the accumulation of moisture or rainfall. Water percolates through slimes, and ingresses into groundwater. This impacts on recharge, aquifer pollution, surface water run-off, that has high salt and metal concentrations. There are return water dams, with ingress, runoff and overflows.

These elements impact upon the hydrological cycle, through surface drainage. The preventative measures that have to be taken are the planned siting of dams, considering prevailing geology and geography, that may influence the degree of pollution.

Tailings contain metals, minerals and other chemical residues that arise from the extraction process. It may be a mud, or a slurry. Bound contaminants are taken up into the water, and can include elements such as cadmium, zinc, and arsenic. Tailings dams can be very large, and have a negative aesthetic impact. They require continuous management, and present a potentially serious safety and environmental hazard. An example is the disastrous collapse of the Merriespruit tailings dam in 1994.

Effluent discharges can include sediment, disease-causing agents, eutrophic nutrients, organic chemical loads, inorganic chemical loads, radioactive material, and thermal pollution.

Mining uses return water dams, to allow for the concentration of salts. These dams have impermeable liners, to prevent surrounding soil ingress. Dams allow for recycling of water. There must be optimal management of any dam, to prevent groundwater and surface water pollution. There must be sufficient freeboard, to avoid accidental overflow, and surface run-off.

Evaporation pans can be used to decrease volumes, to be treated, by concentration of the salts. They have to be carefully designed, with impermeable liners, to avoid groundwater contamination. They are not favoured by Government Departments, being perceived as unsustainable and an unacceptable environmental risk.

There is the matter of groundwater salination. Groundwater salination load will depend upon water movement, time-frames, rock types, temperature, and salt load of the recharging water. Groundwater salt concentrations are typically much higher than those of surface water. Where the dissolved solids prevail in adequately low range (sometimes constrained by solubility limits) water can be used for many diverse applications, such as household, agricultural and industrial use. There can be occasional natural processes that may lead to high salt concentrations.

There are problems that can be associated with holdings and shafts. They can create a point of ingress for groundwater. This will impact on recharging groundwater volumes, rising water levels and surface decant, together with increasing concentrations of contaminants in the ground water.

Processing plants present their own problems. Processing may use hazardous substances that through improper management can leach to the groundwater system. Bioremediation can provide a treatment, provided that it is appropriate to the problem. Processes can require high water consumption, leading to resource depletion. Water discharge may have elevated dissolved solid content, and this will increase salinity in receiving water bodies.

Solid Waste can create the following problems. Open pit operations produce more waste than underground workings. Heaps of mine waste (and tailings dams) occupy vast areas of land. They disfigure landscape, as can be seen along the Witwatersrand goldfields. Wind turns these sites into dust pollution sources. We are fortunate in that there are regulatory mechanisms that cover all these matters.

Abandoned or "orphaned" mines create problems that are a contentious issue in South Africa. The corporate veil is used to absolve responsibility for their existence. The problem of taking over management of these sites has to compete with other social issues, such as unemployment and housing, for attention. Abandoned mines are no longer operational, properly managed, or rehabilitated. As a result, they cause significant environmental and social problems, for which no responsible party can be held accountable.

There are risk management approaches. When the economic performance is poor, a mine relies only on minimum compliance. With improvement, it will try and identify inherent risks, and make the necessary provisions. When everything goes well, only then will it implement comprehensive and sustainable practices. Many mines are categorised as marginal, and they cut corners, wherever they can.

DISCUSSION

Question (Mvundika): You talk of an environmental management plan, which must include an amount of money that is committed to rehabilitation. How is this done?

Reply: Before there is any mining activity, there must be an EIA. This report is then submitted to the various relevantly responsible government departments. Unaddressed issues are raised, with the request that they be addressed. After this process has been completed, the company submits an environmental management programme. This is a set of commitments as to how impacts will all be managed. This is costed at two levels. The first is concerned with on-going rehabilitation throughout the mining process. The second concerns that, which will remain at the end of the economic life of the operation, and will require rehabilitation. There is an income tax regulation that provides for contributions, throughout the life of the mine, for planned closure, and post-closure impact management. There is also the possibility of (unplanned) impact at any time. They have to be quantified, and adequate financial provision made for them. If it becomes necessary to close tomorrow, financial resources should be adequate to meet the costs of such decision. This could be in the form of a cash guarantee from a bank, or an insurance cover. This is applicable to all new mining operations. Old mines, existing before these regulations, now have to provide the Department with a programme, that will, in time, get them to a point where these abovedescribed guarantees can be met.

Question (Dia): Africa has many mining activities to manage. I have problems with respecting the commitment of mining companies. An environmental management plan is required, when a licence application is submitted. But the mining companies sometimes show no respect for these commitments, and the State ends up having to close the mine. Rehabilitation of these open mines is a large liability. What is your coordination between the mining and environmental sectors, and the water resources administration?

Reply: EMP is reviewable on an annual basis. The Department of Minerals and Energy, and the other relevant government departments, each year, have to visit the mine, and audit implementation against their plan. Corrective measures are taken, if pledges have not been met. Any decision on state closure of a mine has to depend on an assessment of current and consequent impacts, in terms of type and their extent. Mines are sometimes allowed to pollute on a controlled basis, this being regarded as the lesser of several evils, which may include a lay-off of many employees on closure. We had a case, where new ownership of a "bad" mine brought about a turn-around, and it is now a clean, responsible and successful operation. This underlines the importance of corporate ethics.

Governance as a Trialogue

Hanlie Hattingh, Water Resources Competency Area, CSIR
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I shall explain why the CSIR has decided to examine governance, specifically with respect to the water resources groups. I shall elaborate on the development of the governance Trialogue, and how we interrogated this governance Trialogue. I will deal with the outcomes and will examine some research themes. I will expand on (these new) CSIR Research Focus Areas, our vision, and our mission.

One may ask, why governance? We were in the process of formulating government departmental policy during the fiscal year 2003-4, specifically for the Department of Water Affairs and Forestry, when they identified implementation as a major outcome. We started investigating obstacles to what would be expected to be the normal processes of implementation. We identified a number of obstacles, both strategic and tactical, but the major problem was the lack of understanding of the concept, *governance*. We consulted literature, and spoke to people, and concluded that the term was vaguely defined. In response, we have developed a proposed Trialogue Model for Governance, to specifically apply to ecosystem and water governance.

The proposed Trialogue Model consists of three "players", these being Society, Government, and Science. Each of the "actors" has processes and interactions that occur within their domain. Science involves knowledge generation, and the natural, political and social science interactions. Government involves rule-making, rule application, and rule adjudication. Society involves itself, the economy and the environment. This constitutes three main active clusters, with their underlying and respective processes. There is an interface between each of these active clusters, and has more importance than the clusters, themselves. If the interfaces do not perform their role, there will be no governance. The quality of governance will be determined by the quality of interaction along these interfaces.

The Model is valid for all locations, world-over, but may be distorted in proportions, according to specific local circumstances. Different examples could be a young democracy, compared with a mature democracy. The mature democracy has already defined "rules of the game". The level of economic development could be a skewing factor, as well, as in a poor economy, basic needs are perceived as a priority.

We needed to test the Model and thus convened an International Symposium on Ecosystem Governance in 2005. The focus was on natural resources, but excluding activities, such as mining. There were eighty national, regional and international specialists present. Papers that interrogated the Trialogue Model were presented. Two international publications arose from these contributions.

Most participants accepted the Model as being viable as a basis for further development, and it can be applied in terms of policy development, implementation, and protection of natural resources. However, a number of questions were raised concerning the Trialogue Model and hypothesis. Questions raised were:

- What are the balances that will constitute good or bad governance?

- What constitutes the differences in the balance, when one compares one society or nation with another?
- When the model is applied in different site-specific situations, in different countries, one finds that there is a need to account for different power relationships.

We further asked contributors to develop a research agenda for ecosystem governance, based on the discussions during the symposium. Ten research themes were identified. The specialists raised research themes, as well as specific questions associated with governance, at international, national and regional levels. Themes that we re-identified are:

- Define governance, and explore the link between social and ecological systems more explicitly.
- Ground water governance is a huge area that needs investigation. There has been very little prior work, especially with regard to trans-boundary issues.
- Communication was identified as a major theme, as well as how interfaces are generated, considering the varied perspectives held by different role players, as regards governance. How can scientific information be effectively communicated to others, in all eleven official languages?
- There needs to be an integration, and a shared understanding of values and objectives. How do we integrate traditional knowledge with formal knowledge systems?
- There is focus on sustainable livelihoods. There must be planning for disasters.
- Then there is the question of indicators, and thresholds. How do we measure good or bad governance, and how do different site scenarios affect such assessment?
- There is the issue of participatory decision-making.
- The last point is leadership – without leadership, any initiative will fail.

I wish to spend time on the current activities of our new CSIR group. Our vision is to be the world-leading research group in sustainable implementation of integrated water resource management, for the equitable benefit of all in South Africa and Africa. Our mission is to conduct world-class, goal-directed, trans-disciplinary research and technological innovation, with partners and stakeholders, in the field of integrated water resource management, to contribute to the social, economic and environmental improvement of South Africa and Africa.

The group currently focuses on:

- transboundary governance (1 PhD),
- groundwater governance (1 PhD),
- integration, decision-making and values (2 PhDs),
- issues of scale (2 PhDs),
- linking socio-ecological systems (2PhDs),
- communication and learning systems (1 MSc).

DISCUSSION

Question (Dia): Do you think that you can facilitate dialogue between scientists and politicians? We need the advice.

Reply: Our water resources governance systems group is made up of natural scientists, social scientists, anthropologists, and political scientists. It took time to communicate at a common level. The magic formula is not there. We conduct workshops, and they enrich one another, through hearing each one's perspectives. This aids in finding common goals. The process is trans-disciplinary, and open.

Sanitation options

JN Bhagwan, Water Research Commission of South Africa
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My area of responsibility is in low-cost water supply and sanitation. Low-cost sanitation is a challenge to all developing countries, and this is the focus of my address. We work against huge backlogs, which create health and service issues, and knock-on effects on environment and the economy. There are targets to be met, and we face unintended consequences in the process of getting there, particularly when looking at conventional technology, as an option.

I quote from Eran Ben Joseph – *Sanitation Standards and the Shaping of Cities*: "The paradigm of sewer infrastructure shows that dependencies on past decisions prevent the application of alternative technologies. Historical decisions about the methods and systems for sewerage collection have locked our current practice into a specific mode of operation. Such a situation means that ecologically appropriate alternatives are rarely advanced as options before decision-makers, and therefore cannot gain wide acceptance".

We are trapped by the notion that there is only one option, disregarding other technological options as viable alternatives.

I offer another quote regarding the sanitation standards and the shaping of cities. "We can discover a difficulty in rightly judging the works of a city in the fact that innovations or changes are frequently resisted by those in charge, either from a force of habit, adhering to old customs, or from the inconvenience of altering existing laws". The author is Rudolph Hering, 1881, in Report of the Results of an Examination Made in 1880 of Sewerage Works in Europe. This is the common trap of habit. First world standards, applied to third world situations, can put service delivery beyond the reach of many citizens.

I show a picture of a ventilated improved pit (VIP) latrine, and Archloo, a VIP latrine constructed from local materials, and a urine-diversion toilet. The next slide is of Ascaris round-worms, and of tape-worms. This four-year old Kenyan girl, on deworming, voided this enormous mass of roundworms. The next is the life-cycle of the Schistosomiasis (bilharzia) parasite. There is elephantiasis from microfilaria. Flies are disease vectors. These are all related to sanitation (or lack thereof). When talking of sanitation, there is a tendency to focus on the facility, alone. Sanitation is about improvement of health, at individual and public level, and of the environment. It is about breaking of the so-called faeco-oral routes of disease transmission. About 90% of human diseases originate from faeces. Water is a medium for 15% of these illnesses. Hygiene and sanitation are thus paramount. Sanitation is about improvement of sanitation facilities (the toilet), hygienic behaviour, water drainage (including greywater and stormwater), creating awareness, dignity, and health improvement.

Sanitation approaches can be divided into two technologies. There are the dry, on-site VIP units, and derivatives (composting and anaerobic digestion systems), being the more "natural" exploitation of faecal disposal mechanisms. It is slow, but does not require water, and is suited to the individual household. On the other hand, there are the wet systems, such as septic tanks. Off-site wet systems include water-borne sewerage. This is commonly aerobic, and more rapid,

and controllable, attaining acceptable effluent quality. It is more communal in nature, and requires large volumes of water, both in terms of supply, and disposal, and only offers economy in terms of scale. Public health benefits of these reticulated systems have been proven over the past 200 years. There are troublesome consequences in the developing countries, however. Poor decision-making and support leads to inoperative treatment works. We see water supply, without the essential drainage. We see overflowing sewers from poor operation and maintenance, becoming a general and unstructured disposal conduit for all sorts of waste, including solid waste, creating both a health and environmental hazard. I show an example of a sprawling settlement, with dry sanitation, where cramming offers no space for a second pit, and there is no access for equipment to desludge these units, when they are full. There is hazardous leachate running down the streets. These are the unintended consequences of failure to plan ahead, often through having to acceed to political pressure. There are problems with poor construction and workmanship, problems with access for service equipment on steep slopes, and poor education, which leads to abusive damage of a facility.

Our objectives are to provide a sanitation service that is acceptable, reliable, environmentally safe and sustainable, does not contaminate water, is affordable to both the household and the municipality, has operation and maintenance requirements that are manageable, that supports good public health, and provides appropriate, affordable and acceptable sanitation in the poorer unserviced areas.

There are challenges. Sanitation intervention, and technology choice, is influenced by sustainability, affordability, environmental impact, user acceptability and demand, finances, political value, and available technology.

The challenges in these developing areas arise from inadequate finances for capital infrastructure, lack of understanding of the technology and its use, lack of competency and capacity, problems with affordability and cost recovery, fragmentation of technologies and their function, lack of operation and maintenance, lack of community participation, where uniform levels of service is inappropriate, and there is poor institutional support, and problems choosing the correct technology. There is also usually a lack in user participation. This is a problem that exists in all developing countries, and not only in South Africa.

Poor or rich, what to people want? It is the convenience of "flush and forget", as well as the status that this brings.

Options can be placed in four quadrants. One dimension is off-site, or on-site. The other dimension is wet or dry technology. Off-site wet systems are the conventional water-borne sewerage installations, the intermediate (Brazilian condominial) shallow sewer systems, and the small-bore systems (septic tank effluent drainage systems), and vacuum systems, that minimise water requirement. Then, there are the off-site dry systems, being bucket systems and chemical toilets. There are the more advanced on-site dry systems, such as dry digester units (VIP & variations), and desiccating / drying (urine diversion systems, and composting) installations. On-site wet systems are septic tanks, conservancy tanks, wet digesters, and customised packaged plants.

The emerging issues are as follows. Current approaches are very civil engineering orientated (in a narrowly focused sense). Research is "north (European) orientated", with less focus on "needs of the (undeveloped African) south". Project management style compromises the community and household-based approaches, and their engagement. Sustainability is overlooked (what happens when the pit is full?), with no forward planning for operation and maintenance. A ten-year design life can be the norm. These all, in time, have future consequences on environment, and on public health.

This is my view of what future focus should be on low-income areas, in terms of technology choices. Technology should always consider the situational need. We have the alternating twin pit urine-diversion ventilated latrine, and its derivatives. It is suitable in situations where there is only

a 25 litre/person water allocation, and where correct institutional support for this technology is available. As an on-site sanitation technology, it has a longer design life, and has easier access for faecal desludging, drawn from the alternating chambers. We have developed some of the Mexican concepts, and created hybrid and more permanent facilities, with municipal desludging being an adopted requirement. Dense low-income areas with adequate water supply (>50 litres/person/day) are amenable to the aforementioned Brazilian condominial sewerage reticulation, especially if drainage is an issue. Advantages are lower cost, the same user convenience, and its flexibility is more suited to unplanned areas.

I end on the topic of hygiene education. Experience teaches us that we need to do more about hygiene awareness. Hygiene education is not about coercion. Hygiene education is that intrinsic component of water and sanitation, which provides users with knowledge that will bring about behavior change. It is not the same as health education.

DISCUSSION

Question (Dia): Have you any pre-emptive or anticipative process regarding problems with informal settlements, their initiation and growth?

Reply: From the standpoint of the WRC, no, but the Department of Water Affairs and the Department of Provincial and Local Government, with the Department of Home Affairs, have a programme that studies these trends. There is a rural migration to urban fringes. These people come from a rural poverty situation, onto municipal or government owned land, these locations being easy points of entry. There are emerging entrepreneurs that tend to trap these people, and expand these settlement areas. As government finds proper housing for these people, more arrive, expanding the informal areas, even further. So, the backlog remains. There are dynamic and economic factors, where people rent their allocated formal housing to others, and elect to remain in the informal settlements. There is a department that keeps these matters under observation. Research shows that poor people elect for unstructured settlement in areas that are reserved for drainage, pipeline and power servitudes, where they have access to water, and drainage. Liabilities, legal and otherwise, arise on both sides, for both the service providers and those who occupy these servitudes.

Question: I see the advantages of the condominial sewage. But what are the treatment methods used for this system?

Reply: There are a variety of options. If it is not mixed with industrial wastewater, then one can use anaerobic batch reactors, sequencing batch reactors, which are low-energy-input high efficiency systems, which will produce effluent of requisite specification. If mixed and diluted by other wastewaters, then one needs to use trickling filters, or activated sludge basins.

SESSION 5

Knowledge Café Workshops

KNOWLEDGE CAFÉ

Identification of Water Resources Management Issues in Africa

Facilitator: Rivka Kfir
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Kfir: We have listened to a number of presentations, from the different countries, and we have heard many and various matters of concern. The purpose of the following session is to generate list of issues that relate to water resource management. We will go around the table, each person being asked to submit an item that he or she believes to be one of the three most important key issues of concern. This can be either in the context of their own country, or as perceived, as a consequence of what has been heard, thus far, at this meeting. All these submissions will be noted. The question is: "what can science and research do, towards addressing these areas of concern?" In terms of water resource management, it could be issues of quantity, quality, sustainability, or equity. In terms of resource, or use, it could pertain to mining, domestic, or other area, with the attendant, and inevitable consequences of pollution and sanitation. After this session, we will then re-group around three separate tables, and through interactive discussion, prepare a list of issues.

The compiled lists that were created are given below.

KNOWLEDGE CAFÉ – LINKING WATER RESEARCH AND MANAGEMENT (GROUP 1)

Water research issues in Africa

- Land use impacts*
- Climate change
  - Hydrological cycle
  - Variability and extreme events
  - *Eutrophication / algal-blooms, algal-toxins, water hyacinth
  - Land-use planning – long term impacts on water resources
  - Pollution of surface & ground water
- Monitoring systems
  - Compatibility
  - Remote sensing
  - Computer science
  - Economically optimal modelling system
- Institutional definition between Water Services provision and WRM
- Funding for research programmes *(*linked to Institutional technology… – see last bullet)*
- Science / policy linkages / users / private sector / NGOs
- Long term futuristic scenario building in WRM
- Technological innovation for water supply and sanitation
  - More cost effective
- New technology for water storage in arid zones

- Institutional technical capacity / resources / laboratories for data analysis (research infrastructure)
- Improved productivity of water in agriculture (water use efficiency for all uses)
- Improved water and waste efficiency
- Long-term water availability and assessments
  - Planning
- Water pricing and true value of water
- Environmental flow assessments
- International convention sharing water
  - Transparency equity and peace

Additional:

- Water Asset Management
- Participatory approaches is research project cycle
- Risk assessment – disaster, health etc
- Guidelines and standards for water use and waste management
- Gender roles in WRM
- Water and Energy e.g. jatroha, hydro-power
- Managing ungauged rivers

Modalities for effective R&D (S&T) cooperation

- Mobilising research funds
- Research agenda has to be in line with continental partners/regional/ local e.g. AU, NEPAD – respective level issues
- Active participation and co-operation with international bodies
- Capacity building (cross-cutting)
- Networking – water professionals
- Mobility of researchers
- Grounding post-graduate students in Africa (incentives for retention of researchers in Africa)
- Scope for blue-sky research
- Public participation beneficiaries' involvement in defining research agenda
- Funding for research programmes
- Science / policy linkages / users / private sector / NGOs
- Database of African Water Researchers
- African Water Research Facility to coordinate research
- Creation of centres of excellence to share research expertise
- National Research foundation per country
- African water research network similar to WISA
- Strengthen role of Academy of Sciences – link researchers to policymakers
- Water to future more prominently in Academy of Science

KNOWLEDGE CAFÉ – LINKING WATER RESEARCH AND MANAGEMENT (GROUP 2)

Water Research Issues in Africa

1. Data gathering for water quantity and quality
2. Need for coordination of research (National, Regional, Continent)
3. Appropriate technologies (water, wastewater, sanitation)
4. How to manage water with limited data
5. Holistic management of groundwater and surface water

6. (Interrelationships) Environmental impact of anthropogenic activities (e.g. pollution)
7. Climate change
8. Efficient water use: Industrial, domestic, agriculture
9. Effective constitutional arrangements and frameworks
10. Infrastructure and asset management of water systems: dams, canals, treat distribution
11. Gender issues
12. Ecosystem functioning
13. Water resource assessment and planning
14. Water and energy (solar, hydro, wave...)
15. Use of innovative technologies (satellite, nanotechnology, membranes...)

Modalities for effective R&D (S&T) cooperation

1. Research sharing and dissemination in Africa (society, website, newsletter, journal, conferences...)
2. Networking – communication between researchers
3. African water research facility (coordinate funding and research)
4. Database of African researchers and research
5. Exchange programme (both professor, researcher and student)
6. Creation of centres of excellence
7. Country-based foundation for water research
8. Strengthen and mobilize the political will
9. Strengthen Academies of Science to mobilize the political will
10. A unified African presence in international water research bodies
11. Sourcing of funding without donor agenda attached
12. Improving research condition of researchers to avoid brain-drain
13. Standardizing monitoring and other systems
14. Strengthening of Intra-African capacity
15. Enable blue-sky research

KNOWLEDGE CAFÉ – LINKING WATER RESEARCH AND MANAGEMENT (GROUP 3)

Water Research Issues in Africa

- Integrated Resource Assessment
- Water quality and pollution
- Climate change and variability
- Appropriate technologies
- Water pollution
- Over-exploitation of water research (sustainable use of water)
- Governance of water
- Competing & interest – water allocation
- Safe water
- Decision-making systems and data management – data gathering methods
- Knowledge application
- Socio-cultural issues (participation)
- Environmental water use (reserves)
- Management with limited data
- Groundwater – surface water integrated management
- Infrastructure asset management

- Water asset management
- Climate change and pollution resource vulnerability
- Risk management (disaster, health)
- Hygiene education
- Water supply and wastewater management
- Participatory approaches
- Environmental impact for anthropogenic activity
- Water storage technology
- Techniques for desalination
- New or improved desalination technology
- Sanitation

Modalities for effective R&D (S&T) cooperation

- Cooperative networking
- Local and centralised coordination
- Open publication (e-publication)
- Infrastructure
- Commonality of interests
- Sharing of resources
- Mobility of expertise
- (Un)integrated management structures
- Easy access to resources
- Focus of capacity building
- Retention of existing skills (Remuneration and training, career prospects)
- Champions in search of research excellence
- Research findings – Linkage to policy-makers
- Promoting science-tech culture
- Research plans – lobby decision-makers (interaction) – policy agenda (capacity importance of the academies enhances)
- African facility for research funding
- Active participation in (viz) international programmes
- African Conference on Water
- "Who's who" of African researchers (database of some form)
- At a country level – fund for water research
- Centre of African Excellence
- Exchange programmes
- Standardised monitoring systems

KNOWLEDGE CAFÉ

Capacity Building and Funding

Facilitator: Rivka Kfir
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Kfir: In yesterday's three groups, we discussed modality, modality being modes of cooperation. Do we need to itemise and prioritise this area?

Question: are modalities not the consequence of the research priorities?

Kfir: Some modalities are generic. We need to identify commonalities that will work in synergy.

Proposals were made for new labels or categorisations. One of these would be an enabling environment. Referring to Table 2, Issues, Modalities, one could include points 11,12 and 15, and add thereto, the grounding of post-graduate students in Africa. Items 1 to 5 could be grouped as science and technical cooperation. These listings need clustering, to emphasise the relationships of one to the other.

Question (Dia): What is the objective of what we are doing? Will this be a message to the authorities, or a message to the African members of IAP?

Kfir: The IAP Programme tries to harness the academies, world over, in the quest for research capacity, and ultimately into water resource management. There are other African initiatives, like NEPAD, that try to be centres of excellence, and foster research connectivity in Africa. Thus, one should not focus on the IAP programme, alone, but look some form of integration of the various endeavours that are taking place. This workshop can report on what we believe are ways to improve water research in Africa, for better water management capacity. The idea is that the IAP will carry this forward to the general Academy assembly, where there is collective strength, where they have the ability to promote funding for some functional structure, able to turn wish into action. We are not simply here to generate another document. We wish to exert influence.

Cortesão: This is a first meeting, at which we are trying to identify issues, and build and agenda. IAP, and most of the academies, will not undertake research, themselves. Their focus is on the capacity-building of managers, bridging science and management, in each country, enhancing water management capacity. Thus, it is important to identify where we are operating, on a broader horizon. We can focus more on specifics, as we progress. The five objectives, identified by IAP, are development of local capacity-building and water resources management, networking of researchers and managers to enhance water management capacity, improvement of policy and decision-making processes, bridging science management with government and civil society, increasing public awareness on water issues, to bring the major international water programmes to the table, to discuss complimentary work with them, and to avoid irrational duplication of effort. This is the vision, which should help us in our exercise.

Dia: I attended a meeting at Alicante (Spain), at the close of which there was a call for action, declaration, and endorsement.

Cortesão: There was an initial difficulty in settling the focus, with respect to the establishment of the Water Programme. One view was an integrated and holistic water-shed management, with a discussion that concentrated on groundwater management. The prevalent view in IAP has

been that a systematic view should be adopted. As capacity building is developed, then specific actions on groundwater could follow, but this would constitute a specific focus. The Alicante declaration was not an IAP declaration. There is a defined process, as to how IAP issues any declaration. Proposals are submitted to the board of the Academy of that country. Individuals have subscribed, in their independent capacity, to the Alicante declaration. Individual Academies may do likewise, but this particular declaration was not an IAP statement. It can become one.

Dia: I know. What we need, is to voice the message from Africa. We only had two African countries at that meeting.

Cortesão: That initiative was not organised by the IAP Water Programme. The Spanish Academy of Sciences proposed the activity, had discussed it with one of the co-chairs, and we accepted it, with support, but it was not organised, initially, by the IAP Water Programme, as you may have seen by reading the invitation that was sent to you.

Kfir: The WRC has been aware of these initiatives, and of the IAP Programme. We are represented on NEPAD, as well. Our DST started an initiative, a while ago, the OECD, that dealt with capacity building. We invited Prof Tundisi from Brazil, to engage with the NEPAD representatives. We have an involvement with several initiatives, yet we ask whether there is sufficient funding, in addition to other resources needed, to back all of these efforts? We need to resolve this situation. With no research ability, there can be no capacity in management. We are here to make some contribution, directly to the IAP Water Programme. Kevin will take it through to NEPAD, for Africa. Today's opportunity is better than that which has been provided by other previous workshops. The African Departments of Science and Technology all interact with NEPAD's science and technology initiative. Looking at our lists, are not all of these items concerned with an enabling environment?

Comment: I support and prioritise the idea of clustering. If we cluster too much, however, then issues of specific action may become diluted. I recommend a list of five, from each of us.

Kfir: You may cluster, or submit a specific activity, as you choose.

Dia: I submit the following: Creation of Centres of excellence; African water research network; science policy linkage to user; mobility of researchers; strengthen the role of the academy.

Next contributor: Networking, database (a sub-element thereof) of African researchers; research sharing and dissemination in Africa (groups, meetings, newsletters, publications); creation of funding mechanisms at national and regional (continental) levels; African water research facility/national research foundation for water; strengthening the national academies, mobilising/influencing political will (in an independent manner); linkages between policy-makers; creation of a centre of excellence.

Next contributor: Creation of centres of excellence; mobilisation of research funds; capacity-building (researchers and infrastructure... linked to centres of excellence); networking; sharing and dissemination of information amongst researchers.

Next contributor: Research sharing and dissemination to be part of the Africa water network. The other points have already been covered.

Next contributor: Create a proper institutional framework, at national level, for research. This includes coordinating bodies.

Tungaraza: Integrated management/focus of centres of excellence (addressing fragmented research/implementation), multi-disciplinary integration, coordination of research facilities.

Cortesão: Foster research conditions/environment that counteract adversities of brain-drain, under the umbrella of creation of an enabling environment.

Kfir: We could deal with financial issues, but they are somewhat outside our sphere of control. We should focus on capacity building, for water resource management, as it is the key issue of the IAP programme. Capacity building can mean different things of different people (students, managers). We need to define capacity building for water resource management.

Dia: We need a split. We had a training course, called the Lake Victoria tropical management, and we had many managers, with monodisciplinary training, and little knowledge of the catchment-integrating factors. The training needs to be interdisciplinary, to open up their minds, in terms of new solutions.

Tungaraza: Is research not part of capacity building, through the gathering of knowledge for water resources management (WRM)?

Contributor: There will be the overall policy of WRM. Within this will be the research, training and management (decision-makers) components.

Cortesão: One needs to increase public awareness and participation in policy-decisions. This should also cover operators and plant managers. This could then be integrated with centres of excellence, which would provide an environment for networking of researchers, related to the capacity building in water research, provision of training courses (managers and operators), developing activities to enhance policy and decision-making, as well as public awareness. These would all be better articulated through these centres of excellence.

Kfir: Do we not have to build capacity in government for technical capacity for monitoring skills?

Cortesão: This depends on the country. It will be the government in some, by universities in another. Databases are consequently scattered, without a communication network.

Kfir: University databases are aimed at research, and not necessarily aimed at WRM. It is not the source of information that is commonly used by government for decisions regarding WRM.

Olago: Operators work with (non-technical) managers, in order to implement policies at ground level. In Kenya there is a strong case for building technical capacity in laboratories. They have had no further training since their higher national diploma, or BSc. There has been no exposure to latest technology. There is a lack of proper training in instrumentation, and lack of support for instrumentation in water quality laboratories. This needs to be another bullet to the centre of excellence heading. Laboratories can be national, or private.

Tungaraza: With reference to the managers/operators; they embrace the technical laboratory technicians? We are dealing with WRM. Many of those, who are responsible, do not need laboratory facilities, but are active in the field. Operators include all those involved in the activities of WRM.

Kfir: The works and plant operators (water services) may monitor their own operations, but we are considering a different institution, where at a government level, there are information and databases regarding water quantity and quality, at national, and not local level.

Dia: If you consider Senegal's framework of management, there is the ministry, then a national company, who must elaborate on policy. Then there are the technical departments, in which there are the engineers, who monitor all projects. There may be a private company, in charge of distribution, and a technical department that has to undertake the monitoring of the operations of this company. Moreover, it has to report compliance or non-compliance with standards that have been set. The role of these bodies has to be emphasised. The role of the manager and the technician in monitoring is different. They have problems in the execution of their responsibilities, through lack of capacity.

Kfir: it is an issue of monitoring, regulation, and enforcement, at all levels, and can extend to matters such as public awareness in water conservation. Do we need cross-cutting capacity building in government? What is our role?

Comment: We should not lose emphasis on water research, as a prime focus.

Kfir: If we produce sufficient students, does this create a mobility of these people to government, to populate this level to an adequate degree?

Comment: In the short term, no, but in the long term, yes. The current responsibility is water research with its supporting portfolio.

Cortesão: This is correct, in a sense, in terms of what the role of the academies should be, in terms of fostering water research in each of the countries. But there are two discussions.

One is the need for development of capacity building, with several initiatives in action, from the IAP Water Programme and each of our own institutions (universities, and so on). The other is unclear. The IAP Water Programme will not fund research, per se. We could have specific research, or even a study, developed on WRM or development of capacity, as well as water resources research and management, though IAC. This serves as a background to our discussion. IAP will not develop a training centre, or a centre of excellence. This, along with other local institutions, will be the domain of the best strategy of that country, either to develop existing facilities, or initiate additional ones. These institutions will have their own research priorities. The IAP Water Programme can focus on capacity building in management. This has to be integrated with the capacity building and research that will have to be done, not by IAP, but by the institutions.

Kfir: There was a workshop in Brazil. When they spoke of capacity building in (water resource) management, what was their approach?

Cortesão: The other workshops had an understanding on an action in capacity building for managers, operators, on technical monitoring, regulators, and on initiatives, to increase public awareness or address policy and decision makers. This would be developed within the programme. This has to be anchored on the requisite water research, which will not be developed by IAP, or by the academy.

Kfir: If we need capacity building (for WRM), what is it that we require, to achieve this (in human terms)? Pick three issues. What is Africa's initiative towards the IAP Programme, through cooperative structures to build WRM in areas other than in research?

Tungaraza: There needs to be multidisciplinarity in the composition of those involved. Data collection and management must be in the hands of those who are able and informed in such matters.

Kfir: But what can we do to make this happen, at IAP, that there will be capacity, in our country, for WRM? This must come from our side, not from elsewhere. Training can be multidisciplinary.

Cortesão: This will be a cross-cutting issue.

Tungaraza: I put forward (routine) analytical skills. The last point is general knowledge on water science, relating to pollution, interactions, and other factors that affect quantity and quality of available water.

Rugumayo: I focus on courses on WRM. Long courses will include MSc and PhD.

Cortesão: IAP will foster the creation (compile curricula) of postgraduate courses, but will not implement them.

Rugumayo: Would you finance study?

Cortesão: Not from IAP funds.

Rugumayo: Workshops and seminars will build capacity.

Comment: Sharing of information, through purpose-written publications and research briefs, with managers. We can provide them with a list of expert consultancy services (water experts).

Comment: I have one item, a short course on EIA methods, and major (recent) developments in the field.

Comment: Mobilisation of funding resources, for capacity building. This involves the academies.

Tungaraza: This is a dilemma for academic institutions, having to solicit funds for enabling government institutions (the water managers). It is possible at the collaborative research level.

Kfir: But is this not different, in being action research, involving decision makers and practitioners? It is nevertheless, as good point to record.

Dia: How do you involve the decision maker?

Kfir: We send them the proposal, and ask them whether they believe that the outcome will be of use to them. They become part of the process and are obliged to attend (progress) meetings. This retains some form of on-going mutual interaction and understanding, between them and the scientists.

Comment: I ask about the involvement of decision makers. I thought that we were concerned about building capacity.

Kfir: You build their capacity for involvement. They may first have to attend courses, for example, before they can understand the nature of their involvement.

Comment: We have an example, dealing with adaptation options to drought. The district coordinator for the area is involved from the start. We discuss implementable measures, how to conduct pilot projects, and what assessments should be done. His knowledge base increases, as a result of this interaction with a whole range of other experts.

Dia: Facilitating researcher mobility through an international exchange programme.

Kfir: You need to build capacity between the decision maker and the operators..... not the researchers.

Dia: I accept. The problem with decision makers at technical/academic level is that they lack common grounds for mutual understanding. Training courses and seminars are needed, and facilitating mobility meets part of the need.

Kfir: Some people in technical departments of the water utilities also service chairs at the universities. Some of you have also been in government. This exchange and mobility, in itself, builds capacity.

Tungaraza: there is an overseas facility, where people from industry are invited to spend a short period at a university. Individuals from the university reciprocate by spending time in industry, to experience problems from another perspective.

Kfir: there are the dual appointments, especially in the Netherlands, and in Germany, where individuals work both in academia and in industry.

Dia: We have this arrangement in Senegal (I hold two positions).

Cortesão: This all relates to fostering centres of excellence. We will not, at first, have centres of excellence in all countries, but this is our goal. We should try and identify, in each of the regions, where we can build on existing institutions and structures, including centres of excellence, which could foster regional capacities in WRM. For this, we need the training courses, workshops that bring different actors together, to address water issues, through a multidisciplinary approach, to influence policy and decision-making processes, to enhance public awareness, networking of researchers and managers (though water associations – WISA, in South Africa), including conferences, international, national and regional. We need to create an atmosphere for research enablement.

Kfir: I have separated workshops from centres of excellence, as one does not necessarily need a centre of excellence for a workshop.

Cortesão: We must bring, to the table, the different programmes and initiatives, to discuss common action, in the avoidance of duplication of effort. We must stimulate publications, which are targeted at capacity building.

Olago: As an example, we have a manager of water resources in Pretoria, and we, at our academy, can have papers that can be put into a brief, to be sent as information to this manager. I refer to this form of publication.

Kfir: I think that we have covered the major issues. The third and final Knowledge Café session will deal with action plans. The issue of finance can be incorporated into this session.

KNOWLEDGE CAFÉ

Implementing the S&T Action plan

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Kfir: There is a need to formulate an action plan, arising from the discussions that were held yesterday. We reviewed our African water vision, the issues, and modality, for effective research cooperation. Each of the two groups raised five issues, and they were compiled in an order, without assigning any hierarchical importance to them ("1,2,3..."). Key research issues were identified as the following: availability and compatibility of monitoring systems, for both quantity and quality; technological innovation in both water storage, supply and sanitation; identification and development of appropriate technologies; anthropogenic impacts on the environment; resource quality degradation and pollution; water use efficiency, and the application of water allocations; surface-ground water interactions, including transboundary resources; climate change issues.

We examined modality for cooperation, and we decided that the key modalities are the creation of centres of excellence, African water research networks, science policy user linkages (trialogue approach), mobility of researchers, and strengthening the role of the academy (this links to science policy). We need to strengthen the water element within the academy, and the role of the academy within the country, and as a voice abroad.

There is a need for research on management, to build management capacity. Research approaches should be multidisciplinary/holistic/integrative. There should be networking in the use of laboratories and facilities. The African research network needs to compile a researcher database. There should be information-sharing and dissemination through societies, newsletters, journals, and conferences. We have examined the science policy user linkage, and how influence could be exerted, locally or globally, through IAP. We have identified the need for mobility of researchers/students, by various means, including exchange programmes. We need to strengthen the role of the academy to influence political will, and to support the creation of an enabling environment for the retention of scientists and researchers in their respective countries, through the academies, and through the IAP programme. There should be creation of an institutional framework and funding mechanisms at national and continental level, including a coordination body, such as an African water research facility, and a national research foundation for water research. These will provide the institutional framework.

We discussed capacity building for water resource management. We addressed the IAP focus. We need capacity in water research; having the scientists. We need capacity building for policy and decision-making. We need capacity at manager and operator levels, for water services, as an example. We need capacity at technical level, for monitoring and regulation, in quantity and quality assessment laboratories, be they government institutions, or otherwise, to provide water resource data for planning and management. We need capacity in terms of public awareness and participation. Capacity is thus a combination of several components, with the centres of excellence playing an important role. We talked of capacity building for water resource management under the umbrella of IAP. We need to develop short courses (such as EIA), training material, using the integrated multidisciplinary approach. We need to develop analytical skills for routine analysis

and a general knowledge of water science, including issues that affect water quality and quantity; we need to publish. We focused on course development (MSc, PhD) that can involve the various universities in the African structure, and elsewhere. Publications are to be shared with managers (research briefs, for communication at an appropriate level of mutual understanding); lists of services that can be provided by water experts (the academies can play a role). Funds need to be secured for all these undertakings. There must be on-going involvement of decision makers in research programmes (steering committee meetings). We need to facilitate mobility within the academies, and advocate dual appointments, such as posts in government while also being in academia. These mixed roles augment capacity. Decision makers can participate in training at universities; scientists can participate in government. We spoke of workshops, to promote water resource management and enhance public awareness, and networking between researchers and managers (WISA being an example). IAP and national academies should promote a research culture, build an enabling environment, and should have common actions, avoid duplication of effort, and build on common issues.

In the light of all this, what will be the key action proposals that we would wish to put forward? Discuss this in pairs, raising five actions, with their proposed mechanisms for their efficacy.

Karar: My group has six points. The outcome of this workshop must be communicated to the other African academies that are not represented here today. This should be done by ASSAf, and the IAP.

Cortesão: We have been trying to get the academies to nominate a national focal point. This has not yet been done, and it is part of creating this global network. We need to foster their involvement through e-mails, letters, telephone calls, and personal contact. There will be a meeting in Lusaka in January, where this can be dealt with.

Karar: NASAC (African network) can be lobbied, to establish a water programme that is affiliated to the IAP.

Cortesão: We have achieved such a water programme in the Americas. NASAC is new network, and might not yet have the official initiatives. We could suggest that NASAC initiates and supports a water programme, which would work jointly with this existing IAP one.

Karar: The third point is for this group, after endorsement from the absent members of the African academy members, and after discussions with NASAC, is to take these outcomes of this meeting to the IAP conference general assembly, that meets in December.

Cortesão: There will be a water symposium, as a satellite meeting, on this occasion. It will be a good opportunity for this group to convene there, with the others who were not present at this current meeting.

Karar: Between now and December, we could get feedback from these other academies that have been not been represented at today's meeting.

Cortesão: Each of us should report back to our own respective academies, to make this an issue for the academies themselves, and not just for a national focal point.

Karar: The other action item is a database of water researchers, and the need to start populating it. We could use African Water, as a beginning, as the web site exists, being hosted with WEDEC (University of Loughborough, UK), and owned by EU. We (WRC) can act as a post office, but the responsibility lies with all of us to provide the required information.

Kfir: How difficult is it to locate it more as an African database, as an objective, in the sustainable long-run?

Karar: This could be borne in mind. Continuous data updates will be needed, as people move around constantly. The next point is identification of key role players in the continent, NEPAD, AMCOW, AMCOST, and interact with them, as they are already established structures.

Kfir: But this does not constitute an action plan. We can ask someone from the WRC, like Kevin (Pietersen) to do this?

Dia: There is also the next AU meeting, which is also an opportunity.

Kfir: Eiman (Karar) is involved with the database. You can continue with information that is given to you? We need NASAC to give us names. Who will communicate these outcomes to the other academies, and to get them to participate – Marcos (Cortesão)?

Cortesão: It should really be someone from your (African) region.

Kfir: We will assign this responsibility to the ASSAf and the IAP. We also need to lobby the water programme through NASAC. Mohammed Hassan, and Prof Dia are the appropriate persons. What is our time frame for all these actions?

Cortesão: Could we have another meeting, like this one, during the IAP general assembly, for report-back? This work needs to be completed by the end of November.

Karar: This will have to include a consolidated endorsement, with a legitimate request for funding.

Kfir: This meeting in Egypt will allow for planning of further developments. We need to take the outcomes to the IAP Assembly in Egypt.

Cortesão: South Africa, as the African focal point, will be responsible for that.

Kfir: I nominate the ASSAf and the WRC. Next, today's participators are each to report back to their respective academies, and we would be eager to receive their response. We can now review longer term objectives. One is publication of the state of water resources. There are current (UN) global assessments, but they are "crude".

Cortesão: We had people from major international water programmes at the Brazil meeting, last month, and their impression was that there was no such thing as a compendium for the Americas, or for Africa, on the state of the art of water management, water research, existing water supplies, or problems and challenges. These are all long-term issues.

Kfir: We also need to consider financial implications. Daniel (Olago) and Kevin (Pietersen) can work together.

Cortesão: Consider it, and in December, we can see what is happening in the other regions. The proceedings of this meeting must be well circulated. Our water programme will be launching a web site in a month. The idea will be that each region will have an allocated space, where all documents can be uploaded, for easy access.

Kfir: You are asking for an African corner on the IAP web site?

Cortesão: There will be the information, that we have, but regions can involve themselves, which will be even better. Let us wait until December.

Kfir: Can we have the contributions from the next group?

Rugumayo: Our points are: Networks of centres of excellence (long term). Identify existing centres. Establish criteria for selection.

Kfir: NEPAD has already done this. It is a very political procedure. Can we not "piggy-back" on this exercise? We could accelerate NEPAD, and influence matters concerning the centres of excellence. Parallel operation is both costly and wasteful.

Dia: I can give a report to the Ministry of Science in Senegal (where the NEPAD science and technology drive is located).

Kfir: I am allocating this to Kevin (Pietersen) as well, as he can start to drive it.

Olago: The second point is concerning the network, with database, in the long term. We have to work through the national focal points for establishing this African network for water research and sanitation. We need to identify a coordinating centre, which the previous group has dealt with. We need criteria.

Kfir: How do you establish this?

Olago: We ask what this network is supposed to do, and who will host it? We already have this listed.

Kfir: We can move this item from short to longer term. UNESCO may have available funding. We have to interact with NASAC. We can use the WRC as a focal point, if wanted, as well as the

ECA, and the African Development Bank. We can also consider IWA, and EU, for support. We need a mission (what do we intend to do). Will anyone around this table volunteer to take this responsibility? Uganda, Cameroon, and South Africa accept; thank you.

Olago: Point number three is science policy user linkages (long term). These are actions for the National Academy. Next, is to establish links with national science institutions and stakeholders. Lastly, is to enhance dialogue through workshops, public lectures, preparation and dissemination of briefs, seek recognition through influence by legal status of the academy, where such legal recognition (parliamentary act) is not yet in place.

Karar: Legal status does empower any entity. But if you are informal, and voluntary, you have the freedom to say what you wish, whoever, or wherever you may be.

Olago: The idea is that there are many kinds of structures. A legal framework (in a way, a government endorsement, through enactment) helps credibility, and will get others to listen to you.

Dia: I agree. We received our legal status, by presidential decree, at he start of this year. I accept that some academies have problems, through lack of legal or formal recognition.

Cortesão: Could this not be marked for discussion at NASAC?

Kfir: May I add legal recognition, with the rider of no loss of independence of view?

Olago: We identify mobility of researchers. The task of the water network (and the academy) is to identify existing opportunities for exchange (fellowships). Many of these are available through independent organisations. We have to collate this information, and distribute it. Next, under institutional framework and funding mechanisms, is to lobby for the establishment of this national research foundation for water. The academies (for each country) will attend to this. We need closer collaboration with AU and NEPAD. Lastly, there is the necessary liaison with other international funding agencies.

We identify funding/lobbying for the creation of the African foundation for science and technology. Restriction to the subject of water, alone, will create difficulties. At this stage, we include water. This will be done through NASAC. Prof Dia and Kevin (Pietersen) can be involved in the communication, for NEPAD.

The final listing, refined and compiled by Dr Kfir, is given below.

WATER RESOURCE MANAGEMENT IN AFRICA – CAPACITY BUILDING ISSUES

The African Water Vision 2025: "An Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation and the environment"

Linking Water Research and Management

- Water research issues in Africa
- Modalities for effective research and development (science and technology) cooperation

Group 1 - 5 key research issues

1. Monitoring system availability and compatibility and data gathering
2. Technological innovation and water supply and sanitation and storage
3. Environmental impact due to anthropogenic activities
4. Water use efficiency
5. Climate change

Group 2 - 5 key research issues

1. Quality degradation and pollution

2. Appropriate technology identification and development
3. Surface water/ground water interactions
4. Data gathering and monitoring (quality and quantity)
5. Climate change

Key research issues

- Monitoring system availability and compatibility, and data gathering and monitoring (quality and quantity)
- Technological innovation and water supply and sanitation and storage - appropriate technology identification and development
- Environmental impact due to anthropogenic activities - quality degradation and pollution
- Water use efficiency
- Surface water/ground water interactions
- Climate change

Modalities for cooperation – key issues

- Creation of centres of excellence
- African water research network
- Science policy users linkage
- Mobility of researchers
- Strengthen the role of the academies

Modalities for Cooperation – key issues

- Creation of centres of excellence (research and management capacity building, holistic approach, integrative research, lab research facilities)
- African water research network
  - Africa researcher database
  - Research sharing and dissemination (society, newsletter, conference, journal, etc.,)
- Science policy users linkage
- Mobility of researchers (exchange)
- Strengthen the role of the academies (influence the political will)
  - Support the creation of enabling environment for retention of scientists/researchers
- Creation of institutional frameworks and funding mechanisms at national continental level (coordinating bodies, African water research facility, National Research Foundations for Water Research)

Capacity Building

- Capacity building for WRM
  - Capacity Building for water research
  - Capacity Building for policy and decision-making
  - Capacity building for manager/operators (managing water services)
  - Capacity building for technical monitoring and regulators
  - Capacity building in technical water quality/quantity labs (data to support resource planning management)
  - Public awareness and participation

Capacity building for WRM – IAP Focus

- Capacity building in WRM
  - Short courses - Training material using multi-disciplinary approach
- Short course Environmental Impact Assessment (EIA),

- Develop analytical skills for routine analyses
- General knowledge of water science, issues affecting water quality and quantity (publications)

- Focus on development of courses (MSc and PhD)
- Publications shared with manager e.g. research briefs
- List of services that can be provided by water experts
- Mobilise funds for the above
- Involvement of decision makers in research
- Facilitate mobility – exchange, dual roles, decision makers take part in training, two ways approach, participation in actual research
- Centres of excellence (to mobilise funds, develop the courses, give courses)
- Workshops to promote WRM, enhance public awareness
- Networks between researchers and managers (national, regional, Africa, conferences)
- IAP or and the national academies stimulate research atmosphere (enabling environment) Common actions, avoid replication of effort, build on common issues

Implementing an African S&T Action Plan

- Action proposals
- Support mechanisms

Implementing an African S&T Action Plan – deadline Nov 2006

- Communicate outcomes of this meeting to the other African Academies – Participants, ASSAF/ IAP(associated to IAP) - aim is to get them to joint this group
- NASAC – to lobby a water programme affiliated to the IAP (e.g. Latin America) Prof Dia
- Thereafter, take the outcome to IAP assembly in Egypt, December 2006 (meeting of this group or a wider group) ASSAF/WRC
- Participants to report back to their academies
- Share the outcome of the meeting with NEPAD, AMCOST, AMCOW, AU (next meeting of AU is about S&T) - WRC

Implementing an African S&T Action Plan – longer term

- Publication regarding state of WRM for Africa (SA -Kevin and Kenya –Daniel, format, funds)
- African corner in the IAP website – ASSAf
- Centres of excellence - accelerate NEPAD activities, influence the format, mobility/exchange Prof Dia, Kevin Pietersen
- Develop and populate a data base - use EU project as the basis, and look for a long-term African based home (e.g. NASAC, NEPAD) -WRC plus academies, NASAC
- Establish a African network for water (sanitation) research – Uganda, Cameroon, SA, identify a focal point, criteria, ToR, mobility/exchange (UNSCO, NASAC, ECA, ADB, EU, GEF, etc)
- Actions for national academies
  - Establish links with stakeholders
  - Enhance dialogue through workshops, public lectures, briefs
  - Seek recognition through the legal framework where appropriate
  - Lobby for NRF for water (share modalities)
- Lobby for the creation for African Foundation for S&T (to include water) – Prof Dia, NASAC, Kevin- NEPAD
- Improve S&T applied expertise in Africa (NRF and Africa Foundation)
  - Network
  - Conferences
  - Centres of excellence

2006

IAP Water Programme: Regional Workshop for Africa. Proceedings Report

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