IMPROVING THE MANAGEMENT OF WATER RESOURCES FOR SUSTAINABLE DEVELOPMENT IN AFRICA AND THE AMERICAS

WORKSHOP PROGRAMME, ABSTRACTS AND LIST OF PARTICIPANTS

12-15 October 2015 – Hilton Hotel, Nairobi, Kenya

IANAS
INTERAMERICAN NETWORK OF ACADEMIES OF SCIENCES

Leopoldina
Nationale Akademie der Wissenschaften

United Nations Educational, Scientific and Cultural Organization
Organisation des Nations Unies pour l'éducation, la science et la culture
Regional Office for Eastern Africa
Bureau régional pour l'Africa de l'Est

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Bundesministerium für Bildung und Forschung

IMPROVING THE MANAGEMENT OF WATER RESOURCES FOR SUSTAINABLE DEVELOPMENT IN AFRICA AND THE AMERICAS

(A workshop bringing together water experts in Africa and the Americas, policymakers in the water sector and stakeholders from both academia and industry)

12-15 October 2015 – Hilton Hotel, Nairobi, Kenya

W O R K S H O P   O B J E C T I V E S

1. Take stock of the relevant issues in water for the African and the Americas Continents;
2. Share experiences and exchange ideas on how science can influence water policy in Africa though regional networks (IANAS and NASAC);
3. Maximize circulation of and reference to the NASAC's policymakers booklet entitled: *The Grand Challenge of Water Security in Africa: Recommendations to Policymakers;*
4. Facilitate dialogue between scientists and policymakers and seek better mechanisms for continuous engagement; and
5. Encourage national uptake of policy advice on water emanating from regional level though NASAC and IANAS.

P R O G R A M M E

Date/Moderator	Time	Activity
DAY I: MONDAY - 12 October 2015		
	8:30am-9:00am	Registration of participants
OPENING SESSION		
Moderator: **Jackie Olang**, NASAC	9:00am-9:45am Opening and welcome remarks by NASAC and Local academies • **Prof. Bernard Aduda**, Network of African Science Academies • **Dr. Katherine Vammen**, InterAmerican Network of Academies of Science • **Dr. Abou Amani**, UNESCO Regional Office for Eastern Africa • **Prof. Salif Diop**, African Academy of Sciences • **Prof. Raphael Munavu**, Kenya National Academy of Sciences • **Eng. Philip Gichuki,** Nairobi City Water and Sewerage Company • **Representative of Ministry of Water and Irrigation**, Government of Kenya	
	9:45am-10:00am	Purpose of the workshop and highlights of NASAC activities on Water Science-Policy Booklet ***Dan Olago***, Chair, NASAC Water Steering Committee
	10:00am-10:30am	<u>**KEYNOTE ADDRESS:**</u> Water Security, Climate Change Adaptation, Mitigation and Resilience In Africa **Salif Diop,** Senegal
	10:30am-11:00am	***Group photo and refreshment break***

Date/Moderator	**Time**	**Activity**
SESSION 1: EUTROPHICATION AND WASTEWATER MANAGEMENT		
Moderator: **Abou Amani**, UNESCO	11:00am-11:20am	Case studies on Eutrophication in Venezuela ***Ernesto Gonzalez,*** Venezuela
	11:20am-11:40am	Role of Water Research Commission in managing eutrophication and wastewater ***Jennifer Molwantwa***, South Africa
	11:40am-12:00pm	Current state of eutrophication of lakes and reservoirs in Colombia, South America: Sources and management plans ***Gabriel Alfonso Roldan***, Colombia
	12:00pm-12:10pm	Plenary Discussion/Q&A
	12:10pm-12:30pm	Success and challenges of landscape interventions to reverse land degradation in the Ethiopian highland **Seifu Tilahun,** Global Young Academy-Ethiopia
	12:30pm-12:50pm	Challenges for the sustainable management of urban water supply and sanitation systems in Senegal – Case study of Dakar ***Cheikh Becaye Gaye***, Senegal
	12:50pm-1:00pm	Plenary Discussion/Q&A
	1:00pm-2:00pm	**Lunch break**
SESSION 2: WATER AND CLIMATE CHANGE ADAPTATION		
Moderator: **Ronald Ng**, Mauritius	2:00pm-2:20pm	Challenges from municipal to catchment to national scales in adapting to climate change in South Africa's water sector ***Roland Schulze,*** *South Africa*
	2:20pm-2:40pm	Lessons from the great California drought ***Henry Vaux,*** USA
	2:40pm-3:00pm	Water and Climate Change in Uganda ***Mark Henry Rubarenzya***, Uganda
	3:00pm -3:15pm	Plenary Discussion/Q&A
	3:15pm-3:30pm	**Refreshment Break**
	3:30pm-3:50pm	Adaptation to climate change in the sector of Santiago de Chile: Lessons from a megacity perspective ***James McPhee***, Chile
	3:50pm-4:10pm	Cross-boundary adaptation and mitigation strategies ***James Phiri***, Zambia
	4:10pm-4:30pm	Innovative technologies for the sustainable wastewater management and climate change mitigation in Ethiopia ***Seyoum Leta***, Ethiopia
	4:30pm-4:45pm	Plenary Discussion/Q&A
	4:45pm-5:00pm	General discussions and conclusions for the day
	6:15pm	Participants assemble at the hotel lobby to proceed for the Group Dinner at a nearby local restaurant

Date/Moderator	Time	Activity
DAY II: TUESDAY - 13 October 2015		
SESSION 3: WATER, ENERGY AND AGRICULTURE		
Moderator: **Woldeamlak Bewket**, Ethiopia	8:30am-8:50am	Smart Village approach to the water-energy-food nexus ***Muhammad Tayyab Safdar***, Smart Villages, UK
	8:50am-9:10am	The water-agriculture-energy nexus ***Katherine Vammen,*** IANAS Water Programme
	9:10am-9:30am	Improving the management of water and energy resources for sustainable development in Nigeria **Mosto Onuoha**, Nigeria
	9:30am-9:45am	Fracking: A new source of natural gas ***Henry Vaux,*** USA
	9:45am-9:55am	Plenary Discussion/Q&A
	9:55am-10:15am	Water for agriculture: Key considerations for sustainable irrigation systems design and management in sub-Saharan Africa ***Mathias Fru Fonteh***, Cameroon
	10:15am-10:35am	Implementing sustainable agricultural practices in Grenada and other small Caribbean islands to prevent pesticide contamination of water sources ***Martin Forde***, Grenada
	10:35am-10:55am	Potential role of indigenous knowledge in crop production – looking back into the future ***Albert Modi***, South Africa
	10:55am-11:05am	Plenary Session/ Q&A
	11:05am- 11:30am	***Refreshment break***
SESSION 4: WATER QUALITY AND QUANTITY		
Moderator: **Hyppolite Agboton**, Cameroon	11:30am-11:45am	Use of Isotopes to assess the charge and recharge mechanisms of aquifers and water quality ***Yousuf Maudarbocus,*** Mauritius
	11:45am-12:00pm	Urban floods in Dakar, Senegal: Reflection on the role of risk factors ***Seynabou Cisse Faye***, Senegal
	12:00pm-12:15pm	Risks to environmental sustainability of a proposed canal through Lake Cocibolca in Nicaragua ***Salvador Montenegro-Guillén***, Nicaragua
	12:15pm-12:30pm	Impacts of climate change on water resources in Cameroon: Facts, vulnerability and adaptation strategies ***Samuel Ayonghe,*** Cameroon
	12:30pm-12.45pm	Water Quality, Water Security, Water Governance: New Challenges for IANAS and NASAC ***José Galizia Tundisi***, Brazil
	12:45pm-1.00pm	Plenary Discussion/Q&A
	1:00pm-2:00pm	**Lunch break**

Date/Moderator	Time	Activity
SESSION 5: ROLE OF REGIONAL NETWORKS ON CONTINENTAL WATER ISSUES		
Interactive Panel Discussion: Among policymakers and academicians **Moderator:** **Nahashon Miguna** NCWSC, Kenya	2:00pm-3:00pm	***What do Policymakers want done by regional networks? Can regional networks of academies deliver on water sector expectations by influencing policy direction***? • **Moses Beckley**, Nigerian Hydrological Services Agency • **Richard Mavisi Liahona,** Kenyan Ministry of Education, Science and Technology • **Katherine Vammen,** IANAS Water Programme • **Brhane Gebrekidan**, Ethiopian Academy of Sciences/NASAC • **Alain Nindaoua Sawadogo,** National Academy of Science, Arts and Letters of Burkina Faso/NASAC
	3:00pm3:30pm	Plenary discussion/Q&A
	3:30pm-4:00pm	***Refreshment break***
SESSION 6: MODELS FOR INTEGRATING SCIENCE ADVICE INTO STI POLICIES FOR WATER		
Talk Show: Moderator: **Paul Baki** KNAS, Kenya	4:00pm-5:00pm	**What needs to be done to influence science-friendly policies at various levels of the water sector in Africa?** • National – **Tendani Nditwani,** SA-DWS • Sub-Regional – **Abou Amani**, UNESCO • Regional - **Thameur Chaibi**, GIZ/AUC PAUWES • Intercontinental – ***Yousuf Maudarbocus,*** NASAC
	5:00pm-5:15pm	Plenary discussion/Q&A
	5:15pm- 5:30pm	General discussions and conclusions for the day

	6:30pm-8:30pm	***Launch of the NASAC Water Policymakers' Booklet*** ***Cocktail Reception and Dinner***

DAY III: WEDNESDAY - 14 October 2015

SESSION 7: FIELD TRIP TO THE NAIROBI WATER AND SEWARAGE PLANT

Field trip to the Nairobi City Water and Sewarage Company (NCWSC)

- NCWSC Ndakaini Dam – **10:00am to 12:30pm**
- NCWSC Ngethu Water Treatment Works – **2:00pm to 4:00pm**

From 8:00am - Participants should assemble at the Hilton Hotel Lobby by 7:30am
(*Refreshments and lunch to be provided*)

4:00pm-4:15pm General discussions and conclusions for the day

Date/Moderator	Time	Activity
DAY IV: THURSDAY - 15 October 2015		
SESSION 8: FURTHER DISCUSSIONS ON PERTINENT ISSUES		
Moderator: **Michael Onyango** NCWSC, Kenya	8:00am-8:20am	The freshwater imperative: Critical reflections on sustainability of water resources in Zimbabwe **Taurai Bere**, Zimbabwe
	8:20am-8:40am	Emerging Nanotechnologies for Water Purification ***Shem Wandiga***, Kenya
	8:40am-8:50am	Plenary discussion/Q&A
	8:50am-9:40am	Participants go into one of three groups • ***Group 1***: How can academies meaningfully engage industry to bring positive change in the water sector? ***Lead:*** **Salvador Montenegro Guillén,** Nicaragua • ***Group 2***: How will massive development of water infrastructure and water use affect water quality, when social impact and biodiversity implications are taken into account? ***Lead:*** **Kenneth Mavuti**, Kenya • ***Group 3:*** How can water stress be managed against increased water demands in Africa? Is water security attainable in developing countries in the short term? **Lead**: **Salihu Mustafa**, Nigeria
	9:40am-10:00am	***Refreshment break***
	10:00am-10:45am	Groups Report back – 10 minutes feedback from the groups and 5 minutes plenary discussions each
SESSION 9: LEVERAGING SYNERGIES FOR IDENTIFIED GAPS		
World Café Activity: *(20 minutes rotation per sub-theme for group discussions)* Moderator: **Phyllis Kalele**, South Africa	10:45am-11:45pm	Question for discussion: **Based on workshop deliberations, please discuss and identify existing information gaps (relevant to Africa) on the following sub-themes**: • ***Group 1***: Eutrophication and wastewater management • ***Group 2***: Water and climate change adaptation • ***Group 3:*** Water, agriculture and energy
	11:45am-12:15pm	Presentations from group discussions *10 minutes each per group*
CLOSING SESSION		
Moderator: **Dan Olago**, Kenya	12:15pm-1:00pm	• Summary of workshop conclusions and recommendations • Next steps • Closing remarks • Vote of thanks and end of workshop
	1:00pm-2:00pm	***Lunch break***

ABSTRACTS OF PRESENTATIONS

0. KEYNOTE ADDRESS

0.1 Water Security, Climate Change Adaptation, Mitigation and Resilience in Africa[1]

SALIF DIOP[2]

***B**ased on the 4th and 5th IPCC reports, it is predicted that the following changes are likely to occur before the end of this century, including:

- An increased temperature of 2 to 4 degrees Celsius or more;
- A decreased rainfall of up to 20%, and a sea level rise that could eliminate agricultural land and move millions of people off their lands;
- Climate change and variability that will negatively affect rainfed agricultural productivity in many parts of Africa as a whole, with more or less important variances occurring in several places and localities;
- Various other changes and modifications that are likely to happen in response to a great variability in the global climate, including extreme aridity in some cases, and flooding in others.

***B**ased on an analysis of such facts and findings, it has become clear that integrating climate change risks and opportunities into development decision-making is a key challenge facing us, particularly for the most exposed African countries, which are most vulnerable to the negative impacts of climate change. There are many implications of climatic variability and change in Africa, including impacts on water resources and hydrological systems, water availability, water resource management and sea level variations, in a nutshell on water security as a whole. Thus, managing the combined impacts of climate, demographic and economic change in Africa is as much a political and development challenge as a technical climate change challenge.

***I**t is well known that the status of water resources in Africa has been changing for many decades, with decreasing water quantity and quality, sinking groundwater levels, more or less changed timing of rainfall, etc.. Indeed, changes in this domain are not new. Nevertheless, climate change will strongly accelerate the rate of these changes, affecting the ability of people and societies to cope and to respond in a timely manner to them and their impacts. Within this framework, managing high rates of change in a context of uncertainty is a challenge for African governments. The main responses to be directed to this effort must include increased resilience at the household, community, national and trans-boundary or regional levels. Increased resilience will enable people, particularly those living in poverty, to respond more effectively to climate-related changes and to recover more quickly from related disasters.

***T**he key elements of resilience are poverty eradication and access to appropriate scientific information in order to make adaptation and mitigation to climate change a development challenge and achievement for Africa.

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[1] *MEETING of NETWORK OF AFRICAN ACADEMIES OF SCIENCE (NASAC) & INTERAMERICAN NETWORK OF ACADEMIES OF SCIENCE (IANAS); "IMPROVING THE MANAGEMENT OF WATER RESOURCES FOR SUSTAINABLE DEVELOPMENT IN AFRICA AND THE AMERICAS" - Nairobi, Kenya - October 12th - 15th, 2015*

[2] ***Professeur of CAD University – Dakar - Senegal; Member of the National Academy of Sciences and Techniques of Senegal (ANSTS), the African Academy of Sciences (AAS) and the World Academy of Sciences for the Advancement of Sciences in the Developing Countries (TWAS). P.O. Box: 5346 – Dakar-Fann, Senegal.***

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SESSION 1: EUTROPHICATION AND WASTEWATER MANAGEMENT

1.1 Eutrophication of reservoirs in Venezuela

ERNESTO J. GONZÁLEZ R.
Universidad Central de Venezuela, Instituto de Biología Experimental.
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Venezuela has more than 110 operating reservoirs that have been built for diverse purposes: drinking and industrial water supply, irrigation, flood control, recreation and hydropower generation. However, their misuse and human activities in their basins have generated several problems. Reservoirs are located in areas with different kind of impacts, from those located in protected areas (low impact) to those which have low or no protection (high impacts as pollution, erosion and water level decrease), showing conditions from oligotrophic to eutrophic, respectively. Water translocation is used to regulate water level of many reservoirs, but when the sources have high nutrient load, the water bodies result affected, increasing their trophic state in few years. In this study, data from 15 Venezuelan water bodies (most of them are used for drinking water supply) were assessed, in order to show the relationships between nutrients and phytoplankton biomass (as chlorophyll *a*). The systems could be separated according to low (<20µg/l) and high (>20µg/l) total phosphorus concentrations. Furthermore, in reservoirs with low NO_3:NH_4 ratios, Cyanobacteria were dominant, and other phytoplankton groups were dominant in high NO_3:NH_4 ratios. Results showed a significant linear relationship between chlorophyll *a* concentrations and nutrients, both phosphorus and nitrogen. Also, linear relationships were found between phytoplankton biomass, zooplankton abundance and zooplankton biomass. Measures taken to enhance water quality in two reservoirs (La Mariposa and Pao-Cachinche) are also discussed. The implication for management of these results is that the control or mitigation of eutrophication in Venezuelan reservoirs should be based on an improved management of the drainage basins, rather than simply that of the reservoirs themselves. For the protection of water bodies and their basins, it is imperative the interaction of all actors in society: scientists, politicians, enterprises, users and organized communities.

1.2 Success and challenges of landscape interventions to reverse land degradation in the Ethiopian highland

SEIFU TILAHUN
Global Young Academy - Ethiopia

Seifu A.Tilahun[1], Tammo S.Steenhuis[1,3], Getaneh K. Ayele[1,2] , Dessalegn C.Dagnew[1,2] , Faskaw A. Zemale[1,2], Mamaru A. Moges[1,2], Christian D.Guzman[3], Assefa D Zegeye[3], Eddy J. Langendoen[4], Charles F. Nicholson[5]

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[3] *Department of Biological and Environmental Engineering, Cornell University, Ithaca, NY*
[4] *US Department of Agriculture, Agricultural Research Serice, National Sedimentation Laboratory, Oxford, MS*
[5] *Department of Supply Chain and Information Systems, Pennsylvania State University, University Park, PA*

Land degradation has become a serious problem in the Ethiopian highlands. Land degradation has increased erosion and reservoir sedimentation and reduced crop productivity. In order to reverse this trend the Ethiopian government and donors have implemented massive upland soil and water conservation practices in the past four decades. Since 2012, as part of Growth and Transformation Plan (GTP) of the country, communities were mobilized to invest two months of their time in implementing soil and water conservation practices. The research group at Bahir Dar University with international partners is conducting research on six upland watersheds in the Blue Nile Basin to evaluate current soil loss, sediment transport, impact of conservation practices and challenges in landscape interventions. Soil loss in the watershed reaches upto a maximum of 500 ton per hectare per year. The sediment yield ranges from five to seventy-five ton per hectare per year. Most past interventions focused on the upslope (and steeper) areas neglecting the downslope areas, where gullies are located. The interventions to reduce this high soil loss and sediment yield since 1980's were effective for short time as the sediment concentration and sediment yield got back to the original order of magnitude. All the interventions in the past had focused on the steep slope hill-slope areas neglecting the downslope areas, where gullies are located.

The results show that interventions in 1980's were effective only for a relatively short time as the sediment concentration and sediment yield returned back to the original levels due to lack of maintenance of the installed practices. Severity of gully erosion is presently increasing. In some cases, 95% of the sediment loss originates from gullies. Our evaluation of current practices in GTP, showed that in the short term direct runoff and sediment yield decreased while sediment concentration remained the same. Any upland reduction in sediment was negated by the entrainment of unconsolidated sediment in the gullies from the collapsed banks and upward head-cut migration. In 2013, in the Bir watershed (one of the six watersheds) we tested rehabilitation of shallow gullies (less than 4 m deep) with community participation. Gully rehabilitation resulted in conservation of 5500 tons of soil with marginal rate of return of 10. Farmers rehabilitated voluntarily five gullies in 2014 after initial resistance in 2013. Landscape interventions in the Growth and Transformation Plan for the next five years, should include treatment of gullies at downslope areas in addition to increasing infiltration of rain water in the degraded upslope areas.

1.3 Role of Water Research Commission in managing eutrophication and wastewater JENIFFER B. MOLWANTWA

Dr JB Molwantwa[1], Mr P Venter[2] & Dr M Mathews[3]
Water Research Commission; Department of Water and Sanitation & Cyanolakes

The National Water Research Commission (WRC) of South Africa has been involved in the funding of the research that is aimed at better understanding the cause of eutrophication and the determination of ways to reduce or sustainably deal with this challenge. One of the longest running eutrophication management programmes in South Africa is the Haartbeespoort Dam Remediation Programme (HDRP) which commenced in 2006. This programme utilizes a multi-pronged approach including harvesting of algae, use of constructed floating wetlands and dredging amongst other interventions. Funded by the Department of Water and Sanitation (DWS), the programme has yielded success in that there is currently a stabilized dam conditions. However, the management of eutrophication in this case study has indicated that there is a requirement for sustained funding and that there associated benefits are not only water quality but social and economic benefits. Currently, the WRC is in the process of reviewing this case study in order to advise the DWS on the way forward.

While there are other projects also funded, the WRC has recently funded a 3-year project that will see satellite earth observation integrated into a national water quality monitoring programme of the DWS. The project is entitled "The integration of Earth Observation into the National Eutrophication Monitoring Programme (EONEMP)" which will be led by Dr. of CyanoLakes (Pty.) Ltd.

The project will exploit data collected by satellites in space, mainly from the European Space Agency, to dramatically increase the ability of government, commercial industry and the public to view and obtain accurate, current information on water quality in dams. This will lead to a significantly improved ability to manage and mitigate the harmful effects of potentially toxic cyanobacteria blooms and nutrient enrichment (eutrophication), which are widespread in SA dams. This new ability has potential positive benefits for a number of sectors including public health and safely, the environment, agriculture and fisheries, and can be extended to significantly improve monitoring of the oceans and estuaries, with many benefits to industries such as aquaculture and water purification. The project makes use of groundbreaking South African-led technological innovation enabling the DWS to be the first national government department in the world to embrace satellites for routinely monitoring water quality.

The success of such a program requires a sustained investment effort to fully enjoy the benefits of this technology. Data volumes from satellites will in the near future amount to several terrabytes per month requiring big-data handling capabilities, and investment in significant dedicated infrastructure. While the raw data are available free from the European Space Agency, there is a need for significant co-investment to make full use of satellites for societal benefit. This includes data capturing, analysis and manipulation into meaningful information that can be used for social benefit. In this regard, the WRC has put the 3 million Rands investment and will use the information from this project to influence decision making, develop human capability (skills transfer) and real time use of research products in national monitoring programme. This project will hopefully influence other potential beneficiaries such as other government departments and private sector to make more investment in earth observation data collection. Given the industry's potential for commercial applications, the sector has an increasing ability to contribute to economic development, job creation and public benefit.

1.4 Current state of eutrophication of lakes and reservoirs in Colombia, South America: Sources and management plans

GABRIEL ROLDÁN

Gabriel Roldán, Dr. rer, nat. Director of Publications, Colombian Academy of Exact, Physical and Natural Sciences. E-mail: groldan@une.net.co

Colombia is located north of South America, has an area 1,200,000 square kilometers and a population of 44'000.000 people. Most of the population lives on the Andes Mountains where agricultural and industrial activities are carried out. It has mountains with heights up to 5,400 m with numerous glacial lakes. Most are oligotrophic, but at lower heights, lakes begin to be eutrophic due to human activities. There are numerous lakes and ponds at sea level for highly eutrophic effects of mining, agriculture, livestock and deforestation. Large reservoirs are designed to generate energy and water supply for cities. They are located on average between 1,000 and 2,000 m. Since the basins are highly used for agricultural activities and inhabited by large cities, these reservoirs are very eutrophic. As in the tropics temperatures remain more or less stable throughout the year, there is no mixing of the water, so the bottom of reservoirs remain anoxic all the time. Usually, oligotrophic lakes and reservoirs have very low levels of nitrogen (0.2 to 0.5 mg / L) and phosphorus (0.01 to 0.05 mg / L) .The hardness and alkalinity are also very low, between 10.0 mg / L and 40.0 mg / L, respectively. In very eutrophic waters, these values can reach up to 10 times higher or more. The transparency of the water is very low, averaging between 1.0 and 2.5 m Secchi Disk. Chlorophyll values can be up to 300 mg / L or more in hypereutrophic reservoirs. These water bodies show a deep green color and give the appearance of being a vegetable soup. Phytoplankton is varied and is often found as toxic algae as *Microcystis* sp. Most of the lakes and reservoirs in Colombia are invaded by aquatic plants, which is an index of eutrophication. The most common plants are "Water Hyacinth" (*Eicchornia crassipes, Hydrilla* sp, and others.

Only about 3% of the cities have wastewater treatment plants. There is a big activity of fluvial gold mining which pollutes water resources with mercury, cyanide and millions of tons of sediments. There is also much deforestation of the rainforest, causing loss of fertile soil due to the heavy rains that are on average between 2,000 and 4,000 mm annually. In the Pacific coast rainfall occur up 12,000 mm of rain, one of the highest in the world. There are few management and prevention measures in the basins. These are usually affected by many human activities, which is already very difficult to control.

1.5 Challenges for the sustainable management of urban water supply and sanitation systems in Senegal – Case study of Dakar

CHEIKH BÉCAYE GAYE
Department of Geology, Faculty of Sciences and Techniques
University Cheikh Anta Diop
Dakar, Senegal

Productive aquifers underlying African cities constitute an invaluable resource that, if managed well, can sustain and expand access to safe water as well as act as a buffer to climate variability and change (Taylor and Tindimugaya, 2012). Under conditions of rapid urbanisation, urban aquifers are vulnerable to contamination from indiscriminate waste disposal including most significantly in Sub-Saharan Africa, faecal effluent from on-site sanitation facilities (Kulabako et al., 2007; Taylor and Tindimugaya, 2012). Adaptive responses to urban groundwater contamination in Europe and North America have commonly involved the importation of water from less-polluted environments but such solutions are constrained not only by the availability of water from remote locations but also the costs of doing so. In Dakar (Senegal), there has been a substantial amount of research applying geochemical indicators to assess the impact of the urbanization on groundwater quality. For example, sources of nitrate have been traced using stable isotope ratios of O and N in nitrate (Re et al., 2010; Diedhiou et al., 2012); contamination from trace elements (B, Br, Sr) has also been mapped (Cissé Faye, 2012). This information has been used to identify different sources of urban recharge.

SESSION 2: WATER CLIMATE CHANGE ADAPTATION

2.1 Challenges from Municipal to Catchment to National and International Scales in Adapting to Climate Change in the South African Water Sector

ROLAND E SCHULZE PhD, PH, FRSSAf
Emeritus Professor of Hydrology
Centre for Water Resources Research, University of KwaZulu-Natal
Pietermaritzburg, South Africa

When projections into the future are assessed, the prospect of climate change places specific and unique challenges to hydrologists and water resources planners which need to be addressed now already in light, *inter alia*, of hydraulic infrastructure having a long design life, being extremely expensive and once constructed, being essentially irreversible. Amongst the key challenges identified in the South African water sector when evaluating climate change impacts and possible adaptations across the scales from local / municipal to international / sub-continental are that water has a memory from upslope to downslope and within a catchment, that changes in thresholds of runoff exceeded are more important than changes in means, that there is an amplification from changes in rainfall to corresponding changes in runoff, especially in the case of design events, that changes in air temperature translate into complex changes in water temperatures with environmental and water quality consequences, that components of hydrological outputs such as stormflow or baseflow have different sensitivities to climate change, that over South Africa climate change will be superimposed over widely differing hydro-climatic zones ranging from summer to winter rainfall regions and from hyper-arid to humid zones, and that changes in future rainfall-runoff events will occur over already largely anthropogenically altered landscapes and channel-scapes. In the presentation outputs from multiple GCMs, downscaled and bias-corrected to local levels, illustrate the above challenges and a range of adaptation options for the different water sectors are discussed.

2.2 Lessons from the Great California drought

HENRY VAUX, JR.
University of California

California is suffering through one of the severest droughts on record. This drought is worse than in the past partly by virtue of recent economic and demographic growth that contributes to water use patterns that are probably not sustainable in any event. The persistent overdraft of ground water is one example. The lessons from this drought are not new but are more compelling due to increasing pressures on water supplies and water management practices that ignore the essential aridity that characterizes the state.

2.3 Water and Climate Change Adaptation in Uganda

MARK HENRY RUBARENZYA

Uganda is richly endowed with water resources including surface water (rivers, lakes, wetlands) and groundwater. The latter constitutes an important water source, especially in the drier regions of the country which are also susceptible to long dry spells. However there exists significant spatial and

temporal variability in these water resources. The country is highly vulnerable to climate change and variability being that the economy is largely dependent on rain-fed agriculture.
Some of the major issues that are currently facing the water sector as a result of the changing climate include depreciating water quality, decreasing water quantity, increasing variability, conflicts amongst water users, increasing numbers of extreme events, increased food insecurity, water related disease, damage to infrastructure, biodiversity loss, and emerging risks to water supplies to some large urban centres.

In response to these challenges, the government, stakeholders, and development partners are implementing climate change adaptation measures designed to mitigate the effects of climate change while enabling the communities to adapt and build resilience. Disaster preparedness has been made a national priority especially in areas that are frequently affected by floods, landslides, and dry spells. Vulnerable communities have been resettled away from disaster-prone areas. Early warning systems have been installed for trial for some communities that are prone to flash flooding. A catchment based water resources management approach has been adopted, that allows all stakeholders to participle in all stages of water resources management. In addition the government is investing in providing water for agricultural production.

Policies have been put in place to guide the government's response to climate change including a Sector Policy Strategy, and the creation of a Department of Climate Change within the Ministry of Water and Environment.

2.4 Adaptation to climate change in the sector of Santiago de Chile: Lessons from a megacity perspective

JAMES MCPHEE

Chile's capital city, Santiago, is a city of six million people located in one of the regions of the world likely to experience some of the most significant changes in climate due to global change. Warming of 2ºC or more and precipitation decreases between 10 and 30% with respect to historical conditions are projected by most global circulation models. Under these projections, the regional government has undertaken a process aimed at identifying areas where adaptation to climate change could be successful and significant. In an area where municipal, industrial and agricultural water uses coexist, adaptation necessarily must break with the status quo in terms of water management. This challenge is exacerbated by the multiplicity of stakeholders, and a lack of centralised decision-making and planning. This presentation highlights the strengths and weaknesses of the current water resources management system to tackle adaptation to climate change, highlights the methodological aspects of effective group planning and seeks insights that could be generalised to other metropolitan areas.

2.5 Cross-boundary adaptation and mitigation strategies

JAMES PHIRI

Abstract to be availed

2.6 Innovative technologies for the sustainable management wastewater and climate change mitigation in Ethiopia

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Environmental pollution from industrial activities is a serious problem in Ethiopia as industries discharge untreated or partially treated wastes into environment potentially affecting the health of people and the environment. It is estimated that only 10% of the existing industries treat their wastewaters to any degree, while the majority (90%) discharge their effluents directly into nearby water bodies and open land without any form of treatment. The agro-process industries discharges different types of wastes into the environment, primarily in the form of liquid effluents containing organic matter, heavy metals, sulphide, ammonia and other salts. The discharge of untreated wastewater affects water quality, causes eutrophication, lower oxygen in water bodies and thus fish kills, generates methane which is a greenhouse gas and causes nuisance to people due to foul smell resulting from generation of sulphides. Our studies on the pollution profile of tanneries along Modjo river, indicated that the mean pollution load of a typical untreated composite tannery effluent contains a mean value of pH above 10, COD more than 10,000 mg/l; BOD more than 5000 mg/l, sulphide above 500 mg/l, total N above 1000 mg/l and chromium more than 60 mg/l. The existing waste management approach in the country are conventional type and thus do not innovatively add value to the wastes in recovering nutrients (Nitrogen & Phosphorous) and bio-energy to improve agricultural productivity, contribute to the ever increasing energy demands in the country, and reduce GHG emissions.

In order to ensure that environment is sustainably managed in Ethiopia, innovative systems were developed for treating industrial wastewater-taking tannery wastewater as a model- through two stage bio-digestion to produce biogas and treatment in a sequencing batch reactor connected to a constructed wetland to remove nutrients, residue organic matter and heavy metals (chromium) to meet national discharge standards. The overall objective of the project was to put in place a model innovative integrated agro-process wastewater treatment system involving wastewater treatment, energy and treated water reuse in Ethiopia to serve as a prototype for wider application of the technology in collaboration with Modjo Tannery, as private sector partnership. The study on the treatment performance of the integrated anaerobic-aerobic reactors connected to the constructed wetland showed removal efficiencies ranging from 90-99% for COD; 80-90% for BOD; 85-95% for TN; 90-98% for TP; >90% for NO_3-N; >85% for $NH4^+$; >90% for S^{2-} and $SO4^{2-}$ and >95% for chromium. The biogas generated from the integrated pilot technology is also ranging between 15-25m3/day with the composition of CH4 (72.4%) and is currently being used to replace wood fuel in the Modjo tannery cooking processes.

The prototype is now turning the industrial wastes into energy and clean water as well as other value added products-linking energy, water and environmental sustainability which effectively address the sustainable development goals (SDG). The innovative solution has also changed the industrial site into green eco-village disproving the perception that “waste has no any perceived value.” The target is to up-scale and roll-out of the technologies to other small–medium sized industries in the country.

SESSION 3: WATER, ENERGY AND AGRICULTURE

3.1 The Water-Energy-Agriculture Nexus

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Agriculture demands 70% of water use globally. The availability of water has an impact on the quantity of energy supply and the generation of energy affects the availability and quality of water. Worldwide the management of these three resources is becoming more difficult due to the acceleration in the economy and considering climate change pressure. As opposed to energy and agriculture or food security, water has no substitute or alternative ways of production of the resource with the same quality. It is important to better understand the relationships between the three resources in order to create better management schemes considering trade/offs of different options to improve the efficiencies and productive uses of water, energy and agriculture.

3.2 Improving the Management of Water Resources for Sustainable Development in Nigeria

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Nigeria as a nation has abundant water resources potential, but these resources are not equitably distributed across the land. Apart from the Niger and Benue Rivers which constitute the most important river systems in the country, other relatively large and fairly significant rivers and their flood plains abound. Available water resources include surface water (about 267 billion cubic meters) and a groundwater (over 92 billion cubic meters). Rainfall is also quite abundant in many parts of the country, constituting another important source of water in the areas where rainfall is abundant, e.g. the areas near the coastland where mean annual rainfall is in excess of 3000 mm. The management of water resources has traditionally been left as a task for the Federal and State governments. Successive governments have historically hinged their water resource management efforts mainly, (i) on increasing the access of the population to safe water for drinking and other domestic purposes, and (ii) ensuring that more water is made available for irrigation purposes in order to boost agriculture and food production. While these goals are noble, the outstanding challenge remains how to achieve these objectives at reasonable and affordable costs amidst competing economic needs in the nation, and in a manner that is environmentally sustainable.

A disproportionate number of Nigerians (over 70 million people), particularly those living outside the urban areas still do not have access to potable drinking water. However, the supply of water for irrigation purposes has been improving over the years. The distribution of groundwater resources is expectedly determined by the prevailing geological environment. Basement complex areas cover about 50% of the Nigerian landmass while sedimentary formations make up the rest. Diverse factors govern the accumulation of groundwater in basement complex areas, but the most notable ones are the thickness of the regolith covering the fresh, unweathered crystalline basement rocks, and the presence of faults and degree of fracturing of these basement rocks. Where the weathered part of the basement ((i.e. the regolith) is sufficiently thick groundwater potentials are usually higher. Sedimentary formations have greater potentials for the accumulation of surface and groundwater.

In order to manage the nation's water resources in an environmentally sustainable way, it is imperative that such a management system must incorporate details on how to deal with issues like water availability, changes in water use and shifts in demand, climate change induced factors, and changing patterns of population movements in response to economic factors security considerations induced by the security challenges being faced in some parts of the nation. Apart from making adequate provisions for hydropower, irrigation, and water for domestic and other uses, our water management system must also effectively tackle water-related problems like soil erosion and gullying, seasonal flooding of parts of the country, and drought. Undertaking adaptive water management systems would be the most ideal for the nation, but such systems are currently being hampered by lack of the physical structures and institutional frameworks needed.

3.3 Fracking: A New Source of Natural Gas

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Hydraulic fracturing or fracking is an new and innovative technology which allows the recovery of natural gas deposits previously tied up in close rock formation. The technology works by injecting water and chemicals into appropriate geological formation for the purpose of fracturing the rock and releasing the natural gas contained therein. Fracking is now widely practiced in the United States and the consequence has been to provide a large new sources of relatively cheap energy. It is also beginning to alter the patterns of global trade in energy. Trade patterns are likely to be altered further as fracking technology is adopted and employed by countries around the world that have abundant supplies of this newly exploitable resource. While fracking is attractive economically it must be practiced with great care to avoid contamination of neighboring land, water and air resources. Appropriate schemes of regulation will be required if such environmental damages are to be avoided.

3.4 Water for agriculture: key considerations for sustainable irrigation systems design and management in Sub-Saharan Africa.

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Compared to other regions in the world, the productivity of farmers in sub-Saharan Africa (SSA) is still very low and Africa is the only region where agricultural productivity has been largely stagnant. One of the reasons for the low productivity is the fact that agriculture is mainly rain fed despite the availability of abundant water resources. Irrigated croplands have much higher yields than rain fed croplands, so investments to expand irrigation in SSA is important to increase agricultural productivity and ensure food security especially with climate change. Irrigation leads to intensification of agriculture, increased productivity and contributes to reducing poverty. This however must be carried out in a sustainable manner. Many irrigation systems in Africa have been a failure and hence there is reluctance of investors to expand the irrigated areas in Africa especially in SSA. The objective of this paper is to analyse the reasons for the poor performance of irrigation in SSA; to identify factors contributing to success stories of irrigation in Africa, and finally to make recommendations for sustainable irrigation systems design and management in SSA in a bid to improve agricultural productivity and contribute to poverty reduction in a sustainable manner. The desk study concludes that: priority should be given to small scale farmer managed irrigation systems with farmers contributing to the project funding; systems should be designed to grow a variety of crops to ensure food security and income generation from the irrigation of high value crops; a participatory approach should be adopted in the design of irrigation systems to ensure adoptability and sustainability of system; small scale irrigation systems should be designed and implemented as a large project to reduce cost due to economies of scale; designs should promote new technologies that minimize degradation of the environment and contribute to poverty alleviation and finally designs should promote the conjunctive use of surface and ground water whenever possible to enhance the reliability of water supplies.

3.5 Implementing sustainable agricultural practices in Grenada and other small Caribbean islands to prevent pesticide contamination of water sources

MARTIN FORDE

Historically, agriculture has long been a main stay of many Caribbean economies. The region currently produces approximately 60 percent of the world's coffee, 40 percent of its banana, 25 percent of its beans, 20 percent of its cocoa, and significant quantities of sugar, corn and other crops. Considerable amounts of pesticides are used for the production of these crops which can and do end up contaminating many surface and ground water sources. With little regulatory supervision in place and the use of inadequate agricultural practices, this poses a serious threat to the region's water sources, threatens the health of the population, and compromises the environmental quality for the continued development and reproduction of many other species. While large scale agriculture operations such as the sugarcane and banana industries have notably waned in many small Caribbean island countries within recent times, this has been followed by a concomitant significant increase in the number of small scale itinerant farming. One characteristic of such farming is the unregulated and improper use of pesticides. There is an urgent need to develop and implement sustainable management practices and specific measures to control the use and application of pesticides in the agricultural sector, thereby reducing the risk posed by these chemical to water sources.

3.6 Potential Role of Indigenous Knowledge in Crop Production – Looking Back Into the Future

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Current research reports and experience indicate that frequency and severity of drought will increase into the future. Therefore, strategies to increase food productivity while conserving water have become increasingly important. These include selection of drought tolerant crops with high water use efficiency. For the large part of human civilisation, innovations in agriculture relied on indigenous knowledge and modern science. However, in recent times, indigenous knowledge has generally been ignored in agricultural development. Consequently, the majority of farmers in the developing world were forced to abandon ethno science in agriculture, which led to unsustainable practices threatening crop germ-plasm and finite resources, namely, water and soil. This paper presents a summary of case studies on preservation and water use of indigenous food crops. The agronomic and food security potential of these crops is explained in the context of original data and review of literature. The focus is on grain and vegetable crops that are produced by small-scale subsistence farmers. The study suggests that participatory approaches to agriculture and extension are important for a meaningful agricultural development as opposed to top-down knowledge transfer systems that ignore indigenous knowledge. It is concluded that there is a need to recognise indigenous knowledge as a science in order to move subsistence farmers to a level of meaningful food security and economic development required of small-scale farmers.

SESSION 4: WATER QUALITY AND QUANTITY

4.1 The use of Isotopes to Assess the Charge and Recharge Mechanisms of Aquifers

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Nearly half of all freshwater used for drinking and irrigation worldwide is derived from groundwater. In Africa, groundwater from aquifer systems provides nearly two-thirds of all drinking water on the continent and an even greater proportion to the population of northern Africa. The steady increase in global demand for freshwater, coupled with rapid industrial and agricultural development, is threatening the availability and quality of water supplies. The efficient and effective management of water, including groundwater, resources has now become of primary importance for the sustainable development of the continent. Although fairly recent, isotope hydrology is now playing a major role in water resources management. The IAEA, which started its isotope hydrology programme in 1963, continues to assist its member states to use this highly cost effective technique.The most important areas where isotopes are useful in groundwater applications include charge and recharge processes, flow and interconnections between aquifers, and the sources and mechanisms of pollution. Under the arid and semi-arid climatic conditions, isotope techniques constitute virtually the only approach for identification and quantification of groundwater recharge.

Both intentionally introduced isotopes (artificial tracers) and naturally occurring isotopes (also known as environmental isotopes) are used in isotope hydrology, although the latter are far more widely utilized. The most frequently used environmental isotopes include the isotopes of the elements of the water molecules (deuterium 2H, tritium 3H, and oxygen 18O) as well as of the element carbon (13C and 14C – i.e. carbon-14). 2H, 13C and 18O are stable isotopes whereas 3H and 14C are radioactive isotopes. Most of the applications of stable isotopes H and O in ground water studies use the variation in isotope ratios in atmospheric precipitation, i.e. the input to a hydrological system. During evaporation, the lighter molecules (normal water) are more volatile than the heavier molecules (e.g. heavy water). On the other hand, the heavy water molecules condense preferentially leaving a residual vapour more and more depleted in deuterium and heavy oxygen. The isotopic composition (or isotope ratios, e.g. 2H/1H, 18O/16O) of groundwater and that of the precipitation can provide considerable information about the recharge mechanisms as groundwater may also be recharged by seepage from surface waters (rivers and lakes). If most of the recharge is from seepage, the water should reflect the mean isotopic composition of the river or the lake instead of that of local precipitation; the river may collect water from a totally different area.

Stable isotopes (e.g. 2H/1H, 18O/16O) are measured using isotope ratio mass spectrometers, whereas radioactive isotopes are measured by counting their radioactive decays by liquid scintillation counters. Although these instruments might appear to be expensive for many hydrology laboratories on the continent, it is strongly advocated to share laboratory resources in order to make isotope hydrology a very reliable and cost-effective technique for groundwater resources management in Africa.
In Africa, isotope hydrology is not new but has been restricted to relatively few sites. Some of the successful projects include the Victoria Nile Basin of East Africa, the Tadla Plain in Central Morocco, the Hodna region in Algeria, the Kalahari groundwater in Botswana, El Minya in the Nile Valley in Egypt, and several sites in South Africa, amongst others.

4.2 Urban floods in the Dakar, Senegal suburb: Reflection on the role of risk factors

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Key words: Urban floods, Climate variability and change, Water Table Fluctuations, risk factors, Dakar

The urban population of sub-Saharan Africa (SSA) is growing at a faster rate than any other region of the world. Rapid urbanization presents critical problems in providing adequate water supply and meets the MDG (for water). Dakar capital city of Senegal is undergoing explosive urban growth with serious questions being raised regarding the environmental sustainability of this development. This situation has been currently aggravated, considering the recurrence of urban floods; the magnitude and damage caused have increased in the Dakar city suburb during the last decade. Urban flooding has appeared recently as the major threat for population living in the suburbs of Dakar. The socio-economic problems of the region do not contribute to a simple solution for this situation as well as natural conditions. Climate variability and change; physical settings and the hydrogeological conditions of the Quaternary sand aquifer which lies beneath the densely populated suburb areas and characterized by high permeability and shallow water table less than 2 m below the ground surface (Cissé Faye 2004, Mandioune et al., 2011) will aggravate the urban flooding problems. This study aims to review the urbanization processes and concern has been expressed over the city extension for different time periods and urban floods associated with these outlined factors. The severe floods that occurred in Dakar since 1989 are presented. The principle factors that affect the hydrological risk are identified as the increase of the vulnerability. The occurrence of severe storms, current environmental pressures perfectly related to the rapid expansion of unplanned urban and peri-urban settlements in Dakar since 1942 and defect of the superficial drainage system as well as the rising groundwater level during high period of recharge are primary factors in the increase of the urban flood risk. This study underlines the necessity for scientific and researchers to take a balanced view of all factors that define the vulnerability of its urban spaces and to develop proper and sustainable management of the water resources.

4.3 Water Quality, Water Security, Water Governance: New Challenges for IANAS and NASAC

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Freshwater is a fundamental resource for the economic development of regions, countries and continents, for human health, and for the preservation of ecosystems and ecosystem services. It is also a key resource for food production, for eradication of poverty and overall security of the human population. Yet, more than 2 billion people lack sanitation facilities, 800 million do not have access to water, and water related diseases affect millions of people around the world. Water quality is a key problem for water security and human health. From mid-19th century up to today there was a gradual deterioration of water quality is all countries and continents. Water quality deterioration is aggravated by climatic changes. Increase of temperature of rivers, lakes, reservoirs, wastewater discharge and blooms of invasive species of cyanobacteria are common problems affecting human health increasing

the cost of water treatment and interfering with the functioning of ecosystems. Water quality deterioration affects water security, water accessibility and human health.

At present, water governance is not prepared to deal with climatic changes, water quality degradation and water scarcity, all together. Integrated watershed management is fundamental for water governance and to promote water security. This management has to include water quantity, water quality issues – that vary from region to region – and water security. Capacity of prediction and dealing with a certain degree of uncertainty is fundamental in the new water governance paradigm. The use of ecohydrology – the nature's software" as a tool to control water quality and to manage water resources at watershed level in an important advance.

Countries of the Americas, specially Latin America and African countries have many common issues as regards water quality, water security and water governance. Lack of sanitation and access to clean water is one fundamental problem similar to both continents. Community participation on water governance, education and capacity building could be common themes for discussion and for promoting an overall integrated agenda to be shared with decision makers, managers and scientists. The strengthening of the IANAS and NASAC networks is an advanced towards the design of a common agenda for integrated water resources and watershed management for the two continents.

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4.4 Impacts of climate change on water resources in Cameroon: Facts, vulnerability and adaptation strategies

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Climate change, also referred to as global warming, is caused by an increase in the global average surface temperatures of the Earth. There is already scientific consensus that this increase in temperature is caused primarily by the release of greenhouse gases such as carbon dioxide into the atmosphere. The hydrologic cycle has an enormous impact on our livelihood especially through precipitation but it is being disrupted by these increasing temperatures, leading to changes in weather patterns such as erratic rainfall patterns which cause droughts, floods, and affect the availability and quality of potable water. It is clearly evident that water is the first sector to be affected by such changes in the frequency, intensity and spatial distribution of rainfall as it will impact not only its availability but also its quality, especially in Cameroon where, due to its geological setting which is predominantly crystalline rocks with the absence of adequate groundwater resources, the potable water resources are limited to surface water which is vulnerable to these climatic changes.
Since the various complex processes that drive the hydrologic cycle are still major scientific challenges especially for African scientists, this presentation been based on results of analyses of:

- The trends of surface temperatures and rainfall patterns in Cameroon over the past 70 decades and comparison with global trends, and
- How climate change is affecting the different types of water resources in the country (surface and groundwater) and
- The vulnerability (quantity) and quality (physico-chemical and microbial quality) to the impacts of climate change and other factors, and

However, it is paradoxically evident that the combination of population growth and development in the country is leading to an increase in the demand for potable water while at the same time reducing its availability and quality. Thus, the continuation of the three factors - climate change, population growth, and development - into the future could produce water crises of unprecedented magnitude. It is conclusive from these studies that the most immediate challenge is in the northern part of the country (Sahel) where considerations towards managing the variability of the water sources such as by constructing water storage structures such as dams to retain water during the rainy season for use in the dry season are being considered as one of the adaptation strategies. Other adaptation strategies towards ensuring the availability of this resource across the country in a variable and changing climate will therefore be essential. This could be enhanced if a forum of stakeholders comprising researchers, policy makers and the community at large meets and shares information and experiences on these issues of providing potable water to various sectors of the country despite the continuing impacts of climate change on this resource.

4.5 Risks to environmental sustainability of a proposed canal through Lake Cocibolca (Nicaragua)

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The largest tropical lake of the Americas, Lake Cocibolca or Nicaragua, has been included as part of the route planned for the Interoceanic Canal through Nicaragua. Possible impacts on this unique shallow lake during the construction and operation of the canal are considered here such as the risk of salinization due to sea water income through the locks, release of sediments due to dredging and possible resedimentation from its severely eroded watershed into the channel caused by active lake hydrodynamics which include wind action and currents, and the location of the canal planned route along the lake bed in a sensitive seismic zone of Central America. These impacts would have strong effects on the potential of the lake as a source for drinking water and irrigation which could stimulate the future development of Nicaragua, and also potential environmental risks to the projected works themselves as well.

SESSION 8: FURTHER DISCUSSIONS ON PERTINENT ISSUES

8.1 The Freshwater Imperative: Critical Reflections on Sustainability of Water Resources in Zimbabwe

TAURAI BERE

Utilisation of resources within the assimilative capacity of the environment is key to achieving sustainable development. Thus, increasing anthropogenic compromise of the assimilative capacity of the freshwater environments has captured public interest because of the consequent diminishing important ecological good and services relied upon especially by the poor people. Our successful civilization, which is largely due to our skills as ecosystem engineers, has major indirect and unintended effects on ecosystems (e.g. siltation, eutrophication and water pollution) which affects biotic integrity of aquatic ecosystems. Alteration of aquatic systems through such activities as damming of rivers, water abstraction, discharge of untreated sewage, siltation and pollution in general severely compromises the biotic integrity of aquatic ecosystems in Sub-Saharan Africa. This anthropogenic habitat loss in its varied forms is the primary threat to aquatic ecosystem biodiversity worldwide. This chapter uses Zimbabwean examples to explore the different kinds of habitat loss, its drivers and implications on aquatic ecosystem/ ecological integrity. Remedial measures are also recommended.

8.2 Emerging Nanotechnologies for Water Purification

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Water scarcity, purity and delivery have become major challenges of humanity but especially so in Africa. Globally 748 million and in Africa 325 million people lack access to safe water. Water diseases kill 842,000 people annually. The majority of those who lack water live in rural areas. Africa is second to Australia in dryness but is home to 15% of global human population and has only nine per cent of global renewable water resources. Most of Africa’s surface water has become polluted by human activities and its wells are becoming dry. Impacts of climate change and climate variability is making water scarcity more stressful.

Technologies used for water harnessing are outmoded and inefficient. Africa needs to modernize its water purification technology; it requires to adopt new methods like roof, pavement and urban water catchment to recharge its declining ground water level. Provision of safe drinking water policy need to change from piped water to every home to supply of point of use technologies at every home. There exist some potential new technologies that still require further research. The paper highlights some recent development of nanoscience materials that give promise to future trends. Similarly, small scale water harnessing technologies are outlined for ground water recharge and drinking water purification.

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