Building Resilience to Climate Change Risk and Vulnerability to Meet Water Security Challenges

Proceedings of Asia-Africa Workshop

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Acknowledgements

BACKGROUND

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IWRM and Water Planning in Gurara River Basin

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Lessons Learned and Challenges of Africa in Upscaling Water Security

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BACKGROUND

The impacts of climate change are likely to increase water demand while diminishing water supplies. Climate change affects variability, leading to increased variation in rainfall and air temperatures, resulting in more frequent hydrologic extremes such as high-intensity storms, flooding and drought events. In turn, water supply will be affected, intensifying the competition for water in conjunction with other factors such as the increasing population. As highlighted by the IPCC Fifth Assessment Report (IPCC, 2014), the impacts of recent climate-related extremes such as heat waves and droughts have revealed that both ecosystems and human settlements are highly vulnerable to current levels climate variability.

In Asia, water availability varies depending on climatic conditions. In addition, supply varies over time as a result both of seasonal variation and inter-annual variation. According to the IPCC\(^1\), climate change is projected to increase drought-related water and food shortages in Asia, due to the risks posed to physical systems such as rivers and lakes by floods and/or drought. The magnitude of variability and the timing and duration of periods of high and low supply will become more unpredictable with climate change, further intensifying the challenges of managing limited water resources.

In this regard, there is a need for improved understanding of the hydrological cycle and of the impacts of climate change. The best available scientific knowledge needs to be more effectively transferred to decision makers for improved management of water resources, in terms of both quality and quantity. UNESCO’s International Hydrological Programme (IHP) facilitates and provides data, tools, methodologies and policy advises to member states through flagship programmes such as the International Flood Initiative (IFI), International Drought Initiative (IDI), International Sediment Initiative (ISI), Integrated Water Resource Management (IWRM), Flow Regimes from International Experimental and Network Data (FRIEND), Hydrology Environment Life and Policy (HELP) and Ecohydrology. These UNESCO tools and policy advice help promote the coordinated development and management of water, land and related resources for an integrated understanding of biological and hydrological processes at a catchment scale. In this way, they help promote a systemic approach to ensure water security.

Within the framework of the Eight Phase of the IHP “Water Security: responses to local, regional and global challenges”, the regional workshop on “Building Resilience to Climate Change Risk and Vulnerability to Meet Water Security Challenges” brought together experts working in a range of water-related fields to share knowledge and best practices for improved water security in Asia Pacific and Africa. The workshop was jointly organized by the UNESCO International Hydrological Programme (IHP) and the UNESCO Jakarta Regional Science Bureau for Asia and the Pacific in partnership with River Engineering And Urban Drainage Research Centre (REDAC) Universiti Sains Malaysia. It was organized as part of the projects “Addressing Water Security: Climate Impacts and Adaptation Responses in Africa, Asia and Latin America and Caribbean” and “Upscalning water security to meet local, regional, and global challenges”, supported - respectively - by the Malaysia-UNESCO Cooperation Programme (MUCP) MFIT and the UNESCO/Flanders Fund-in-Trust for the support of UNESCO’s activities in the field of Science (FUST).

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Workshop details

Held during 10 to 11 July 2017 in Langkawi, Malaysia, the workshop brought together a total of 34 participants from 12 countries in Asia and the Pacific and Africa. Participants included policy makers, representatives of UNESCO Category 2 Centres and institutes, UNESCO Chairs in Water Resources, managers and leaders from UNESCO HELP Basins, local partners of IHP Malaysia, as well as experts, universities, and other stakeholders.

Scope of the workshop

The overall objective of the workshop was to contribute to the understanding of how climate change impacts water resources and water-related disasters, and – based on this understanding - upscale existing local approaches in IWRM for water security in order to strengthen regional cooperation. The workshop shared best practices on climate risk management through lessons learnt from case studies, including disaster risk reduction and climate vulnerability assessment in Asia and the Pacific. Discussions were aimed at improving the science-policy dialogue through the development of a set of recommendations for an improved water security in both regions.

Workshop program

The workshop included two main sections:

- A technical session to share and improve knowledge on the impacts of climate change on water resources and water related disasters and on how the HELP and Ecohydrology initiatives can be used as practical tools for delivering IWRM in order to manage those issues.
  
  The technical sessions were organized into:
  
  o Session 1: Delivering IWRM through modular education and water planning
  o Session 2: Addressing challenges for delivering IWRM
  o Session 3: Drought and flood risk and management: vulnerability; monitoring, prediction and early warning; integrated drought and flood management
  o Session 4: IWRM and water security linked with the 2030 Agenda
  o Session 5: Climate risk assessment and early warning

  Discussions covered a broad range of case studies, focusing on ways to address water extremes and scarcity in the two participating regions. The presentations showcased IWRM and Ecohydrology approaches from selected HELP Basins. Also presented were case studies on drought and early warning in Asia and contributions from IHP’s other flagship initiatives, including IFI and IDI as well as the Water and Development Information for Arid Lands (G-WADI-Asia) and the Glacier Lake Outburst Floods (GLOFs) initiatives.

- A policy dialogue session designed to raise awareness of water security at the science-policy interface and to improve the translation of scientific knowledge into action as a contribution towards a sustainable future.

Organizing Committee

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SUMMARY OF THE WORKSHOP

In summary, 34 participants from a total of 12 countries in Asia Pacific (Australia, Indonesia, Iran, Japan, Malaysia, Nepal, Pakistan, People’s Republic of China, Philippines) and Africa (Namibia, Nigeria, Sudan) have:

- Shared best practices from case studies and exchanged views on climate risk assessment on water resources, water-related disasters, as well as tools and best practices for upscaling water security in the region through presentations and discussions in the five technical sessions. The following progress was noted during discussions:
  - Improved understanding of climate-induced water security problems in Asia Pacific and Africa, through the following discussions:
    o Identification of water competition problems at various levels
    o Water quality deterioration in urban and rural catchments
    o Climate and human-induced water problems such as floods, droughts, glaciers
    o The need for constructive dialogue in transboundary river basins
    o Water governance issues
    o Water trading as a means of demand management
    o The use of unconventional water sources e.g. wastewater, desalinated water, water harvesting
  - Improved understanding of IWRM based on a variety of case studies in Asia Pacific and Africa, through the following discussions:
  - Discussions of lessons learned from extreme events (droughts and floods)
  - Sharing of perspectives on how to address water security problems

- Developed a set of recommendations for policy actions based on the workshop discussions, as follows:
  o Multi-level IWRM implementation starting from the community level leading to integrated river basin management can provide a paradigm shift in sustainable water management
  o Accountable water allocation and use, closed water system, and tariffs could be explored as possible demand management and sustainability drivers
  o Energy efficient, cost-effective, environmentally friendly, and socially acceptable technologies for water supply and waste water management should be promoted.
  o Water knowledge centres, universities and chairs are recommended to gather and synthesise data and information from various stakeholders, advise policy makers, disseminate to communities and engage the media.
  o Water knowledge centres and chairs should form strategic partnerships.
  o Enhance public awareness, improve water education and participation to address climate-induced water security problems.
Water Management Curricula Using Ecohydrology and Integrated Water Resources Management

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Water Management curricula using Ecohydrology and Integrated Water Resources Management (IWRM) is part of the programme Comparative Studies of Applying Ecohydrology and IWRM for Upscaling Water Security in Asia and Africa through UNESCO Water Centre Category 2. It is one of the outputs of main component Comparative studies for customising IWRM and ecohydrology for river basin management. The Water Management Curricula is part of the project incorporating new strategies in the framework of the International Hydrological Programme (IHP) Phase VIII (2014-2021) focusing on “Water security: Responses to local, regional, and global challenges” to deeper understanding of the interfaces and interconnections between the water, energy and food nexus, which aims to further improve Integrated Water Resources Management (IWRM) and to deeper understanding of their interfaces and interconnections. Other than contributing to South-South cooperation, it is also responds to priority of beneficiary countries.

The water management curricula have various topics which covers forest, environment oil palms hydrology, freshwater, Lake Ecosystem and river hydraulic. Meanwhile the land and sediment issues under few topics such as highland drainage, debris and mud flow, sediment erosion and landslide control, erosion and its effect are illustrated as the point and non point sources problems need to be seriously focused into. Stormwater management ecohydrology as a showcase has been demonstrated some successful techniques including the new phytoremediation technique and last but not least a curricular module for sustainable science for secondary school teacher. The above subjects are explained in 14 topics with examples and working calculations in the 3 volumes of water management curricula.

The water management curricular is one of the suggested sustainable solutions or approaches in water education deliverables. As it is build on Malaysia expertise or resources, the adaptation and application in each country shall be customised and tailored to its climate, natural resources and national priorities.

\textbf{Keywords:} Water Management Curricula, Ecohydrology, IWRM, Water Education, Water Security
BACKGROUND OF THE PROJECT

Water management curricula using ecohydrology and integrated water resources management (IWRM) is part of the programme Comparative Studies of Applying Ecohydrology and IWRM for Upscaling Water Security in Asia and Africa through UNESCO Water Centre Category 2 funded by Malaysia Fund-in Trust (MFIT). This project was initiated by UNESCO Jakarta and the curricula were developed by the Regional Humid Tropics Hydrology and Water Resources Centre for Southeast Asia and the Pacific, Kuala Lumpur (HTC KL).

Introduction

The water management curricular project facilitate continuous networking for sharing knowledge in water education as well as empowering the regional scientific collaboration in Ecohydrology and IWRM in Asia Pacific and Africa through Category 2 Water Centres such as HTC KL and Asia Pacific Centre (APCE) for Ecohydrology in Asia Pacific and Regional Centre for Integrated River Basin Management (RC-IRBM) in Africa focusing on LDCs and/or SIDS (ASPAC/Africa), contributing at least to 5 LDCs in Asia and Africa’s water resources management development. This project as well will contribute to UCPD Programme 4: IHP, and the developing a long-term strategy for water resource management to achieve water security as well as contributing to South-South Cooperation.

Water Management Using IWRM and Ecohydrology Concepts

Water security is the capacity to provide sufficient and sustainable quantity and quality of water for all types of water services and protect society and the environment from water-related disasters. Sustainable water solutions, whether at the local, regional and global levels, require creativity, new advances in scientific knowledge, discoveries and innovations. Innovation geared towards sustainable development has the potential to lift economic growth, create jobs, and boost inclusive social development while at the same time contributing to water protection and conservation.

Under the natural science the solution could be through Stormwater Management control at source best management practices, adopting green technology such as through Integrated Catchment Management Plan (ICMP), Integrated River Basin Management (IRBM), IWRM and Ecohydrology.

The basis of IWRM is that different uses of water are interdependent. The goal is the sustainable management and development of water resources. Integrated management means that all the different uses of water resources are considered together. IWRM at the river basin level is a process that leads to water security and helps mitigate water-related risks such as floods and droughts. It strives for effective and reliable delivery of water services such as municipal and industry water supply, water waste management, agriculture uses, hydropower by coordinating and balancing the various water using sectors.

Ecohydrology is the transdisciplinary, integrative, environmental science, based on assumption that the water and thermodynamics has been a major driving force in determining the evolution of ecosystems. Thus, understanding the relations between water and biota at different geographic zones should be the key for regulation of water biota interplay toward enhancement of carrying capacity of river basins and harmonisation of their ecosystems potential with society needs for achieving sustainability.

While under the social science, could be through stakeholders’ engagement, community participation, through water education, cooperation and networking approach. It is agreed that Education is key to water security as stated in UNESCO-IHP VIII. This was agreed, based upon recognition that water is fundamental to sustainable development and a basic component of national, regional and global ecosystems.

As such, the effort of developing and publishing The Water Management Curricula using Ecohydrology and IWRM is indeed timely and relevant. Water Management curricula using Ecohydrology and Integrated Water Resources Management (IWRM) is part of the programme Comparative Studies of Applying Ecohydrology and IWRM for Upscaling Water Security in Asia and Africa through UNESCO Water Centre Category 2. The programme was supported by the Malaysia Funds-in-Trust (MFIT). It is one of the outputs of main component Comparative studies for customizing IWRM and Ecohydrology for River Basin Management.

The other output of this component is Customizing IWRM at the River Basin Level meanwhile the other component under this programme is Round-up Workshop on Applying Ecohydrology and IWRM for Upscaling Water Security
in Asia and Africa involving at least 5 LDCs in Asia and Africa, 5 universities and 2 category 2 centres (one from Africa and one from Asia). The workshop was conducted at Berjaya Times Square, Kuala Lumpur on 7th - 9th March 2016 to discuss thoroughly the adaptation and application of the curricula as well as to disseminate the developed curricula.

There are 14 Topics altogether which includes forest/oil palm hydrology, stormwater management ecohydrology, freshwater water ecosystem, urban drainage, highland drainage, sediment, erosion and landslide control, natural channel hydraulics, point source and non-point source pollution control, humid tropics hydrology, managing climate change, lake and wetland management, sustainable science for secondary school, etc.

Volume 1 of water management curricula focus on tropical forest/oil palm hydrological, freshwater and lake ecosystem. As oil palm is identified as main commodity crop in Malaysia, the best management practices (BMPs) in oil palm agriculture and its impact towards hydrological components including water quality as well the future strategies and solutions about forest conversion to oil palm agriculture towards sustainable forest management and sustainable oil palm agriculture were discussed thoroughly. It is also discussed the concept, function and diversity of freshwater, lake environment and river ecosystem in terms of hydrological cycles including the invertebrate consumers in lakes and heterotrophic microorganisms in lake and streams. Finally, recognize and exposing to the importance of Environmental Monitoring and its interface for ecohydrology based lake management.

Meanwhile Volume 2 of water management curricula focuses on land and sediment issues in few topics such as Highland Drainage, Sediment Control, Erosion, phyto remediation technique as well as Integrated Stormwater Management Ecohydrology. It is discussed the concept and overview on highland drainage, mudflow, debris, sediment erosion and landslide control as well as Mitigation on Sediment Control. Other than that Volume 2 as well discussed the philosophy of phyto remediation technique by applying various hydroponic plants for sustainable development in IWRM and green technology technique that have impinge on many application decisions or solutions and finally the design of Ecohydrology as a tool in stormwater management.

Volume 3 of water management curricula focuses on learning natural channel (river) behavior, its ecosystem, its biodiversity, morphology, compound channel, overbanks hydraulics, sediment transport, erosion and riverbank protection, stream stability, example of rainfall distribution profiles, flood control, flow routing, etc. It is explained in the context of scientific, technical and innovative idea, and river channel hydraulics based on the author’s experience, research works, courses, teaching, discussion, collection of information and references used by the author. It is also discussed on the curricular module for sustainable science for secondary school teacher. This guide has been developed to assist secondary education teachers, from different subject areas, in embedding sustainability science education across the school curriculum.

Conclusions and Recommendations

The Water Management Curricula is in line with UNESCO’s mandate through framework of the International Hydrological Programme (IHP) Phase VIII (2014-2021) to deeper understanding of the interfaces and interconnections between the water, energy and food nexus, which aims to further improve IWRM and to deeper understanding of their interfaces and interconnections. Other than contributing to South-South cooperation, it is also responds to priority of beneficiary countries. This project facilitate continuous networking for sharing knowledge in water education as well as empowering the regional scientific collaboration in Ecohydrology and IWRM in Asia Pacific and Africa through Category 2 Water Centres such as HTC KL and Asia Pacific Centre (APCE) for Ecohydrology in Asia Pacific and Regional Centre for Integrated River Basin Management (RC-IRBM) in Africa focusing on LDCs and/or SIDS (ASPAC/Africa), contributing at least to 5 LDCs in Asia and Africa’s water resources management development. This project as well will contribute to UCPD Programme 4: IHP, and the developing a long-term strategy for water resource management to achieve water security.

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HTC KL would like to acknowledge Malaysia Fund-in Trust (MFiT) for the fund, UNESCO-Jakarta for the successful collaboration and the platform, Department of Irrigation and Drainage (DID Malaysia) all the authors of all the topics from Infrastructure University of Kuala Lumpur (IUKL), University Tenaga Nasional (UNITEN), University Putra Malaysia (UPM), University Technologi Malaysia (UTM), Universiti Kebangsaan Malaysia (UKM), University Science Malaysia (USM) and the reviewers appointed by UNESCO Jakarta.

References

The Langat River Basin in Malaysia is one of the UNESCO-IHP HELP (Hydrology for the Environment, Life and Policy) River Basins since 2004, classified as an “Evolving” HELP Basin under the framework of UNESCO-IHP HELP Network out of 91 catchments, from 67 countries in the world. The IWRM and HELP approaches have been implemented in the management of water resources and river basin in Langat, which involve the application of ecosystem health approach, sustainable ecosystem management approach, integrated river basin management (IRBM) approach, urban stormwater management approach, sustainability science approach and many others. Some works in progress especially on local sustainability efforts have been carried out as local actions from a global initiative at improving the environment and river basin. The efforts are part of an initiative towards improving the current level of Langat UNESCO HELP River Basin from an “Evolving” to an “Operational” River Basin in the future. A sustainable and integrated water resources management and water planning in this basin will help Langat to move forward to achieve this agenda. This will also need to be supported by an IWRM Awareness-raising, Advocacy and Capacity Building (AACB) programmes, which include training and education programmes, modular and material development, communication and delivery system, facilities establishment, as well as appropriate governance mechanism to improve the current water management system and practices, and ensure local participation and governance of Langat to be achieved and mobilised.

**Keywords:** IWRM, Water Planning, Langat, HELP, River Basin.
Introduction

Integrated Water Resources Management (IWRM) is a process which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an adequate manner without compromising the sustainability of vital ecosystem (GWP 2000). Malaysia has adopted an IWRM approach and brought modifications in its institutional arrangements for better water resource management (Leendertse, Mitchell et al. 2008). These initiatives have been carried out to improve water management in the country, however, water and associated resources management practices are yet to develop especially in cases of active participation of stakeholders at lowest appropriate level for decision making, joint monitoring, water demand management, effective waste management, conflict resolution, individual capacity building and above all preparation of local level strategies (Bartram and Ballance 1996). In Malaysia, water resources management practices are carried out by different sectors and through different subject areas are a complicating factor, but can simply be done with a holistic approach. At the federal level, the National Water Resources Council (NWRC) was set up in 1998 to pursue a more effective water management, including the implementation of inter-state water transfers. To ensure sustainable water resources and efficient water supply services, the Federal Government is moving towards greater involvement in the management of water resources and water supply services, and the implementation of IWRM. As a part of pioneering initiative for IRBM implementation, Government of Malaysia has formed the Selangor Water Management Authority (Malaysian acronym is LUAS) in 1999 as a river basin organization and Langat River Basin is one of the three river basins is now managed by this authority (Mokhtar, Toriman et al. 2011) Role and responsibilities of the authority and collaboration, coordination and enforcement mechanisms are well defined by the Selangor Waters Management Authority Enactment 1999. But existing organizational structure, manpower and functional experience are inadequate to address all these issues derived from the inevitable consequences of critical factors of economic and population growth as well as climate change effect prevailing in the basin area (Hossain, Mokhtar et al. 2011). IWRM implemented primarily at the basin-wise context under the principles of good governance and public participation. Integrated River Basin Management (IRBM) which is a subset of IWRM can be seen as the implementing arm of IWRM in a national water planning context. IRBM is a process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems (GWP, 2000). The Langat River Basin in Malaysia is one of the UNESCO-IHP HELP (Hydrology for the Environment, Life and Policy) River Basins out of 91 catchments, from 67 countries in the world. It is classified as an “Evolving” HELP Basin under the framework of UNESCO-IHP HELP Network since 2004. Various local actions and initiatives have been undertaken which include local ecological governance and public participation of Langat for a more appropriate water resources and river basin management strategies and best practices. Some IWRM/IRBM initiatives that have been carried out in the Langat River Basin, Malaysia are:

1) Ecosystem Health of the Langat Basin by Institute for Environment and Development (LESTARI UKM) 1997-2004
2) River Basin Authority Establishment through Selangor Waters Management Authority (LUAS) 1999
3) Integrated Catchment Development and Management Plan (CDMP) for Putrajaya Lake Catchment (Sub Catchment of Langat) (PPj) 2000
4) Pollution Prevention and Water Quality Improvement Programme of Langat River by Department of Environment (DOE) 2003
5) Acknowledgement of Langat as UNESCO HELP River Basin (LESTARI UKM & UNESCO) 2004
6) Langat Integrated River Basin Management (IRBM) Study by Department of Irrigation and Drainage (DID) 2005
7) Integrated Water Resources Management (IWRM) Research Group Establishment by the National University of Malaysia (UKM) 2007
8) Harmonising Environmental Considerations with Sustainable Development Potential of River Basins (LESTARI UKM & UNESCO) 2010
9) Acknowledgement of Putrajaya Lake and Wetlands as UNESCO Ecohydrology Demonstration Site (LESTARI UKM, PPj & UNESCO) 2010
10) Development of Decision Support System for Langat River Basin (UKM) 2010-2014
11) Upscaling of MSMA-SME (Stormwater Management Ecohydrology) at Catchment Level (Langat River) (LESTARI UKM & HTCKL) 2012-2015
13) Langat River Basin Management Plan by Selangor Waters Management Authority (LUAS) 2015
14) Establishment of Sustainability Science Demonstration Pilot Project on Restoring and Managing Langat River, Malaysia for Future (LESTARI UKM & UNESCO) 2015-2016
15) Langat River Conservation Programmes (FoLR, KeTTHA & LESTARI UKM) 2017
Conclusions and Recommendations

The IWRM and HELP approaches have been implemented in the management of water resources and river basin in Langat, which involve the application of ecosystem health approach, sustainable ecosystem management approach, integrated river basin management (IRBM) approach, urban stormwater management approach, sustainability science approach and many others. Some works in progress especially on local sustainability efforts have been carried out as local actions from a global initiative at improving the environment and river basin. The efforts are part of an initiative towards improving the current level of Langat UNESCO HELP River Basin from an "Evolving" to an "Operational" River Basin in the future. A sustainable and integrated water resources management and water planning in this basin will help Langat to move forward to achieve this agenda. This will also need to be supported by an IWRM Awareness-raising, Advocacy and Capacity Building (AACB) programmes, which include training and education programmes, modular and material development, communication and delivery system, facilities establishment, as well as appropriate governance mechanism to improve the current water management system and practices, and ensure local participation and governance of Langat to be achieved and mobilised.

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References


This study is prompted by the need to develop a Water Allocation Plan and establish a framework to share the water resources of the Gurara River Basin between human and environmental needs, achieve equitable water distribution and ensure larger benefits from water uses across the basin’s communities and users. This is due to the fact that the water resources of the basin is already in competition for water supply for irrigation, generation of electricity for the Kaduna industrial zone and municipal water supply to the Federal Capital Territory (FCT) with little or no consideration for the immediate communities who are without water and electricity.

The water allocation studies was developed to maximize the benefits (social, environmental, and economic) of water to society; explore the socioeconomic and environmental consequences of water regulation in the Gurara River Basin (GRB); and develop a water resources allocation system and investigate the extent to which the framework is “sustainable” in the medium and long terms.

Water planning is a step-by-step process that requires constant re-evaluation and updating to address changing social, political, economic, and environmental parameters. Therefore the scope of this paper is limited to Water Allocation Studies carried out and situational analysis accomplished, in order to set the directions to developing a comprehensive, publicly-supported Water Allocation Plan, and maintain a comprehensive and viable water planning process that covers various aspects of water resource development, transport, water treatment, allocation among various competing uses, conservation, waste-water treatment, re-use, and disposal. The Stages of the Water Allocation Plan Development as well as the Follow-up actions to be undertaken in order to complete the processes and to achieve the set objectives are outlined.

**Keywords:** IWRM, water resources, water planning, water allocation, Gurara basin, ecosystem.
1 Introduction

Water is perhaps our most important resource, providing a fundamental requirement for sustaining life and economic production. With the marked fluctuation in quantity and quality between wet and dry seasons, water allocation planning is of critical importance to ensure the sustainability of water resources to meet the needs of all water users, including the environment.

Water planning is an analytical planning process developed and continually modified to address the physical, economic, and sociological dimensions of water use. As a planning process it must assess and quantify the available supply of water resources and the future demands anticipated to be levied upon those resources. The water planning process requires constant re-evaluation and updating to address changing social, political, economic, and environmental parameters. While the ultimate objective of such efforts is typically the development of a comprehensive, publicly-supported Water Plan, it is also critical to develop and maintain a comprehensive and viable water planning process that covers various aspects of water resource development, transport, water treatment, allocation among various competing uses, conservation, waste-water treatment, re-use, and disposal.

Water Allocation Plans are set rules for the sustainable use of water resources. They establish a framework to share water between human and environmental needs. Restrictions on intakes reduce the amount of water being used when the water reaches the minimum flow level and allocation limits establish the amount of water that can be taken to manage the relationship between accessibility and reliability of supply. These management controls help to ensure the water supply is reliable and access to it is equitable.

The Gurara River Basin, North Central Nigeria, is central to sustainable water supply to the Federal Capital Territory (FCT) and its water resources is already in competition for water supply for irrigation, generation of electricity for the Kaduna industrial zone and municipal water supply to the FCT with little or no consideration for the immediate communities who are without water and electricity. This has brought to fore the need to develop a mechanism for water resource allocation in the basin. Whereas water resources in the wet season are more than adequate to fulfill the basin needs, there are regional water shortages during the dry season, when only less than 5% of the annual flow reaches the downstream communities of the Gurara River. Recent rapid agricultural and economic development in the basin following the completion of the Gurara dam and water transfer infrastructures has led to increasing competition among the riparian communities for the Gurara waters. This development calls for a structured approach to the management of the basin, including efficient, equitable, and environmentally sustainable water allocation rules that support the socio-economic development in the basin.

1.2 Study Area

The Gurara River Basin is situated in Northern Nigeria, between latitudes 8°15' and 10°05' N and longitudes 6°30' and 8°30' E (Fig. 1.1). It has a total catchment area of 14,913 km$^2$ at the confluence with river Niger. The Upper Gurara watershed has an area of 4,693 km$^2$ at Jere. The Gurara River extends over a distance of 570 km from the plateau at an elevation of over 700m, through Jere at 530m and into the Niger confluence at an elevation of 40m. The Gurara River flows in a general direction of northeast to southwest in its upper reaches, and then turns southwards as it flows through FCT to its confluence with the Niger River. The climate is influenced by the seasonal movement of the Inter-tropical Convergence Zone (ITCZ), which results in two distinct wet and dry seasons.
Figure 1.1: The Study Area

The basin lies in the southern Guinea Savannah zone of Nigeria and its vegetation type is basically savannah grassland interspersed with remnants of tropical forest. The watercourses are particularly forested with large trees from the fringing forests, with a few patches of typical natural forest reserves. The terrain is undulating and dissected, conforming to the dominant geological structure of the underlying rocks-undifferentiated basement complex. The soil type is generally gravely red laterites, and in the river valleys it is alluvial.

2 IWRM Concepts

IWRM is an approach to support decision-making in such complex situations. It is defined by the Global Water Partnership (GWP 200) as ‘A process which promotes the coordinated development and management of water, land and related resources in the river basin in order to maximize the resultant economic and social welfare in an equitable manner, without compromising the sustainability of vital ecosystems’.
IWRM sets out to reconcile multiple, competing users for water, with legitimacy attained through public participation, and with coordination and technical competence assured through specialized basin entities or agencies where they exist.

In practice, however, the benefits that can be obtained from an IWRM approach are very important in water planning and allocation. Implementing IWRM at the river basin level is an essential element to managing water resources more sustainably, leading to long-term social, economic and environmental benefits. Because water is managed locally, a river basin approach provides a practical framework, defined by geographical and hydrological characteristics, which facilitates implementation of IWRM by involving downstream and upstream basin wide issues as well as incorporating environmental and socio-economic aspects. Finally, the administrative and institutional (control) system is of importance.

2.1 Existing IWRM Institutional Framework in the Gurara Basin

Institutional mechanisms for cooperation among the riparian water users in the Gurara basin have been in place since 1975 when the Upper Niger River Basin Development Authority was created to manage and develop the water resources in the basin in a sustainable manner.

The Gurara Dam Water Management Authority (GDWMA) was created in 2009 to regulate the Gurara dam reservoir water use for sustainable water supply to the FCT. The Integrated Water Resources Management Commission (NIWRMC) – one of the agencies of the FMWR was also created to regulate water resources development in Nigeria, while the Federal Ministry of Water Resources (FMWR) is responsible for developing the policies to regulate the water resources development in Nigeria.

The Gurara Water Allocation project was initiated in 2012 as a research project of the RC-IRBM and was shared with some UNESCO Category II Water Centres as a collaborative research.

However, despite the existence of these institutions, comprehensive water allocation rules for the basin have not been developed.

2.2 IWRM Issues in the Gurara Basin

The Gurara River Basin is Nigeria’s largest and pioneer water transfer scheme. The Transfer scheme was designed to enhance the use of Gurara River by storing, regulating and controlling the flow of Gurara River through a 53m high Rockfill Dam which created a 880MCM capacity large reservoir and a Spillway capacity of Q= 4,200 m³/s. The dam reservoir is specifically to:

- Release 10m³/sec of water for Irrigation of 6,000 hectares (phase I) and 14,000 hectares (Phase II / Gurara II) of irrigable land downstream of the dam;
- Meet the raw water daily demand of the FCT in the next 50 years through the supply of a maximum flow of 12m³/sec of water to augment the FCT water supply through a 75km long gravity Conveyance Steel Pipeline System (diameter: 3m; maximum flow rate: 13m³/s) running between the Gurara and Usuman dams;
- Generate 3 x 10MW (first phase) of hydro-electric power for the Kudenda Industrial Areas Kaduna (Phase I) and 300 MW (Phase II) of hydro-electric power. All phase II are planned for a second dam on the Gurara just upstream of the Gurara Falls.

The dam reservoir is to meet all these demands, with little or no considerations for;

- The immediate communities who were without water and electricity;
- Downstream Communities who depend on the water of the Gurara during the dry season;
- Environmental flows as the river downstream of the reservoir is dry for greater part of the dry season;
- Biodiversity.

For the purpose of developing the Water Allocation plan, the Gurara basin was classified into:

- Upper Catchment; comprising of part of the basin upstream the Gurara dam axis
- Lower Catchment; comprising of part of the basin downstream the Gurara dam axis.

3 Methodology

Water allocation planning is a multi-disciplinary process that requires diverse skills, detailed information and knowledge of stakeholder values and expectations. These skills and information were integrated to develop policies that achieve an acceptable trade-off between environmental sustainability and water use. Considering that water
allocation planning is, in fact, a specific kind of strategic planning, the following generic steps were applied to the development of a water allocation plan for the Gurara River basin.

The project was implemented in phases and only the Phase I and II were accomplished during the studies. Other phases will come on stream annually and the entire project is expected to be completed in the next year.

### 3.1 Planning Initiation

Planning is the first stage of the project and it involved establishing the planning processes; organizing the human resources required to drive the process; further development of the concept note through review meetings; constitution of tasks team, review of institutional and legal framework; and identification of all stakeholders relevant to the project execution which included:

- Staff of NWRI-RC-IRBM
- NWRI Capacity Network Institutions
- Knowledge Centers within and outside the Gurara Basin University of Ilorin (UNI-Ilorin), Bayero University Kano (BUK), Ahmadu Bello University (ABU) Zaria, Federal University of Technology Minna (FUTMIN).
- Stakeholders (FCT-Water Board, Niger & Kaduna State Water Boards, Private and NGOs)
- Regulatory Agencies; Nigeria Integrated Water Resources Management Commission (NIWRMC), Gurara Dam Water Management Authority (GDWMA).

Seven groups were identified to carry out various components of the project with specific terms of reference for each group. The groups are as follows;

1. Surface Water Resources
2. Groundwater Resources
3. Biodiversity
4. Water Quality
5. Socio-Economics
6. Institutional Mechanisms
7. Remote Sensing and GIS

Thematic Areas and Terms of References for each group are as follows:

#### 1. Surface Water Resources:

1. Using existing resources produce a map of the Gurara River basin Catchment and sub-catchments, river systems, dams, reservoirs and other usable surface sources of water including their characteristics;
2. Source Capacity Assessments;
   - Rainfall and stream-flow data analysis for surface water resources
   - Describe the Climate and variability
   - Determine catchment yield at locations of dams and reservoirs
   - Carryout reservoir flood routing using 24hr or appropriate time steps to determine outflows
   - Conduct reservoir water balance using appropriate model and 24hr or appropriate time steps
   - An assessment of the available surface water resources, storage capacities and distributions.
3. Conduct Water Demand Assessment Study;
   - Identify existing water uses (consumptive & non consumptive).
   - Existing water supply production facilities, characteristics and distributions
   - Existing and future water demand for reticulated public water supply; Livestock, Domestic, Industrial, Irrigation, and Aquaculture etc.

#### 2. Groundwater Resources:

1. Using existing resources, produce or source for the geologic and hydrogeologic map of the Gurara River basin and their characteristics;
2. Source Capacity Assessments;
a. Groundwater occurrence and yields in the basin;
b. Pumping test analysis for underground water sources; annual trends of recharges
c. Water level measurements of point water sources
d. Groundwater variability in the basin

iii. Conduct Water Demand Assessment Study;
a. Identify existing groundwater uses (consumptive & non consumptive)
b. Existing groundwater water supply production facilities, characteristics and distributions
c. Existing and future groundwater demand for reticulated public water supply; Livestock, Domestic, Industrial, Irrigation, and Aquaculture etc.


3. Biodiversity:
   i. Identify all water dependent ecosystems, ecosystems services (surface & under groundwater), distribution and timing of water use;
   ii. Identify invasive aquatic and alien plant species in the basin
   iii. Assess the quality, quantity and timing of environmental water required for the water dependent ecosystems and invasive species and identify their intrinsic, economic, scientific and aesthetic importance.
   iv. Identify the environmental values and roles of the Gurara river, lake, and aquifer in the ecosystem, their recreational value, natural character and cultural and spiritual qualities
   v. Determine the detrimental effect or otherwise on the quantity or quality of water arising from uptake or water use by the ecosystems
   vi. Identify existing protection mechanisms for the ecological functions of water resources and dependent biological diversity
   vii. Produce ecosystems distribution map of the basin.

4. Water Quality:
   i. Identify basin population and all water-affecting activities
   ii. Analysis of contaminants inventory including point and area sources affecting both surface and groundwater resources
   iii. Identify existing point and non-point water pollution sources and pollution protection mechanisms for:
       a. Quality of surface & groundwater
       b. Examine the ecological functions of water resources and dependent biological diversity.
       c. Prescribe appropriate protective measures.

5. Socio-economics:
   i. Identify all water-affecting activities / businesses in the basin e.g. fisheries, poultry farming, irrigation farming, mining, hydropower generation, block making, domestic and industrial water supply etc.;
   ii. Determine the unit cost of water and appropriate values of water
   iii. Identify population distribution within the basin and assess per capital water (surface & groundwater) demand for all uses.
   iv. Study the socio-economic impacts of the two extreme conditions (flooding and drought).

6. Institutional Mechanisms:
   i. Identify all water regulatory Institution and Water Management framework (Regulator, Providers and Users) in the basin and their synergies
   ii. Identify all water related social, political, economic and administrative organizations
   iii. Identify existing water regulatory instruments
   iv. Existing water rights systems and operations
   v. Propose Institutional framework to address emerging challenges
   vi. Review existing literatures relating water governance while liaising with relevant MDAs and private Institutions.
7. Remote Sensing and GIS:
   i. Using appropriate satellite data produce land-use map of the Gurara basin with proper indexing and attributes
   ii. Mapping of point and non-point pollution sources including sediment sources into the rivers and reservoirs
   iii. Establish project database using GIS
   iv. GIS Modeling.

3.1.1 Baseline Data Analysis and Reporting

Teams of Experts were constituted in seven (7) disciplines relevant to the project deliverables and thematic areas and for each group, their terms of reference were developed. Each group of experts collected baseline data and they conducted a series of technical investigations towards understanding the current status of water resources, environmental and other public benefits, uses, and socio-economic factors as well as future threats, risks and opportunities in the basin. Each task team analyzed the baseline data collected and prepared planning reports on their findings and chatted the way forward for the project execution. Each group came up with a budget and cost estimate of the fund needed to execute and complete the water allocation plan.

4 Follow-up Actions

Water planning is a step-by-step process which requires constant re-evaluation and updating to address changing social, political, economic, and environmental parameters. The Water Planning process so far carried out stopped at the Water Allocation Studies and situational analysis. The Stages of the Water Allocation Plan Development as well as the Follow-up actions to be undertaken before completing the processes to achieve the set objectives are outlined as follows;

4.1 Setting Directions

Broad decisions based on the results of the situation analysis will be taken concerning attainment of the objectives and outcomes that are being sought. Expected activities at this stage include:

a. Setting local objectives, including environmental objectives, for surface and groundwater use and protection;

b. Development of management and allocation criteria in line with ecologically sustainable use principles. Water allocation criteria will be developed with due considerations of the following objectives:
   - Sustainable use of the underground water resource
   - Encourage the development of new industries
   - Efficient use of water
   - Equitable allocation of water

Other considerations shall include:
   - Water available for allocation
   - The present and anticipated future needs of the occupiers of land within the basin
   - Those needs in relation to existing requirements and anticipated future capacity of land in the basin, and
   - The likely effect of the criteria for the allocation of water resource on the value of the land within the basin.

c. Determining appropriate values and uses for the resource;

d. Developing water transfer strategies. Water transfer criteria including temporary and permanent shall be developed in consideration of the following objectives:
   - Efficient use and management of water
   - Flexibility in developing the water resource
   - Sustainable use of the water resource.
   - Review of water transfer processes and policies.

e. Devising protection priorities and mechanisms for dependent ecosystems;

f. Providing protection strategies for places of cultural significance related to water;

g. Devising infrastructure protection policies;

h. Where appropriate, providing rehabilitation and remediation programs;
i. Taking account of regional planning strategies and local government planning schemes, and by providing recommendations to local government regarding inclusion of specific water protection strategies and mechanisms in planning instruments (such as buffer zones, for example), and
j. Developing and budgeting for local monitoring, reporting and review mechanisms.

4.2 Identifying and Assessing Strategies

This is usually achieved through a process of identifying and assessing options (benefits, impacts, mitigation measures) by the application of a hydrologic-economic model which allows for the analysis of water allocation and use under alternative policy scenarios. An optimization technique is to be combined with a multiple agent system framework for the GRB, in which water users, water uses, reservoirs, and downstream ecological zones are defined as agents. Iteratively water prices for each water use agent in the context of water market will be determined for optimal basin water use benefits. The results will lead to development of strategy for either to redistribute the benefits instead of the water resource or vice versa in order to achieve both equitable and large benefits from water uses across basin and sectors.

4.3 Building in adaptability

This step identifies how implementation and outcomes will be monitored and what should happen if things do not work as expected (for example; implementation failure, wrong assumptions, ineffective strategies, improved data, or situational change). Arising from this is a monitoring strategy and triggers for adaptation or change.

Development of systems for monitoring and reporting the condition of both the water resource (surface and ground) and the condition of water-dependent ecosystems;

4.4 Strategy selection

This involves comparing trade-offs (including socio-economic and equity factors) and deciding on a preferred approach. Arising from this are strategies, activities and measurable targets and actions.

4.4.1 Water Permits

All water affecting activities in the basin shall be identified and the level of their compliance to the following objectives determined for the purpose of developing guidelines and criteria for granting of permits in order to:

- Protect the quantity and quality of water resources
- Prevent deterioration in the quality of underground water
- Protect the ecological functions of water resources and dependent biological diversity

4.4.2 Taking and Use of Other Water Resources

Provisions relating to taking and use of water and other resource, if this is likely to affect the management of the Gurara water resource will be established.

4.4.3 Water Access Entitlements

Priority regimes shall be established and allocation limits determined to regulate how water takes from a river, lake, or aquifer are to be restricted especially during the dry season when it is close to its minimum flow or level.

4.5 Plan approval

This shall be the final Ministerial endorsement that incorporates the outcomes of the process into a statutory framework. The five major themes that relate to water planning are:

a. Defining and describing environmental and other public benefit outcomes, and putting in place management arrangements to achieve those outcomes;
b. Defining resource security outcomes and water allocation and trading rules, and adjusting over allocated or overused systems;
c. Putting in place mechanisms for risk management and adaptability to improved information and knowledge, including monitoring and reporting;
d. Consultation and community engagement, including Indigenous communities; and

e. Settling the trade-offs between competing outcomes for water systems, using best available science, social and economic analysis, and community input, and to address impacts on affected entitlement holders and communities.

4.6 Funding

The funds are to be provided for in the 2017 Appropriation for the National Water Resources Institute allocation in the 2017 budget of the Institute, under the capital budget line “RC-IRBM 2017 Capital Budget”.

Conclusion

It is very critical to develop and maintain a comprehensive and viable water planning process that covers various aspects of water resource development, transport, water treatment, allocation among various competing uses, conservation, waste-water treatment, re-use, and disposal.

The water planning process requires constant re-evaluation and updating to address changing social, political, economic, and environmental parameters in order to develop a comprehensive, publicly-supported Water Plan.

The water allocation plan when accomplished will go a long way in addressing the IWRM issues in the GRB to ensure that water is shared equitably between the users as well as the environmental eco-systems.

References


Emerging Ecohydrology Approaches in Malaysia and Future Challenges

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A greater awareness of the unhealthy state of rivers across the world has led to the popularity of river restoration and rehabilitation initiatives in many countries. Emerging ecohydrology approaches in any of the integrated water resources management (IWRM) is one of the river up-scaling at river basin level. There is a realisation that when rivers are degraded, interactions of water and ecosystem services that are so important to society are lost. Malaysia has implemented river restoration and rehabilitation projects such as the River of Life Project (RoL) for Klang River and the Malacca Waterfront for Melaka River in an attempt to recoup some of these losses, and to do so in more aesthetically-pleasing ways. Recent years have also seen a wide range of applications of ecohydrology globally, from at site, community and finally to regional scale, aimed at the sustainable use of water and nutrient cycles. For countries in the humid tropics region, there are many ways in which ecohydrology can capture the emerging opportunities for sustainable water use, despite the huge environmental challenges posed by rapid development in these nations. Malaysia, for instance, is seeing the emergence of a number of ecohydrology-based water management initiatives that escalates the property values. With the rapid urban development in Malaysia, and very intense rainfall in short durations, the task of managing urban stormwater grows more challenging. The situation is exacerbated by the fact that urbanisation leads to increasing on impervious areas, which alters the catchment ecohydrology that require the best IWRM along with the river hydraulic characteristics changes. Thus, urban planners and engineers are consistently on the lookout for making better manage of water in our future expanding cities. Existing solutions in water management, however, are based largely on a technical approach which often does not consider the functioning of the ecosystems as a whole but to do rapid disposal to the downstream catchment. An initiative of such application of ecohydrology for purification of various kinds of pollution by using the constructed wetlands in Putrajaya is the first emerging ecohydrology concept initiated by the Malaysia Government since 1999. The Humid Tropics Centre in Kuala Lumpur too is experimenting with the use of phytoremediation technique for improving water quality in a few localities of Malaysia. It is also leading the way with a demonstration project in its own compound that involves combining stormwater management with the ecohydrology approach of constructing what is known as the Manual Saliran Mesra Alam (MSMA) Integrated Stormwater Management Ecohydrology (MSMA ISME). These initiatives use ecosystem properties as the management tool to achieve IWRM objectives. This paper discusses five case studies of river restoration and rehabilitation efforts and the application of ecohydrology as a customisation strategy in mainstreaming IWRM in Malaysia.

Keywords: Ecohydrology, IWRM, MSMA, river restoration, storm water management
INTRODUCTION
Emerging ecohydrology approaches in Malaysia and future challenges is one of the topics under the Customising IWRM at the River Basin Level study completed in 2016. A wide range application of ecohydrology signifies another customisation strategy of IWRM at the river basin level. Ecohydrology proposes the regulation of interactions between humans and the ecosystems in a river catchment scale. Thus, this concept adopted for ecohydrology in Malaysia is the river restoration and river rehabilitation. This paper presents a comparative study of ecohydrology applications with a view to upscale water security in Malaysia, which highlights the cooperation between the Humid Tropics Centre Kuala Lumpur (HTC KL) and a network of local universities and partners. The key lessons from the applications of IWRM and ecohydrology in Malaysia for future implementation are presented in the conclusion.

ECOHYDROLOGY FOR IWRM
In general, ecohydrology is a function of vegetation and water that supports living on planet. The theory and practice of IWRM and ecohydrology will evolve in tandem when there is a new development, with water security as the ultimate objective. Ecohydrology where it delivers natural balancing in the river ecosystem is one of the concepts of IWRM for the sustainable development goals. One challenge in designing a programme on ecohydrology is related to the integration of water ecology and engineering. To improve water resources from further degradation and provide ecosystem services to societies, one need to develop new understanding of that inter-dependency in a systematic way. The programme must also pay more attention to the role of culture and social factors in harmonising the biosphere's potential with the humanity.

Emerging ecohydrology at river basin level results in river restoration and river rehabilitation solution for Malaysia. There are five river restoration and rehabilitation projects in Malaysia as a regional or larger scale showcases. They are Kelana Jaya Lakes, Melaka River Beautification, Putrajaya Lake and Wetlands, RoL and MSMA ISME.

2.1 Kelana Jaya Lakes
Prior to 1996, the Kelana Lakes former tin-mining ponds water quality had been degraded due to the rapid surrounding development which had added wastewater, solid waste, and storm water overflow to the main lake in the area. The lake ecosystem had degraded and changed completely due to poor water quality and the loss of wetland plants and animal life. The Kelana Lakes initially as flood retention areas are converted to part of a public park in 1996 for fishing and recreation. The decomposition of the sludge generated in the lake had eventually caused bad odour.

As a response, the local residents formed a stakeholder forum, comprising 400 Friends of Kelana Jaya Park, and led by a 15-member steering committee including Petaling Jaya City Council (Majlis Bandaran Petaling Jaya (MBPJ)) in 2007. The rehabilitation of lakes in Kelana Jaya Municipal Park started from 2007 to 2009 through community participation and partnerships.

The tangible impacts were seen after some months, with the quantity of solid waste and wastewater from storm drains in the lakes reduced by 60 percent. Later, with the strong commitment from NGOs and the local authority, the quality of discharge from an oxidation pond improved after refurbishment work was carried out. Water quality in the lake subsequently improved, benefiting fishing and lake ecosystems, as well as the overall public health of lakeside communities.

2.2 Melaka River Beautification
The Melaka River which was once known as the Venice of the east during the fifteenth century flows north-south through the middle of Melaka city. However, illicit and discriminate dumping of trash, the run-off of nutrients and raw sewage directly into the Melaka River build-up sediment in the river bed, resulted in it becoming non-flushing, foul smelling, murky and blackish in nature. It grows algal blooms in certain locations when nutrients as source of food to the algae and bacteria. By the 1990s, the waterway had deteriorated and became one of the dirtiest rivers in the country.

To restore Melaka River to its original and clean condition, the state and federal government since 2001 have undertaken a major river restoration programme not only for flood mitigation, but also for, cleaning, beautification, and by upgrading some of the river facilities for the Melaka river mouth. The project focuses on ecohydrology as a 'garden-city' concept in integrating upgraded sewage treatment plants along the river with physical features such as landforms, vegetation, and ensure that all the domestic and industrial wastewater water bodies to produce the green scenery of the city entering the river was treated. The 570,000 cubic meter contaminated sediments along the 13.5 km stretch of the river was removed and the river was hydraulically reshaped, so that it would become naturally self-flushing. When the project was completed, the water quality of Melaka River was found to have improved from Class III to Class IIB (INWQS, 2008).
Today, Melaka is well-recognised as a world heritage city receives at least 1 million Melaka Waterfront and River Cruising visitor average annually (Tourism, 2016). The Melaka River was successfully transformed from a drainage channel to a popular and award-winning cultural amenity.

### 2.3 Putrajaya Lake and Wetlands

Putrajaya, the administrative capital of the federal government of Malaysia, is located in the Klang Valley region, south of Kuala Lumpur. Putrajaya or was named as Perang Besar has an approximate area of 49 sq km which was previously covered by vegetation, that is, rubber and oil palm plantation. Putrajaya is characterised by the 'garden-city' concept, physical features such as landforms, scenery of the city. The size of the Putrajaya Lake catchment is 51 sq km. A portion of it lies in the state of Selangor, while around 70 percent is in Putrajaya. The Putrajaya Lake Catchment is only a small part of the bigger 2,350 sq km Langat River Basin. This catchment is located within a fairly urbanised area, with rapid development going on all around it involving local and international activities. The Putrajaya Lake was created by inundating the lower part of the valleys of Chua River and Bisa River. The lake contains Putrajaya Wetlands, the largest constructed wetland system in the tropics consisting of 24 cells. The wetlands act as a natural treatment system that filters out most of the pollutants from the river water before it enters the Putrajaya Lake. The wetland system and lake were fully inundated in January 1999.

Ecohydrology constructed wetland treatment system, Putrajaya Wetlands utilises plants and micro-organisms as active agents in the treatment of wastewater. The governing authority, Putrajaya Corporation, put in place an integrated catchment and water-quality management approach that encompasses comprehensive monitoring of the ecosystem's overall status. Biological monitoring surveys were carried out on a monthly basis at six monitoring stations situated throughout the lake (Sharip et al., 2016). The biological data was used to determine species' distribution and diversity, and to form a useful indicator of changes in water quality induced by pollutants. This management regime ensures that the Putrajaya Lake and Wetlands remains a balanced and well-functioning urban ecosystem. The ecohydrological approach that merges the need for the ecosystem into the overall planning and governance of the Putrajaya city has proven to have a positive impact on the Putrajaya Lake when the lake water is at Class I. To date, the Ecohydrology Demonstration Sites of UNESCO-IHP Ecohydrology Programme (EHP) is classified as an operational ecohydrology UNESCO demonstration site, which means that it is implementing ecohydrology principles with full commitment from the stakeholders and government.

### 2.4 River of Life

For many years, the rivers that flow into Kuala Lumpur - the Klang and the Gombak- suffered from severe pollution due to rapid and uncontrolled development. As a response, the government in 2010 introduced the River of Life (RoL) project to clean up the rivers and rehabilitate their banks into vibrant and liveable waterfront areas with high economic value. The project, set to be completed by 2020, is in tune with the government's overall aspiration of turning Greater Kuala Lumpur into a metropolis in Asia that simultaneously achieves top-20 economic growth and becomes one of the global top 20 most-liveable cities by 2020. The RoL project consists of three components: river cleaning, river beautification, and land development.

The river-cleaning component of the RoL project spans across three municipals and eight rivers, covering a total 110-km stretch of rivers and their banks that need to be rehabilitated and restored. The project has both ecological and hydrological objectives. It aims to improve and sustain the water quality of the Klang River and its tributaries to the Class IIB, which means that the water will be suitable for body contact and recreational use. It also aims to provide an adequate level of flood mitigation and protection to the areas demarcated within the project with a view to achieve the Greater Kuala Lumpur City status. Improving the river water quality will require non-structural measures such as Public Outreach Program (PoP) and structural measure such as upgrading the existing sewerage facilities and installing wastewater treatment plants at wet markets, as well as social interventions such as relocation of squatters to reduce sewage, sullage and rubbish in the Klang River. Under the project, to date the government has already installed and maintained 375 Gross Pollutant Traps (GPT) in sewerages. GPT is a technique used to remove litter, debris, and sediment from stormwater as a measure of stormwater quality control and some GPT can filter out such as bacteria, dirt, chemicals and floatable oil. One of the factors that affect the amount of gross pollutants is community behaviour. The RoL POP is a programme to foster stakeholder partnerships and to improve attitudes and behaviours of target groups to reduce illicit pollution in the Klang River, Malaysia. The current achievement shows through the POP, one of a component of the RoL initiative mooted by the Department of Irrigation and Drainage (DID) Malaysia has its own and unique positive result. In the study commissioned by the HTC KL, the results was found that the annual gross pollutant wet load captured by each GPT based on landuses (commercial, residential and mixed development), was between 36 kg/ha and 360 kg/ha (DID, 2015; HTCKL, 2016). The annual gross pollutant wet load in kg/ha/yr/GPT by upper Klang River catchment with PoP was compared with Kerayong River catchment without PoP was 145 kg/ha/yr/GPT and 338 kg/ha/yr/GPT respectively (DID, 2017). The percentage different for the annual gross pollutant load between upper Klang River and Kerayong River catchment is around 57 percent. These results indicate the first successful POP contributed in improving the ecohydrological system at Klang River. The final objectives of the RoL restoration and rehabilitation targets will be seen in year 2020.
2.5 MSMA Integrated Stormwater Management Ecohydrology

With the rapid urbanisation in Malaysia, and its propensity for very intense rainfall in short durations, the task of managing urban stormwater grows more challenging. The situation is exacerbated by the fact that urbanisation leads to cumulative construction of impervious areas, which alters the catchment hydrology and the river hydraulic characteristics. Existing solutions in water management, however, are based largely on an engineering approach which often does not consider the functioning of the ecosystems.

As a response, HTC KL combined stormwater management with the ecohydrology approach to construct what is known as Manual Saliran Mesra Alam (MSMA) Integrated Stormwater Management Ecohydrology (MSMA ISME) in its own compound as a demonstration project (Figure 1).

At the demonstration site in Kuala Lumpur, there are two office buildings, three toilets, one prayer building, one store cabin and two parking areas. The total area of the study compound is estimated at about 3,800 sqm, of which about 30 percent is impervious, while the rest is considered pervious. In order to accomplish the objectives of MSMA ISME, three types of urban potable water, wastewater and stormwater were integrated for complete urban water cycle management. The on-site green technologies used include Greywater Reuse System, Green Roof System, Rainwater Harvesting System, Porous Pavement System, Bioretention System, Swale, and Constructed Wetland. It is proven when the small demonstration site at HTC KL has improved the water quality and protected the excess flood water during the 2013 flood surrounding the HTC KL areas.

INTEGRATED MANAGEMENT

The use of ecosystem properties as a management tool marks the shift from managing water by 'regulation of issues' to a holistic action focusing on the 'regulation of processes' in hydrological and ecological systems at the river basin level. This shift requires a deeper understanding of the cause-effect relationships between abiotic factors, such as hydrology and temperature, and biotic factors in all types of ecosystems, and their relationships. The process of building this understanding, in turn, marks an important step in customising (Figure 2), that is, in developing solutions which are tailored to the needs of a particular river basin. The implementation and the needs are required to be understand and coordinate in a properly manner through policies commitment.

CONCLUSIONS AND RECOMMENDATIONS

National initiatives in forest and wetlands protection for river basin management, which is less costly than building dams and more sustainable non-structural activities in the long run is in parallel with ecohydrology concept focussed locally will be shared regionally and globally. Some lessons learnt through the ecohydrology of five projects in Malaysia made us more self-cleared in the process of project planning and management including maintaining the status of the specific targets achieved. Few discussions have been carried out on the suggestion of the establishment of River Basin Management Committee in DID. The committee will set the objectives and will monitor the status of the river basin master plan. This committee can set the detail scope activities of the river including the established river catchment master plan according to technical requirements without neglecting some political jurisdiction and key performance indicators established at ministry level.

Future Challenges

With urbanisation rapidly in progressing, Malaysia and other countries within the humid tropics belt require innovative solutions to ensure balanced development. The current and future challenges in humanity, climate change, policies and laws and guidelines will never be underestimated. While Malaysia has made some progress in realising IWRM, there are still many more issues that remain to be tackled; this would require combined and continued efforts. Recent years have seen Malaysia following the international trend of restoring and rehabilitation river projects by using ecosystem properties as a management tool. Initiatives in Melaka, Kuala Lumpur and Selangor featured more hydrological solutions with some ecological components. The case of the Putrajaya Lake and Wetlands as UNESCO-IHP Ecohydrology Programme represents an eco-design for a new city with a balanced treatment of its hydrological and ecological components that never outside its own challenges. With the establishment of the Regional Humid Tropics Centre in Kuala Lumpur in 1999 and its subjects focus on the hydrology and water resources, Malaysia has begun to search for home-grown ecohydrology practices as a tool for IWRM and disseminate these findings to UNESCO water families and south south cooperation in the water education through coordination activities.

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I would like to acknowledge UNESCO Jakarta, supported by the Malaysia Funds-in-Trust (MFIT) in the publication of Emerging Ecohydrology Approaches in Malaysia and Future Challenges topic in Customising IWRM at the River Basin Level study, which I hope will facilitate a better understanding of ecohydrology as an IWRM tool among water resource managers and decision makers.
Figure 1: MSMA Integrated Stormwater Management Ecohydrology (MSMA ISME) at HTC KL

Figure 2: IWRM and Ecohydrology
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HELP and IWRM challenges in Nepal

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Abstract

HELP (Hydrology for the Environment, Life and Policy) was initiated by UNECO IHP in 1999 with the objectives to address a wide range of interrelated issues, water and climate, water and the environment, water quality and human health, water and food, as well as water and conflict. The Upper Kaligandaki river basin, a basin lying in the cold and arid Trans- Himalayan region of Nepal was considered as a Network of HELP basin from the third phase of IHP HELP in 2009. Under HELP initiative in the basin, studies were carried out on the impacts of climate change on hydrological regime, on local livelihoods and on sediment transport trends in the main river. Results indicated that the snow reservoirs are depleting, spatial and temporal variability in precipitation is increasing and sediment yields in the main river is also increasing. Based on results of HELP activities in the basin, a 3-years research program on adaptive governance of mountain ecosystem services for poverty alleviation enabled by environmental virtual observatories (Mountain-EVO) was conducted. Mountain EVO activities were focused to water resources and ecosystem management through citizen science. Participatory monitoring was adopted in the basin and found successful in developing ownership and increasing the confidence in the research activities and in the implementation of the research outputs by communities as well as by government stakeholders. Livelihood over the basin is threatened which needed implementable policies of Integrated Water Resources Management (IWRM) to sustain. Stakeholder's participation ensured the management, sustainability and data utilization, all of which are parts of IWRM.

Legal based was derived from Water Resources Act-1992 for the inclusion of the Integrated Water Resources Management (IWRM) philosophy in Water Resources Strategy-2002 and National Water Plan-2005 of Nepal. Water Resources Act-1992 came up with the sectorial prioritization of water resources. Since 1992, relevant organisational regulations, related acts, policies and cases are added for the optimum uses of water resources in Nepal. In spite of all attempts, acts, regulations and policies, there are issues to be solved for the coordinated management of water, land, and related resources to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Water resources is also scaring due to climate changes which has been also demanding the implementation of IWRM efficiently. But there are challenges for successful operational of IWRM principles in water resource development in Nepal. Assessment made known that dialogues among the main stakeholders and understanding on perceptions of IWRM could not be synchronized with cross-sectorial and cross-ministerial coordination in the respective policies formulation sufficiently. Further, challenges lie in synchronizing of the policies with changing administrative system ahead since the implementation of new constriction of Nepal-2015. The Government of Nepal has been starting initiation to reformulate the water resources policy in line with IWRM principles for local, basin, national and over all perspectives.

Keywords: Water resources, IWRM, HELP, Citizen Science. Nepal
1. Background

1.1 HELP initiative in Nepal

HELP (Hydrology for the Environment, Life and Policy) was initiated by UNECO IHP in 1999 with the objectives to address a wide range of interrelated issues: water and climate; water and the environment, water quality and human health; water and food; and water and conflict (Shahbaz Khan, 2010). Based on proposal and request made by Nepal National Committee for IHP, the Upper Kaligandaki river basin, a basin in the cold arid Trans-Himalayan region was considered for HELP initiatives in Nepal since the third phase of HELP in 2009. Upper Kaligandaki river basin lies behind Himalayan range and Annapurna range on the Trans-Himalayan Region (Figure 1). Rain bearing monsoon cloud can only enter into the Mustang valley from the gorge between Dhaulagiri peak of 8,137 above mean sea level (amsl) and Annapurna peak of 8091 amsl. It is on the rain shadow area and windy area with alpine cold, dry, arid climate. Average annual precipitation is 275 millimeters.

The objectives of HELP initiatives in Upper Kaligandaki basin were i) developing and managing water resources in a holistic manner, ii) recognizing and adopting best technologies and practices to manage scared waters, iii) utilizing water sustainably to ensure conservation of resource and protection of the environment, iv) delivering water services in a decentralized manner by involving accountable stakeholders and agencies (public, private, community and user based organizations), and v) sharing of water resources benefits among the communities on equitable basis. Due to budgetary constraints, studies under HELP initiatives was limited to the impacts of climate change on hydrological regime, local livelihoods and trends in sediment transport within the basin. Major issues identified are climate change and stress on traditional livelihood system. Major ecosystem services are water, soil, rangeland, herbs, unique landscape and Culture. Other findings (Bhusal & Chapagain, 2011) are as below.

- Traditional agro-pastoralism is still a major source of livelihood
- Highland (livestock/ grazing) pasture productivity is decreasing because of spatial and temporal variation in snowfall / precipitation. (Decreasing trend in snowfall & increasing trend as liquid precipitation).
- Scarcing waters and climate change is impacting agro-based livelihood in the region
- Trends of increasing rainfall intensities have added threats to mud roof houses and have been adding potential risks of water induced disasters (loose & fragile topography).
- Some settlements (like Samsung & Dhey.communities) are at the junction of migration due to drying water sources used for domestic purposes.
- Low moisture holding capacity of soils demand more irrigation water

Upper Kaligandaki basin was selected for a 3-years (2014 to 2017) research project funded by UK EPSA-NERC research grant on “Adaptive governance of mountain ecosystem services for poverty alleviation enabled by environmental virtual observatories (Mountain-EVO)”. HELP initiative was supportive to consider this basin for Mountain Evo program, which was launched in Nepal, Peru, Kyrgyzstan and Ethiopia (Buytaert et al, 2014). Study on Upper Kaligandaki river basin have revealed that farmers are facing multiple problems such as less water available for irrigation, less information on hydro-climate and environmental data and, steep topography, windy and freezing climate for the implementation of developed techniques like drip and sprinkle systems,
decreasing pasture productivity and migration dynamics (Bhusal et al, 2016). The following are key messages from the research:

- Involvement of citizens in scientific measurement, data collection and co-generation of adaptive knowledge supported in fulfilling data gaps and increased awareness on importance of local environmental data.
- Citizen science enabled communities to understand climatological scenarios of the areas and to plan activities to improve livelihoods.
- Citizen science was found an effective tool in capacity building on water management by co-generation of knowledge on irrigation water requirements, soil moisture conditions etc.
- Co-generation of knowledge supported in governance mechanism, in decision making, water and land use management.

Participatory monitoring was adopted in the basin and found successful in developing ownership and confidence building in the research activities and in implementation of the research outputs. Stakeholders’ participation has ensured management, sustainability and data utilization. HELP initiatives has inbuilt the principle of the Integrated Water Resources Management.

1.2 Integrated Water Resources Management (IWRM) in Nepal

Integrated Water Resources Management (IWRM) philosophy is incorporated in Water Resources Strategy-2002 and National Water Plan-2005 of Nepal. Strategy and plan have focused to several issues such as, water supply and sanitation; irrigation, hydropower, environments, legal and social norms, institutional capacity, international relation and, water resources database (WECS, 2002, 2005). Water Resources Act-1992 came up with the sectorial prioritization of water resources. This Act prioritizes water uses as i) Drinking & domestic use, ii) Irrigation, iii) Agricultural uses (animal husbandry), iv) Hydropower, v) Cottage industries, Industrial enterprises, Mining, vi) Navigation, vii) Recreational use and, others (GoN, 1992). Some other legal documents are, Electricity Act, Water resource regulations, Irrigation policy, Hydropower development policy, Nepal water supply sector policy, Drinking water regulation and, Regulation on water users group (WUG) etc. As of 2016, there are more than 19 institutions including eight ministries managing water resources and related activities in Nepal. In spite of all existing acts, regulation, policies and organisations, IWRM faced various challenges (Diana, et al, 2015; Adhikari, 2016; Thapa, 2016).

2. Challenges

Water Resources Strategy-2002 and National Water Plan-2005 of Nepal have visioned a coordinated management of water, land, and related resources to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. These policies have emphasized the Integrated Water Resources Management. Neither the strategy nor the plan are effectively implemented due to various challenges as briefly summarized below.

2.1 Cross-sectorial coordination

IWRM principles that are incorporated into national water policy and water resources strategy could not be synchronized with cross-sectorial and cross-ministerial coordination in the respective policies formulation sufficiently. Interests of sectorial ministries and international donors are also reflected in the water resources policies formulation and implementation, which further added complication for bureaucratic reforms to implement IWRM success.

2.2 Institutional barriers

The prevailing budgetary power remained at sectorial ministry’s representatives, largely at the district level and the division level, which dominated the decisions on selection and implementation which, reflected as the institutional barriers to effective, inclusive and accountable decision making in water resource management. Water and energy commission secretariat which is to be an apex body to implement IWRM, could not performed its mandate for cross-sectorial coordination as envisioned in WRS and NWP. The formulation of new institutions like integrated river management committees at local and connecting them with the wider decision-making systems in water resources management is a pertinent challenge to ensure informed, inclusive and accountable decision making.

2.3 Sectionalized funding
Pilot projects that were initiated mostly with donor’s funded had sectionalized funding which made easy to the institutional barriers for IWRM implementation because, the main stakeholders and the most powerful actors role was individual.

2.4 Capacity building

Deriving from the views on institutional barriers, implementation of IWRM is linked with issue of bureaucratic reform. Institutional set-up and capacity building has not been materialized that was versioned in National Water Plan (NWP). NWP assumes that sectorial ministries come up with the right institutional set-up and mechanisms of implementation; and to which donors are also concerned about to end sectionalized funding.

2.5 Climate Change

Necessity of efficient water use management is further increased due to climate changes (MoSTE, 2014). Climate change issue which were not seriously considered in WRS and NWP, is an added advantage to motivate to implement IWRM.

2.6 Synchronizing with changed administrative system

The new Constitution of Nepal -2015, has considered water as the primary natural resource of the country and has divided it's sharing and responsibility among the center, province and local entity. Existing IWRM policies need to accommodate the constitutional spirit. Rights Water resources to is not clearly defined (only says major natural resources belong to the state gov.). The constitutional Commission (National Natural Resources and Fiscal Com) will have further challenges to manage conflicts between local, province and federal governments in coming years.

3. Policy revision

A comprehensive national water resources policy is under formulation in the leadership of Water and Energy Commission Secretariat, Government of Nepal. The water resources policy revision has been considering gaps in the existing policies and lessons while implementation (Adhikary, 2016, WECS, 2013). Climate changes effects like water availability situations with respect to space, time and changing circumstances are considered. Trans-boundary issues are noted. Revised policy emphasises on transparency and tools like statutory arrangements for water sharing among various uses and users. The policy provides directives and guidance for building the legal institutional structures in order to implement the constitutional provisions of all levels of state organs. The policy has stressed on a water resources database information system, stakeholder participation and gender equality guaranteed. Policy has also emphasized on the water quality standard for various uses; preventing water pollution; minimize losses by water induced disasters and drought. It is expected that the new policy, also backed by the constitutional provisions would be able to overcome challenges in IWRM implementation.

4. Conclusion

Lack of coordination, lack of appropriate institutional set-up and capacity building, sectionalized funding, scarcing waters and, trans-boundary issues are some of major challenges in efficient water resources management.

Issues of water rights and environmental considerations were underemphasized in the existing water resource policy of Nepal. Trans-boundary issues on water resources were not visibly addressed in the existing IWRM of Nepal. Nepal lacked legally a strong agency to deal with IWRM and to enforce its implementation.

Water, environment and livelihood are interlinked and needed intervention through IWRM. The water resources policy objective is to utilize water resources in integration by maximizing its social, economic and environmental value for a well-developed nation. Preparation of comprehensive river basin plans through IWRM principles are in the process in Nepal which aim to consider of all aspects of water uses including economic, social, and environmental and conservation values.

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Droughts as consequences of Climate Change/Variability in Iran; A Case Study of Lake Urmia

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Severe decline in precipitation causing droughts as consequences of climate change/variability poses a serious threat to the resilience and security of communities and regularly impacts the lives of millions of people worldwide. Extreme, widespread drought challenges the security of the world’s food supply and the integrity of critical infrastructure, causes extensive health and economic impacts. The impacts of climate change/variability are expected to increase the frequency, intensity, and duration of droughts in many regions, and persistent drought could force foundational changes in the way communities use and live on the land. The economic impacts of drought can be extensive, with water-intensive industries potentially relocating and agricultural production shifting to other regions. The far-reaching impacts of drought impact human and environmental health in many ways, due to factors including compromised water availability and quality, poor air quality, compromised food and nutrition, and increased incidence of illness and disease.

Droughts due to climate conditions have also had dramatic impacts on the world’s lakes both quantity and quality wise. Lake Urmia Water Basin as one of the six main water catchments, located in the north west of Iran with an area equivalent to 51876 km\textsuperscript{2} is amongst the world’s severely hit lakes affected by this phenomenon. Lake Urmia, located in this basin, is considered as the largest lake in Iran and the sixth largest saltwater lake in the world with a surface area of around 5200 km\textsuperscript{2}. According to the latest information, the rate of precipitation has decreased to a level of 18\% during the past 20 years due to climate change/variability. This has led towards a serious decline in surface runoff in the basin which results in a considerable decrease in the lakes inflows. Figure 1 demonstrates the Lake’s shrinking situation since 1972. The average surface water resources inflows to Lake Urmia has decreased from 4939 MCM to 2440 MCM (~ 50\% decline) within the past 20 years. This has also resulted in a considerable decrease in
the Lake’s water level being accompanied with less water flowing towards this Lake due to water losses increase (~36 %) throughout its reach.

Lake Urmia surface and the water volume have decreased seriously over the last two decades. The surface area of the lake with an ecological water level of 1274.1 was 4348 km2 with a volume of 14.5 BCM. The lake’s surface area has been estimated to have been as large as 5,585 km2 in 1974 with a water level of 1277.1 m from the sea level, with a volume of around 29 BCM, but since then the area has dramatically declined to only 1100 km2, approximately 20% of its original surface area and with a water volume of around BCM in 2016. The Total dissolved Solids (TDS) in its ecological water level was 205 gr/lit. which is now higher than 500 gr/lit. This has caused a serious decease of aquatics which have almost disappeared from the lake.

The drying up process of Lake Urmia has caused severe socio-economic and environmental impacts in the region. The basin area is an important agricultural zone with a population of around 6.4 million people; an estimated of 76 million people live within a radius of 500 km of the lake in five countries including Iran, Turkey, Iraq, Armenia and Azerbaijan. Those around the lake fear a situation similar to Aral Sea, which has dried up over the past several decades. Disappearance of the Aral Sea has been an environmental disaster affecting people throughout the region with windblown dust-storms. The population surrounding Urmia Lake is much denser putting more people at risk of impact. Urmia Lake bed is exposed to wind erosion causing enormous dust storms threatening agricultural land and pollution of nearby cities with salt storms spreading around and seriously threatening the health of inhabitants. Today’s miserable situation of Lake Urmia is result of long neglecting the lake conservation and ignorance of impacts of rapid development of agriculture, industrial and urban water use on the water flow towards the Lake. The drying of the lake has been the result of climate change/variability which has resulted in a considerable decrease in precipitation and surface runoff and complex and varied human factors such as increasing the agricultural lands, changing the crop patterns, producing high water consuming products, low water productivity and lack of effective protection from the basin ecological and environmental resources.

As a conclusion, after precisely investigating the causes of the current Lake Urmia crisis via data collection, processing, modeling and vast analysis carried out, a solution has been brought up with several concrete conclusions under a Plan called “Urmia Lake Restoration Plan (ULRP)” taking benefit of four main strategies: (1) decreasing water consumption in the agricultural sector by focusing on less consuming products (2) releasing water from nearby dams towards the lake as one of the most important water resources (3) decreasing the water losses in the buffer zone area of the lake and last but not least (4) transferring water from nearby water basins. According to the developed roadmap of activities, the time schedule for the ecologic water level restoration of the lake will take around 10 years and the total required budget for the Urmia Lake restoration is estimated to be over five billions USD.

As a separate approach, the Islamic Republic of Iran submitted a resolution to the 35th session of the General Conference of UNESCO in 2009 (35 C/DR.13) proposing to establish the International Drought Initiative (IDI) that would support the execution of the seventh phase of the International Hydrological Programme (IHP-VII). After several board and executive meetings, UNESCO adopted this initiative in 2012 with the purpose of drought prediction and mitigation particularly in the Asian countries as an approach to risk and crisis management and recovery of drought losses. UNESCO Regional Centre on Urban Water Management has been assigned as the
responsible entity (IDI secretariat) to run this important initiative. If well practiced this initiative will be able to provide effective solutions and approaches towards better managing huge water bodies including Urmia Lake. This initiative has so far lunched two main projects as:

1- Development of a Grid-based Precipitation Dataset for West Asia to feed Climate Change Studies with the aim of providing an online and easy to use version of PERSIANN precipitation data produced for the West Asia. The products of this dataset can be used for different purposes such as predicting phenomena including floods, drought, extreme precipitation events, climate sensitivity, evaluation of climate models and further studies.

2- Development of a National Water Security Atlas to Support Sustainable Water Governance in Iran with the purpose of bringing the concept of water security into practice to support sustainable water governance. Apparently, water security promotes sufficient, safe, affordable, and clean water to lead a healthy and productive life for all human beings, where communities are protected from floods, droughts, and water-borne diseases. It also endorses environmental protection and social justice by addressing the conflicts and disputes that arise over shared water resources by providing common platforms for different disciplines and interest groups.

**Keywords:** International Drought Initiative, Climate change, Urmia lake, drought
Climate is changing in different parts of the world including Pakistan. The intensity of rainfall is increasing with simultaneous increase in gaps between two events. The same is the reason that heat waves, droughts and floods are getting frequent. Floods are occurring almost every year since 2009 in different parts of the country. On the other hand, extended span between two rainfalls damages the crops. The heat waves during summer not only affect the crops in a limited time, but also the urban population. During the heat wave of 2015 almost 2000 people were reportedly killed in Karachi alone, whereas the drought which prevailed recently from October to December, 2016 damaged the wheat crop in rainfed areas.

The global climate modeling studies predict that air temperature and precipitation would increase consistently in Pakistan. The temperature is likely to increase during summer in northern areas, whereas in southern areas it will increase during winter and spring. The river inflow is therefore likely to increase during the 21st century in the Indus basin due to accelerated snow and glacier melt and extensive and intensive rainfalls during the monsoon. Interestingly, the percentage of increased river flow is larger in winter than in summer, which shows that snowmelt component would be dominantly contributing to river flow. It does mean that climate change would increase water availability in the Indus Basin, which can be an opportunity, if this additional water is conserved and used appropriately to bring more area under cultivation.

Northern areas of Pakistan are hit by rising temperatures and intruding monsoon. The areas are mother well of water resources of Pakistan, which feeds the world’s largest Indus Basin Irrigation System, commanding 16 Mha. The region is the home of the world’s largest glaciers like 76-km long Siachin, 67-km long Biafo, 63-km long Baltoro, 57-km long Batura and a number of others. Besides, the areas annually receive a handsome amount of seasonal snow, which contributes almost 70% to the river inflows. According to a study, monsoon belt has intruded 80-km westward from the eastern Himalyan region to the western Karakorum in Pakistan. The same is the reason that Gilgit Baltistan and Chitral areas now face floods in almost every monsoon.

Gilgit-Baltistan areas are mostly barren devoid of vegetation and are therefore prone to erosion, which is increasing with time due to intensive monsoon rainfalls. The situation can be gauged from the fact that maintenance budget of the Karakoram Highway has increased 10-times during recent years due to more landslides. Besides, these landslides occasionally take toll in terms of human lives. The mountains are composed of loose material giving rise to huge sediments, which ultimately deposits in the draining streams and rivers. All those stream/rivers ultimately dispose into river Indus, in which daily sediment load in Tarbella is 500,000 tonnes. Moreover, the forest area is declining by 28000 ha/year including GB. The situation of erosion and sedimentation would therefore worsen in the coming days. The situation requisitions to implement climate smart technologies, which can replace the nude mountains by vegetative cover.

Communities’ resilience to climate change can be developed by introducing sustainable technologies. Such technologies will be sustainable due to being socially acceptable, environmental friendly and economically viable. Pakistan Council of Research in Water Resources (PCRWR) introduced the following technologies in the region: (i) solar-powered drip for raising apple orchards and (ii) routing high-altitude streams through pipes for irrigation on foothills of Karakoram. Both the activities were carried out in participation with the local communities at Morkhoon and Shahabad ares of Hunza. There is no carbon emission or other environmental concerns associated with the interventions.

Solar-powered drip by lifting river water for orchards:

The idea of raising apple orchards on barren lands through solar-powered drip was a simple idea but it did pose a number of challenges during implementation i.e. (i). river water carries high sediment load, which is damaging for the pumps (ii) high river flow and wind pressure making the system vulnerable and (iii) choking of the drip system emitters due to sediments. The intervention was carried out at Morkhoon, Tehsil Gojal, District Hunza. An outer filter was developed for the pump to avoid sediment entry and damage thereof. A 10 inch dia porous UPVC pipe was wrapped with finely-meshed green net, and was tightly bound together. The filter was placed in the river, transverse to the direction of flow, so that river flow force can be harnessed for water filtration through green net and small-
openings of pipes. The filter and pump were properly tied to the tree on the river banks for safety against river flow and wind. The solar panels foundations were properly developed to withstand wind pressure.

Water thus entering into the outer filter (10 inch dia UPVC pipe wrapped in green net) was mostly sediment free. It was pumped through submersible pump (Lorentz, Germany 1 HP) powered by 500 watts panels to storage tanks (1000 gallons) placed at 100 ft height. The water from the storage tanks was routed to the apple saplings through drip system. Due to high pressure in the drip system (100 ft), a few sediments carried by water are thrown away through emitters, minimizing the chances of being clogged. The apple trees are likely to give back earning to the farmers in a few years. However, farmers have started cultivating vegetables through same water for short-term revenue generation. The daily pumping capacity of the pump is 2500 gallons, which is irrigating around 2000 apple trees. The erosion and sedimentation rate from the barren land patch is likely to reduce significantly besides social and economic benefits.

![Figure 1: Climate smart drip system to use river water under high sediment load]

**Piped irrigation water supply from glaciers:**

Passu glacier is a typical example of climate change, where it has been retreated by 1.5 km due to rising temperatures. Routing high altitude streams/glacier water under gravity to irrigate land in valleys is not a new concept and has been practiced since centuries. A man-made watercourse existed here, which routed water from glacier’s mouth to irrigate Shahabad area. However, due to glacier’s retreat the watercourse flow and irrigated area was severely affected. A significant portion of water is wasted all the way from the source to the irrigated area, resulting in very low irrigation efficiency. Moreover, there is no water shut off mechanism for such routed waters, which ultimately give rise to ponding of water at certain places and dying of trees thereof.

Communities’ consultations suggested that piped water supplies will be extended in the glacier’s retreated span of 1.5 km, which is sustainable and cost-effective. Due to high slopes, the piped water supplies significantly increase the flow and travel time to the destinations. HDPE pipe of 4 inch diameter was selected to cater the water needs of the whole valley. The pieces of the pipes were jointed through butt-fusioning to further minimize frictional losses. The community was speculating low discharges from the 4 inch dia pipe, but convinced when seen the water flowing with high velocity as much as 5-6 ft/sec. It is catering water requirements of the whole Shahabad village. The discharge of the watercourse has now increased 3-times, rather at a number of places the watercourse is overtopping. The irrigation needs of the Shahabad area is being fulfilled, whose half area was abandoned due to low flows of the channel. Re-vegetation of area has developed community resilience, who were forced to migrate due to glacier retreat caused by the climate change.
Figure 2: Routing Passu glacier water through piping under gravity
Session 4: IWRM and Water Security linked with Agenda 2030

“Challenges in Addressing SDG 6 in Asia Pacific”

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Water is integral to numerous global challenges, most obviously climate change, food production, growth and poverty reduction. Yet water management decisions are still made outside the water sector, usually in the framework of agricultural, industrial or infrastructural development objectives.

Globally there is about a 40 per cent gap between the amount of water now available and the amount of water that will be needed in 2030 for aggregate food production, energy, municipal and industrial goals. This is a dangerous situation — acute shortages will emerge, even if ecosystem water needs are not taken into account.

This is the reason why there is an urgent need that water sector managers must get out of the water box if they wish to have any hope of influencing decisions about sustainable development. Actors must start linking water to adaptation, mitigation, national planning, economic and agricultural policy, as well as disaster planning. And all this work must use an ecosystem approach.

Integrated water resources management is one way to do that. It is an internationally acknowledged approach that seeks to avoid the lives lost, the money wasted, and the natural capital depleted because of decision-making that did not take into account the larger ramifications of sectoral actions. IWRM emphasizes the importance of getting all sectors involved to build the needed resiliency for both development and climate change mitigation and adaptation.

Sustainable management of water needs a basin level approach, which often requires both an IWRM approach and transboundary cooperation. While there are numerous regional and basin-level legal agreements on transboundary waters, there are also many cases where no cooperative agreements exist.

IWRM helps to allow sustainable growth and protect essential environmental services. Therefore better coordination between federal and local governments as well as among various departments and sectors is needed to curb damaging externalities, reduce waste and sustainably use all our resources for a prosperous future.

UNSGAB sees IWRM, as important for sustainable growth. IWRM is a flexible tool for addressing water challenges and optimizing water’s contribution to sustainable development. It is a comprehensive approach within the water sector and provides the tools for implementation. Applying IWRM is necessary to more effectively manage the rapidly increasing need for water to adapt to climate change, expand agriculture and maintain environmental needs while using an ecosystem approach.

The Board has included IWRM in all three of our Hashimoto Action Plans. We have advocated that countries report on their progress with IWRM Planning at the United Nations. We have made the point that IWRM is the best approach available for climate change adaptation.

We have also pushed countries to ratify the United Nations Watercourse Convention which is the first global framework on fresh water and the world’s only global framework for transboundary cooperation. The Board was encouraged when the Watercourses Convention entered into force this August. We would encourage the participants here today to urge your countries to ratify the Convention. Right now, Asian countries are not well represented. The convention can help address the fragmentation among basin specific agreements. In addition, further ratifications sends a message that international water law requires states to cooperation over international watercourses. This will help countries better manage their water resources in the future.

The Board has also advocated to include IWRM as part of the post-2015 Sustainable Development Goal on Water. We are happy to announce, that IWRM is now included within the proposed Water Goal under point 6.5 “by 2030 implement integrated water resource management at all levels, including through transboundary cooperation as appropriate”. UNSGAB is committed to continue its efforts through 2015 and advocate for the water goal to be within the post-2015 Sustainable Development Goals.
Lessons Learned and Challenges of Africa in Upscaling Water Security

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Abstract: Africa faces a number of serious socio-economic problems that call for urgent remedial action if current trends towards endemic poverty and pervasive underdevelopment are to be turned round. The crucial role of water in accomplishing the needed socio-economic development goals is widely recognized. Africa appears to have lack of water resources (WR) inspite of its large rivers, big lakes; vast lands and widespread groundwater resources. On the other hand Africa has a high potential for the development of hydroelectric power. Unfortunately, these resources are threatened by certain natural and human factors, which are going to be reported and discussed. These threats and challenges make it difficult to manage the WR in the continent to satisfy the demands of basic water supply and sanitation, food security, economic development and the environment. Addressing these threats, calls for a new way of thinking about water together with a framework for action. Moreover, selected lessons learned will be pointed out and reported. The paper is concluded with several recommendations.

Keywords: Africa WR, Climate Change, Environment, Challenges, Lesson Learned, Security, Upscaling.
1. **Introduction**

Water is a crucial resource with great implications for Africa development. Of the estimated current 1.216 million
who live on the African continent, more than 500 million live in the water-scarce environment. The importance of
water for socio-economic development is well recognized globally, but with increasing population, industrialization
and their demands for water for various uses, water scarcity is looming in many countries of the world. Africa is
considered the world’s second-driest continent, after Australia where the annual per capita water availability of 4,008 m³ in 2009 is well below other world regions except Asia, the world’s most populous continent. This figure
doesn’t reflect the reality, since the Congo basin has fewer population and huge amount of water. Therefore,
renewable WR are unevenly distributed among Africa’s sub-regions. Africa is widely acknowledged as the world’s
poorest and least developed continent because there are significant linkages between water, environment and poverty.

In sub-Saharan Africa, 69% of the population has no proper sanitation facilities, while 40% has no reliable access
to safe water, WHO/UNICEF 2010. Since then the situation has not gotten better if is not worse. Thus, a large number
of countries on the continent still face huge challenges in attempting to achieve the United Nations water-related
Millennium Development Goals (MDGs).

Africa has only about 9% of global freshwater resources but 15% of the global population. Africa’s population
growth rate of 2.3% from 2005 to 2010 was the world’s highest. Over that time, Africa’s urban population grew at
a rate of 3.4%.

A combination of natural and human factors is responsible for wide differences in water availability between African
countries. Africa’s climate is characterized by an overall unreliability of rainfall. There are two rainfall extremes,
ranging from near zero in dry regions such as the Sahara Desert, to extremely high rainfall in the Congo-Guinean
rainforests. There are pronounced seasonal variations in precipitation in many African regions. Hence there are
several constraints facing Africa WR Management:-

- The multiplicity of transboundary water basins;
- Extreme spatial and temporal variability of climate and rainfall, coupled with CC;
- Growing water scarcity, shrinking of some water bodies, and desertification;
- Inappropriate governance and institutional arrangements in managing national and transboundary water basins;
- Depletion of WR through pollution, environmental degradation, and deforestation;
- Failure to invest adequately in resource assessment, protection and development;
- Unsustainable financing of investments in water supply and sanitation.

Using the simplified model of society’s response to water scarcity as a guide, the key issues in Africa are investing
in the development of Africa’s potential WR, reducing drastically the number of people without access to safe water
and adequate sanitation, ensuring food security by expanding irrigation areas and protecting the gains of economic
development by effectively managing droughts, floods and desertification.

2. **Objective**

The study objective is to contribute to the African upscaling of the existing approaches in WR management with
scientific collaboration and tools to support, design and implement Ecohydrology and HELP Strategies and
Policies for sustainable WR Management.

3. **Rainfall in Africa**

On continental basis rainfall in Africa is about 670 mm/year with greater variation in time and place. Temporal
variability of rainfall is typically 40% around the mean. The highest rainfall occurs in the Island countries (1,700
mm per year), the Central African countries (1,430 mm), and the Gulf of Guinea (1,407 mm). The lowest precipitation
occurs in the northern countries where average annual rainfall is only 71.4 mm. The climate varies from humid
equatorial to seasonally arid, tropical and sub-tropical Mediterranean-type climates. Historical records show that
during the 20th century, rainfall has been decreasing over large portions of the Sahel, while rainfall has increased in

For example, northern Africa and southern Africa receive 9% and 12% respectively of the region’s rainfall. In
contrast, the Congo River watershed in the central humid zone, with 10% of Africa’s population, has over 35% of
its annual runoff. Again, in the humid equatorial zone (in the Gulf of Guinea), annual rainfall is over 1,400 mm and
exceeds evaporation. In the Sahara and Kalahari deserts, annual rainfall is less than 50 mm, and it is exceeded by
evaporation. Africa’s total runoff, which is reflected in its useable and renewable WR and accounts for 10 % of the world’s freshwater resources, is thus very low. Ahmed et al 2016. Figures 1, 2 show that in the last four decades the Salel faced continuous, prolong and serious drought and water shortage. This has its negative impacts on the socio-economic development and livelihood of the whole continent.

4. Internal Renewable Resources

A significant feature of WR in Africa is the extremely low runoff in relation to precipitation. Generally, the amounts of surface and groundwater flows that are generated from rainfall within the sub-regions are low for all the sub-regions in Africa.

At continental level, renewable WR constitute only about 20 % of total rainfall while in Sudano-Sahelian and Southern African sub-regions, the figures are 5.9 % and 9.25 % respectively. This may reflect high losses of rainwater. These losses may occur, in part, through evaporation of surface waters or through plants. The low values of the internal renewable resources also show that there is room for improvement in conservation of rainwater. More importantly, they account, in part, for the endemic drought in parts of the continent.

5. Growing Water Scarcity

The climatic variations in Africa have resulted in abundant WR in some areas and spreading drought and growing scarcity of water in others, especially where low annual rainfall is accompanied by low levels of internal renewable WR. The frequency of drought has been increasing over the past 30 years, resulting in significant social, economic and environmental costs borne mostly by the poor. Not surprisingly, there are growing constraints to water supply in the dry lands that occupy about 60 % of the total land area of Africa.

In 1995, Algeria, Burundi, Cape Verde, Djibouti, Egypt, Kenya, Libya, Malawi, Rwanda and Tunisia were facing water-scarce conditions (with less than 1,000 m³ of renewable WR per capita per year). Another three countries, Morocco, South Africa, and Somalia, were reported to be facing water-stress conditions (less than 1,667 m³/capita/year). It has been estimated that by 2025, the number of countries facing scarcity will increase to 14, and the number facing water stress will rise to 11. Already, about one-third of the people in the region live in drought-prone areas, and there is one country where one-sixth of the drinking water supply (in one city) comes from recycled sewage. However, the latter that has been put through very sophisticated treatment processes.

The apparent disappearance of Lake Chad in West Africa is symptomatic of the growing scarcity of water in Africa. Originally believed to have an area of about 350,000 km², the lake was reduced to 25,000 km² in the early 1960s. However, today, it is reduced to about 2,000 km². While the cause of this apparent shrinkage of the lake is not well understood, it is occurring in the same area where the two complementary processes of desertification and deforestation are combining to push the frontiers of the desert farther south in West Africa.

Therefore, two features of Africa WR are critical to effective management. First, precipitation across much of the region is exceptionally variable (both in time and space) and unpredictable. Second, runoff is extraordinary low. The consequence of these two features is endemic drought.
6. Dams in Africa

A number of the world’s largest dams such as High Aswan (162 billion m³), Roseries, Volta, Kariba and Cahora Bassa are found in Africa. South Africa and Zimbabwe have the most dammed rivers and among the world’s countries with large dams ranked 11 and 20 respectively. Ethiopia is constructing the second largest dam in Africa (Grand Ethiopian Renaissance Dam, 74 billion m³). The number and distribution of dams in Africa is limited compared to the potential available. Moreover, the storage capacity is small looking to the African vast area and population size. Storing water is one of the main factors leading to better WR management.

7. Groundwater in Africa

Groundwater is extremely important in Africa. It is estimated that more than 75 % to 80 % of the African population uses groundwater as its main source of drinking water. This is particularly so in North African countries such as Libya and Tunisia, as well as parts of Algeria and Morocco, and in Southern African countries such as Botswana, Namibia and Zimbabwe. However, groundwater accounts only for about 15 % of the continent’s total renewable WR. Widespread, hence it is the source of drinking water for three quarters of the continent’s population. The cities of Lusaka, Windhoek, Kampala, and Addis Ababa are highly dependent on groundwater for municipal water, and groundwater contributes to the supply of other cities such as Lagos, Khartoum, Abidjan, Cape Town and Pretoria.

Finally, groundwater is a source of seepage into water bodies such as rivers and lakes, and this interaction in the water cycle is important for maintaining the integrity of ecosystems. Most countries in the desert areas of Africa such as Libya, Egypt, Algeria, Tunisia, Namibia and Botswana receive very little precipitation and therefore rely heavily on groundwater resources. The Nubian Sandstone Aquifer System underlies virtually all of Egypt, much of eastern Libya, and significant areas of Northern Chad and Northern Sudan, CEDARE 2001.

8. Transboundary Surface Water Basins

Worldwide, there are 263 Transboundary River Basins, which can be defined as basins shared by two or more riparian states. Approximately 60 % of the world’s population depends on these international water systems. Transboundary river basins are also important because of the complex natural ecosystems they support. The potential increases in conflicts over shared WR as well as the effects of climate change (CC) represent significant social, economic and environmental threats. In addition, there is a growing danger to human health from inadequate or unsafe water supplies. Africa has 63 international transboundary rivers basins cover about 64% of the continent’s land area and contain 93% of its total surface WR.

9. Water Withdrawals

Of the total amount of water withdrawn in Africa, 85 % is for use in agriculture, 9 % is for community water supply and 6 % is for industry. In both the continental and sub-regional levels, the withdrawals are rather low in relation to
both rainfall and internal renewable WR. The only exception is in the northern countries of Africa where the withdrawals are 18.6% and 152.6% of rainfall and internal renewal resources respectively. It is noteworthy that for Africa, as a whole, the amount of water withdrawn for the three major uses of water amounts to only 3.8% of internal renewable WR. This may reflect a low level of development and use of WR on the continent. At the same time it tells that there is a good opportunity for further development in different areas related to water utilization. Therefore, upscaling for water security in Africa is possible if IWRM tools are adopted and political will exists.

9.1. Water and Agriculture
Most economies in Africa are closely tied to natural resources. Water is directly or indirectly used in almost every economic sector including agriculture, manufacturing, trade, mining, tourism, transport, and telecommunications… Etc. The agricultural sector accounts for about 20% of Africa’s GDP, 60% of its labour force and 20% of the total merchandise exports, and is the main source of income for 90% of the rural population. Compared to other sectors, GDP growth originating in agriculture is about four times more effective in raising incomes of poor people, (World Bank 2009). However, the potential for navigation development is widely exists.

9.2. Water and Transport
Rivers serve as channels for transportation. Africa increasingly recognizes the value of inland waterways in promoting trade between nations, and for the need to integrate different forms of transport networks across the continent. Examples of the current continental impetus to utilize water transport more include the 20-year rehabilitation and upgrade plan for ports on Lakes Malawi and Tanganyika being carried out by the Tanzania Ports Authority to improve the handling of imports and exports (e.g. coal, coffee, sugar, tea, timber, tobacco and other commodities), Ford 2007. There are extreme navigation problems on most of Africa’s major rivers. There is also uncoordinated development between different water use sectors and inadequate funding to develop or make improvements to the important river navigation systems. Only a few of the waterways, mainly in the Congo, Nile and Zambezi basins are internationally navigable, UNECA 2009.

9.3. Improving the Quantity, Quality and Use of Africa’s Water
Africa faces mounting challenges in providing enough safe water for its growing population, especially for the huge numbers of people migrating to peri-urban areas, where municipal water services are often non-existent. Many African nations failed to achieve the Millennium Development Goals (MDGs) safe water target to reduce by half the proportion of the population without sustainable access to safe drinking water by 2015. However, many more countries missed the sanitation target that stipulates that by that date, they reduce by half the proportion of the population without sustainable access to basic sanitation. Other challenges include avoiding potential conflicts over water in the 63 water basins on the continent shared by two or more countries; adapting to the impacts of CC on WR, which will be greater than most other regions. This is attributed to fact that Africa already suffers from extreme rainfall variability; and developing WR that are adequate for local needs but that are unavailable due to political and economic constraints.

10. Challenges Facing Africa WR Management
   i. Drinking Water Supply and MDGs and improving access to safe and clean water.
   ii. Africa has 63 shared water basins and 94 international water agreements to address potential conflicts over transboundary WR.
   iii. Agriculture uses the most water in Africa and the estimated rate of agricultural output increase needed to achieve food security is 3.3% per year.
   iv. Hydroelectricity supplies 32% of Africa’s energy, but its electricity use is the lowest in the world while the hydropower potential is greater than the entire continent’s electricity needs.
   v. Land degradation and water pollution reduce water quality and availability.
   vi. Africa is one of the most vulnerable continents to CC and climate variability. However, there is an opportunity to provide more and better early warning mechanisms.
   vii. Current institutional, financial and human capacities for managing water are lacking. The opportunities for addressing this challenge include reforming water institutions, improving public private partnerships and expanding the knowledge base through human capacity building.

11. Climate Change (CC)

11.1. Manage Africa water under Global CC
Global warming and its human cause are undeniable. Warming patterns in Africa are consistent with global ones and Africa is already subject to important spatial and temporal rainfall variability. Africa’s repeated
drought cycles kill thousands of people each event, Figure (3). Moreover, floods also occur regularly with severe impacts on peoples’ livelihoods, Figure (4).

Africa is one of the most vulnerable continents to CC and climate variability. Rainfall variability contributes to Africa’s economic limitations in adapting to CC impacts. Population growth in peri-urban areas will exacerbate flooding events. CC will likely increase aridity and water stress with important impacts on food production. Climate variability and change could result in low-lying lands being inundated. In addition it is likely that CC will affect disease vectors. Hence, the main challenge is how to cope with the CC.

11.2. Impacts of CC and Variability on Africa

A combination of various factors that include widespread poverty makes it difficult for most African communities to draw on financial, human, social, physical and natural capital to minimize their vulnerability to the impacts of CC, including the possibility of more severe and frequent droughts and floods. Population growth is an additional strain on scarce resources to adapt to CC impacts. Faced with existing low adaptation capacity, Africa will be further constrained by the direct and indirect impacts of CC and a lack of the financial means to cope. These include increased water stress in some areas and inundation in others, a rise in food insecurity and the potential for an increase in water-related disease vectors.

Although the negative impact of the drought in the recent was increased considerably, however, the flood risk increased in the last 20 years by six folds.

![Figure 3. Number of people killed and affected by Africa’s worst droughts - (EM-DAT 2010)](image1)

![Figure 4. Number of people killed and affected by Africa’s worst floods - (EM-DAT 2010)](image2)

12. The Opportunities
With the knowledge that Africa will face significant impacts on its WR due to CC, the international community has begun to devote considerable attention and resources to CC adaptability on the continent. It has identified many opportunities for managing water to overcome those impacts and the constraints in addressing them. In the following examples of measures which can be adopted: Reinforce traditional adaptation mechanisms; Provide early warning system; Introduce adaptation measures informed by a more reliable system of seasonal predictions; Support public-private partnerships that develop innovative adaptation measures; Improve physical infrastructure.

13. South-South Cooperation for Africa Water Security

This cooperation is important especially if it will be formed after many years of bilateral relationships. The following are some benefits of the South-South cooperation for Africa:-

- strengthening of the voice and bargaining power in multilateral negotiations;
- use of experience and capacity that already exist and the development of new capacities.
- opening of additional channels of communication among countries;
- promotion and strengthening of economic integration among developing countries on as wide a geographic basis as possible;
- enhancement of the multiplier effect of technical cooperation and fostering of economic, scientific and technological self-reliance;
- increased knowledge of and confidence in the capacities available in countries;
- coordination of policies on development issues relevant to a number of countries;
- development of indigenous technology and the introduction of techniques better adapted to local needs, particularly in traditional subsistence sectors such as agriculture.
- promotion of: national science and technology plans; economic and social planning; linkage of research and development with economic growth; project planning and evaluation; use of human and natural-resource potential; modern management and administration; technical, scientific and administrative manpower.

Establish networks for the different institutions working in fields of IWRM in Africa aiming to encourage their cooperation and strengthen joint research and training program.

14. Lessons Learned

a- In Africa several countries have experience with irrigation network management with different degree, e.g. Egypt, Sudan, Algeria, Morocco, Tunisia and South Africa, while most of the other African countries depend mainly on the rain-fed agriculture? The irrigation officially in almost all the African countries might not exceed 35%, therefore, there is a great reason for improvement.

b- In 2008 FAO released that South Africa achieved a notable success in Conservation Agriculture (CA) due to strategic campaigns based on location – Specific Approaches.

c- Increase productivity of any crop per unit cubic meter of water (if water availability is considered the limiting factor in Africa), is not only depends on irrigation management, but also on other factors, e.g. suitable machinery, fertilizers, pesticides (Insecticide and herbicides) and farmers contribution.

d- Improvement and upgrade of the indigenous agricultural practices through new scientific methods and new technologies are more useful than introducing new agricultural practices.

e- Education of all levels of the community and the preparation of managers with new approaches (e.g. IWRM) is necessary development for water resources management in this century.

f- Integrated, predictive management with alternatives for and improvement of the multiple uses must be implanted at the level of hydro-graphic basins in order to decentralize management and provide opportunities for participation to users and public and private sectors.

g- Crop rotation is one of the three principles or pillars of CA, yet farmers are reluctant to plant non-food or non-cereal crops when they are limited by land area or by markets for sales.

h- Livestock have to be considered as part of an overall conservation. Agriculture package in sub- Saharan Africa.

i- Desalinization is one of the solutions that can become viable once the technology makes the cost of it more acceptable, especially for coastal cities.

15. Upscaling of Africa Water Security

Upscaling of African WR management requires a new way of thinking about water. It will result in fundamental changes in current policies, strategies and legislative frameworks, and also in institutional arrangements and
management practices. It should result in a desirable impetus to economic and social development, water for health, and water for food. Therefore, the following issues should be considered: New policy, strategy and legislative frameworks; Bottom-up institutional arrangements; Adherence to demand-responsive approaches while meeting the basic needs of the poor; food self-sufficiency.

16. Conclusions and Recommendations

Water is clearly a major factor in socio-economic recovery and development in Africa. The continent appears to be blessed with substantial rainfall and WR inspite its uneven distribution. Yet, it has severe and complex natural and man-made problems that constrain the exploitation and proper development of its WR potential. It is now recognized that these problems are surmountable. However, business as usual in WR management is not the way to overcome them. It is an approach that is bound to have disastrous consequences. A New Africa Water Approach should be developed accordingly to address these problems and to stimulate a shift in thinking toward a more equitable and sustainable use and management of Africa’s WR for poverty alleviation, socio-economic development, regional cooperation and the environment. A framework for action towards the attainment better livelihood should be defined along with milestones. Africa should learn from the other continents experiences in the field of IWRM and poverty alleviation, e.g. Asia. One of the most promising areas is the water harvesting based on the experiences of North Africa, e.g. Tunisia, Morocco, Algeria. However, the key word in sustainable water resources is “Storage”. The water storage in its wide context, as soil moisture, tanks, ponds, reservoirs, groundwater recharge, etc. Hence, good and efficient governance through proper water policies, strategies, plans in addition to the communities participation based on Eco-hydrology/IWRM. Below there are several important recommendations:-

a- Develop integrated approach to urban water management and sanitation.
b- Develop appropriate regulatory frameworks and monitoring mechanisms for WR. Indicators need to be ambitious but realistic, fitting within the national capacities. Hubs can play a significant role in promoting these frameworks and best practice.
c- To share best practice from across the continent and promote peer-to-peer learning
d- Develop, promote and support responsible water & wastewater management, besides, a participatory approach to WR management
e- Document and share best practice from across the region – peer to peer learning and Create culture of enforcement of policy and regulations.
f- Capacity building at all levels is vital to take this forward
g- Resources should be mobilized from the international community to enable the major step change that is required to ensure effective management and monitoring of water quality.
h- Manage all of the elements of water supply, storm-water, and wastewater as an integrated closed loop - one water. Apply business thinking to waste management – Business models (IWM catalogue is a major resource), therefore we need diverse stakeholder platforms involving both public and private sectors.

17. References


Contribution of APCE in Promoting Ecohydrology to Support Sustainable Development Goals for Target 6 in Indonesia and Asia Pacific Region

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The problem of clean water in Indonesia occurs in almost all regions. The related factors are also varied, ranging from natural conditions, poor management, poor awareness, to less responsible actions committed by some people. Some examples of water-related cases in Indonesia are: Water crisis due to low rainfall factor; Some areas have very heavy rains, risking of flooding and water pollution; Clean water supply in some clogged areas; Limited supply of clean water; The direct use of wastewater by the local people of for economic activities/merchandise. Problem solving and equity of clean water supply in Indonesia requires cooperation from all parties. The different cooperation activities can be started from simple things such as managing the use of clean water wisely, not throwing waste into streams and waterways, diligent plant trees in the neighborhood around the residence etc. The mapping of problems, potentials and various policy trends in water resources management needs to be carefully examined and viewed holistically. Water resources in the Asia Pacific region are quite diverse, such as springs, wells, karst, lakes, reservoirs, river, sea, and so on. Ecohydrology approach could be used as new way to assess precisely and holistically the problem of water resources. This field has finally become very strategic to be continuously developed especially when the world is threatened with water crisis due to different factors such as population growth, demographic impact, industrialization, and other activities. Awareness related to the importance of water resources management based on research is needed. Managing this natural resources can be done with the chemicals, technological, physicals, or other tools. However, technological engineering efforts are known to be very expensive and can disrupt the stability of their natural environment. Therefore, joint research and action that encourages water resource management efforts to emphasize the environmental nature of water resources and includes the involvement of community participation around the environment is significant and highly strategic to be developed. The Asia Pacific Centre for Ecohydrology (APCE) – UNESCO Category II Centre, has the task of coordinating, studying, interacting and enriching science and technology in national and regional local scope. This includes collecting informations from various similar works and disseminates the results. In its activities, this unit will conduct research, monitoring, deepening, modeling, in-depth options and new environmental management techniques, green technologies based on an ecohydrology approach, establishing partnerships for its implementation, and including empowering stakeholders in the management of water resources having impact on sustainable environments.

APCE – UNESCO can also facilitate real needs (companies and other stakeholders) facing unresolved environmental management issues, through research work by scientists supported by adequate laboratories in APCE and other Units located in LIPI, ministries and non-ministries, and universities, it is hoped that it will help to find solutions to problems that affect the management of water resources Good and sustainable. This institute is a place where the interaction of science enrichment with various scientists in various fields who explore and work on ecohydrology issues. The interaction can be done through conventional and electronic publications, meetings, science exchange, technology products, and joint assistance in water resource management systems at the community level. The targeted technology products will not be limited to only the results of the findings or the results of technological innovations, but can also be applicable policy processes and options at the decision-making level or the wider community. The focus of work is to prioritize the output being able to manage the environment more sustainable in and support appropriate quality for life. The important output is not only a financial gain for this organization, but improvements in the process of human interaction in managing its environment and to ensure sustainability of water availability for the present and future.

Keywords: water resources, sustainable management, ecohydrology, APCE, public awareness
Figure 1. Peatwater for daily use

Figure 2. Environmental awareness for young generation

Figure 3. Local people capacity building for drinking water treatment
Managing Disasters in the Philippines

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The Republic of the Philippines is an archipelago in the Western Pacific with 100.7 million Filipinos. It has 18 major river basins, 421 principal river basins, 72 natural lakes and has a coastlines stretching to 266,000 sq.km and with groundwater potential at 20,200MCM per year\(^1\). The country has a tropical and maritime climate, characterized by relatively high temperature, high humidity and abundant rainfall. Twenty (20) tropical cyclones are expected to enter and develop in its area of responsibility annually where eight (8) or nine (9) would progress to landfall. Tropical cyclones and intense rainfall of seasonal monsoons make vulnerability to hydro-hazard a national concern compounded by increasing number of people, industries and infrastructures that are located in highly vulnerable areas.

In the World Risk Index report in 2016, the Philippines is considered as 3\(^{rd}\) most disaster-prone country next to Vanuatu and Tonga. In the research done by the Office of Foreign Disaster Assistance CRED International revealed that 207 disasters affected the country from 2000-2012 with flooding and storm as the top two. In the same study, the total cost of damage reached $3.67million\(^2\).

Disaster management in the Philippines is governed by Republic Act 10121 or the Philippine Disaster Risk Reduction and Management (DRRM) Act of 2010. This Act strengthens the Philippine Disaster Risk Reduction and management system providing for the National Disaster Risk Reduction and management plan, appropriating funds thereof and other purposes. With this law, emphasis is put on prevention, mitigation and preparedness which a departure from a reactive to proactive stance when it comes to disaster management. The Local government units are also expected to invest on disaster mitigation, preparation and response.

The overall goal of the National DRRM Framework is to have a safer, adaptive and disaster-resilient Filipino communities toward sustainable development. Disaster Risk Reduction, climate change, and risk factors are considered in planning and implementation. The organizational structure created for DRRM is chaired by the Secretary of the Department of National Defense (DND) in collaboration and coordination with the four pillar agencies: the Department of Science and Technology (DOST); Department of Interior and Local Government (DILG), Department of Social Welfare and Development (DSWD) and the National Economic Development Authority (NEDA). At the regional level, the Office of the Civil Defense serves as the central command center.

There are four (4) thematic areas: 1) Disaster prevention and mitigation; 2) Disaster preparedness 3) Disaster response and 4) disaster rehabilitation and recovery which are assigned to the pillar agencies.

The Department of Science and Technology is the Vice chair for thematic area: disaster prevention and mitigation. The goal for thematic area 1 is to avoid hazards and mitigate their potential impacts by reducing their vulnerabilities and exposure and enhancing capacities of communities. There are two objectives: 1) reduce vulnerabilities and exposure of communities to all hazards; and 2) enhance capacities of communities to reduce their own risks and cope with the impacts of all hazards. Outcome 6 is the focus of the Department which is to establish ad or develop an end-to-end monitoring system, forecasting and early warning systems. The two agencies that provides critical information on weather advisories and forecasts and monitors geologic events are under it. The two agencies are: Philippine Atmospheric Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) and the Philippine Volcanology and Seismology (PHIVOLCS) are all under the Department.

Various efforts have been made to reduce the country’s risk and vulnerability to natural disasters and climate change. After Typhoon Bopha hit the country, then President Benigno C. Aquino invested on various projects of the Department in order to give an early warning to the community prior an impending disaster or calamity. DOST in collaboration with the academe and private sector was able to develop hydro meteorological sensors such as automated rain gauges, water level monitoring sensors for flood forecasting and monitoring. Over a thousand units are installed all over the country. Through international partnerships, meteorological buoys are acquired and other modern equipment that are used for weather forecasting and monitoring. Some of the projects implemented
by the Department are the Project NOAH (Nationwide Operational Assessment of Hazards); development of multi-hazard maps; flood risks maps through the use of the Light Detection and Ranging (LiDAR) Technology. A first micro-satellite called Diwata 1 was also launched in 2016. The target applications of the satellite are for the observation of cloud patterns and weather disturbances; assessment of the changes in vegetation; assessment of ocean productivity; determine extent of damages from disasters; profiling and archiving of cultural and natural heritage sites.

At the local level, Davao City for instance is building its resilience specially from water-related disasters in collaboration with various agencies. The City experienced flooding in 2011 with a total damage amounting to P11 million affecting 14,726 families with a death toll of 30 individuals. Among its good practices is having a reliable with state of the art Public Safety and Command Center and the Central and the Central 911. It has a Davao River Basin Master Plan (2013-2014). Through HELP Davao Network, it has now a customized Integrated Water Resources Management (IWRM) Manual. The Regional Development Council in Region XI recommended the adoption of the IWRM framework to all the Local Government Units in Davao Region. Recently, it has acquired and installed six (6) public alarm system.

Though considered as the 3rd disaster-prone country in the world, the on-going national, regional and local initiatives are proof of relentless pursuit towards building disaster resilience. For the prevention and mitigation, alliance and partnerships with local and international stakeholders in the creation and implementation of programs, projects and activities played a key role in the country’s disaster resiliency efforts. The academic is a significant partner in Research and Development and in harnessing local technologies for early warning system. In addition, a proactive local government unit also helps in ensuring that the DRRM efforts at the national level will be translated at the regional, provincial and local level. Together with other factors, all of the DRRM efforts are work-in-progress and steps to reach the country’s ultimate goal of having a Safer, Adaptive and Disaster Resilient Filipino communities towards sustainable development.

**Keywords:** disaster reduction, thematic areas, initiatives

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1 nwrb.cm
2 http://collections.unu.edu
3 World Risk Index 2016
In recent years, extreme rainfall events cause flood in parts of north central Regions of Namibia with devastating impacts on communities, infrastructure and land. The flooding incidents happen in 2008, 2009, 2011 and 2017. People living in rural areas, peri-urban areas, and informal settlements are often highly affected as they are most vulnerable. So far little effort has been directed toward improving planning, developing guidelines for town and settlements planning, enforcing regulations and raising awareness about these challenges and their impacts. It is predicted that future risks brought on by climate change will potentially worsen and exacerbate these problems across the Country. For decades, episodes of seasonal flooding in the ephemeral western Cuvelai drainage System has been variously linked to the flooding of the Kunene River overtopping its banks. Although the first known ground surveys in the 1920s and 1930s ruled out such an assumption, this association continues to reverberate in the literatures to the present. Some of these studies employed digital elevation models derived from Shuttle Radar Topography Mission (SRTM) or Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER). For improved hydrological modelling on the western Cuvelai Sub-Catchment, we employed the newly released digital surface model from the Advanced Land Observing Satellite (ALOS), complimented by satellite image analysis and ground-truthing exercises during the dry and rainy seasons.

**Fig. 1. Watershed area at Emanambode with Kunene and Cuvelai tributaries.**

The Cuvelai system drains a mesic to semi-arid area in southern Angola and northern Namibia, wedged between the upper reaches of the Kavango and Kunene rivers to the east and west, respectively. All three drainage systems lie side by side and originate in the Angolan Highlands receiving an average rainfall in excess of 800 mm annually. The Kavango and Kunene are perennial rivers, due in part to their headwaters that are sourced more than 300 km farther north into the wetter Angolan Highlands, reaching the southern equatorial water divide.
Fig. 2. Cuvelai-Etosha Basin drainage system in relation to Kunene and Kavango River Basins

A unique character of the Cuvelai system is a series of anastomosing, shallow and often broad channels, locally known as *iishana* (sing. *oshana*), prevalent in its mid-western and western zones. The perennial upper-middle channels merge with mid-western channels in the centre of the system near Ondjiva. Middle and western iishana finally converge some 100 km downstream at the Omadihya Lakes, before entering the Etosha Pan through the Okuma River (Figure 2). In years with above average rains, water from the up channel of the middle and western sub-catchments in Angola drain southwards and brings along schools of fish dominated by juveniles. Fish migration and subsequent harvesting is a general and common feature in iishana during major floods. In addition, anecdotal accounts reported fish migration in good rainfall years taking place earlier and more regularly in the western than middle zones iishana. Hand-dug wells and (earth) dams (constructed since the 1950s) in the area had to be discounted as a viable fish refugia from which new fish populations could originate to populate local iishana due to continuous fishing activities in this densely populated region. Similar views also suggested fish hibernation, like frogs that occur in iishana, or eggs buried under sands for years. It was thus against this background that this study, prompted by narratives of harvesting of fish migrating from the Kunene River into western Cuvelai channels in Angola, endeavoured to appraise the merit of such reports from hydrologic, geomorphic and fisheries perspectives. For hydromorphology, emphasis is placed on the characteristics of the channels, their continuity and connectivity, spatio-temporal configuration, as well as topography, employing Remote Sensing and GIS.

For fishery, the study focuses on reconnaissance fish movement in the watershed area, in response to the initial flooding conditions during the 2017 rainy season. Subsequent fish explosion in the Cuvelai would be treated elsewhere. The possible trans-catchment movement of fish from the Kunene into the Cuvelai can help explain not only the presence of fish in flood water but also throw light on the species composition in iishana not being reflected in the fish communities in the Upper Cuvelai.
Fig. 3. Fish sampling points at major inflow sites along the Kunene River

Results confirm a hydrological link between the two catchments, which facilitates transient resource fluxes, particularly aquatic life, between the two fluvial systems. However, this linkage does not involve the flooding of the Kunene River overtopping its banks. Instead, there are at least four major sites along the Kunene River where the Kunene and Cuvelai channels are directly connected or lie side by side without a pronounced topographic barrier. Under the influence of heavy rainfall, these streams suddenly form a contiguous body of water, with filled depressions in the watershed zone flowing on either side of the water divide. In two instances, the water divide cuts across contiguous channels flowing in opposite directions. Corroborative results for this linkage emerged from fish migrating upstream of the Kunene tributaries draining from the indistinct watershed zone. In reaching the watershed, characterized by flat terrain and depressions, fish escape into the Cuvelai drainage system and migrate downstream in record numbers. The implications of this fleeting hydrological link are critical for both the hydrological modelling and transboundary resource management. Further investigations may include the role of neo-tectonic and impact of human activities on this critical hydrological linkage between the two catchments.

Fig. 4. Longitudinal profile of Olushandja and Etaka channels connecting Kunene and Cuvelai Basins

Keywords: Cuvelai, etosha pan, fish migration, flood, iishana, kunene
Irrigation Water Management in China for Improving Integrated Water Resource Management: Practices in Ganfu Plain Irrigation District as an Example

Yufeng Luo, Dan Li and Yuanlai Cui

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Abstract: Integrated water management has been adopted in China due to increasing water shortage, flood disaster, water environment degradation and other problems. Agricultural irrigation accounts for about 63% of total water consumption of the whole country, thus irrigation management plays an important role in improving integrated water resource management. We present the practices in Ganfu Plain Irrigation District as an example showing the efforts in implementing integrated water resource management. During the last two decades, irrigation infrastructure has been significantly improved as part of the country’s Water-saving transformation and rehabilitation of large-scale irrigation districts. Water-saving irrigation techniques, such as alternate wetting and drying for rice, concrete lining for the canal system were adopted to increase water use efficiency and save water, thus more water is diverted for domestic and industrial uses. Water-saving irrigation-controlled drainage and artificial wetland system was introduced to reduce non-point source pollution from rice production systems, and thus avoid eutrophication in downstream water bodies, such as the Poyang Lake, the largest freshwater lake in China. Information technologies are also introduced to improve management efficiency and cut down labour inputs. Hands-on training in modern irrigation techniques at the Central Irrigation Experiment Station, exhibition of irrigation history at the Jiaoshi Museum, Leisure activities at the Ten-mile Lotus Pond and other activities are also raising public awareness of water issues in the irrigation district.

Keywords: Irrigation use efficiency; NPS control; Irrigation informatization, Public awareness
# Annex - Programme Agenda

**10 July 2017**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tr>
<td>08:30-09:00</td>
<td>Registration Day 1</td>
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<tr>
<td>09:00-09:30</td>
<td><strong>Opening session</strong>&lt;br&gt;• Prof. Dr. Shahbaz Khan, Director, Regional Bureau for Science, Asia and the Pacific Region, UNESCO Office Jakarta&lt;br&gt;• Prof. Dr. Nor Azazi Zakaria, Director of River Engineering and Urban Drainage Research Centre (REDAc), Universiti Sains Malaysia&lt;br&gt;• Dato’ Ir. Haji Nor Hisham, on behalf of Malaysian IHP National Committee&lt;br&gt;• Ms. Roslinda Binti Mat Musa, Malaysian National Commission for UNESCO</td>
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<td>09:30-10:00</td>
<td><strong>Keynote presentation:</strong>&lt;br&gt;- Addressing Water Security: Climate Impacts and Adaptation Responses in Africa, Asia and Latin America and Caribbean – Anil Mishra, Koen Verbistand AbouAmani, IHP Secretariat (online presentation)&lt;br&gt;- Upscaling Water Security to meet local, regional and global challenges: project results – Prof Dr Shahbaz Khan, UNESCO Office Jakarta&lt;br&gt;Q&amp;A</td>
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<td>10:00 - 10:30</td>
<td><strong>Coffee Break &amp; Photo Session</strong></td>
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<td>10:30 - 12:00</td>
<td><strong>Session 1: Delivering IWRM through Modular Education and Water Planning</strong>&lt;br&gt;<em>Chair: Dato’ Ir. Haji Nor Hisham, DID Malaysia</em>&lt;br&gt;<em>Rapporteur: Dr Asma Younas, UNESCO Chair on Knowledge Systems for IWRM, COMSATS Pakistan</em>&lt;br&gt;- Water Management Curricula using Ecohydrology and Integrated Water Resource Management (IWRM)- Ir. Rohani Ahmad, HTC KL&lt;br&gt;- How Can Water Footprint Contribute to Climate Change Adaptation Strategy?&lt;br&gt;  - Assoc. Prof. Dr. Zainura binti Zainon Noor, Centre for Environment Sustainability and Water Security (IPASA)&lt;br&gt;- IWRM and water planning in Langat HELP River Basin, by Dr Rahmah Elfithri, LESTARI UKM&lt;br&gt;- IWRM and water planning in Gurara River Basin - Engr. Abdul-Qadir Dauda Aliyu, National Water Resources Institute (NWRI), Nigeria&lt;br&gt;Q&amp;A</td>
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<td>12:00 – 13:00</td>
<td><strong>Lunch</strong></td>
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<td>13:00 - 14:30</td>
<td><strong>Session 2: Addressing Challenges for Delivering IWRM</strong>&lt;br&gt;<em>Chair: Prof. Dr. Nor Azazi Zakaria, REDAC USM</em>&lt;br&gt;- Optimizing water-energy nexus for sustainable development – Dr Aftab Ahmad, Murray Darling Basin Authority&lt;br&gt;- Water Resource Management in Arid and Semi Arid Regions of Pakistan - Dr. Asma Younas, UNESCO Chair on Knowledge Systems for IWRM, COMSATS Pakistan&lt;br&gt;- Emerging ecohydrology approaches in Malaysia and future challenges – Dr Norlida binti Mohd Dom, HTC KL&lt;br&gt;- HELP and IWRM challenges in Nepal - Dr Jagat Kumar Bushal, <em>Electricity Tariff Fixation Commission Nepal</em></td>
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| Time                | Session 3: Drought and flood risk and management: vulnerability; monitoring, prediction and early warning; integrated drought and flood management  
Chair: Dr Olivia Castillo, former UN Sec.Gen Advisory Board Member  
Rapporteur: Prof Yufeng Luo, Wuhan University, China  
- Floods – Dr. Tetsuya Ikeda, ICHARM/IFI secretariat  
- Flood Hazard Analysis in Malaysia – Dr. Mohd Sayuti Hassan, Centre for Global Sustainability Studies (CGSS), USM  
- Drought – Alireza Salamat, Regional Centre on Urban Water Management / IDI secretariat  
- Climate smart technologies to build community resilience under the intensive rainfall patterns in Pakistan - Ahmad Zeeshan Bhatti, PCRWR  
| Time                | Coffee break  
16.00 - 17:00 | Group discussion: UNESCO, Category II centers, other partners  
moderated by: Alireza Salamat, RC UWM Iran and Dr Omogbemi Omoloju Yaya, RC IRBM Nigeria  
| Time                | Welcome dinner  
19.30 |

11 July 2017

| Time                | Registration Day 2  
08.30-09.00 |

| Time                | Session 4: IWRM and Water Security linked with Agenda 2030  
Chair: Prof. Chan Ngai Weng, Water Watch Penang  
Rapporteur: Abdul-Qadir Dauda Aliyu, NWRI, Nigeria  
- Challenges in addressing SDG 6 in Asia Pacific – Dr Olivia Castillo, Chairperson, Sustainable Development Solutions for Asia and the Pacific / former UN Sec.Gen Advisory Board Member  
- Contribution of APCE in promoting ecohydrology for addressing SDG Goal 6 – Dr. Ignasius D Sutapa, Asia-Pacific Centre for Ecohydrology (APCE)  
- Lessons Learned and Challenges of Africa in Upscaling Water Security - Prof. Dr. Abdalla Abdelsalam Ahmed  
- Progressing the recommendations on IWRM & eco-hydrology in West Africa: implementation and challenges – Dr. Omogbemi Omoloju Yaya, UNESCO Category 2 Regional Centre for Integrated River Basin Management (RC-IRBM)  
| Time                | Coffee break  
10:30-11:00 |

| Time                | Session 5: Climate Risk Assessment and Early Warning  
Chair: Prof. Dr. Abdalla Abdelsalam Ahmed  
- Managing Disasters in the Philippines – Mirasol G Domingo, Department of Science and Technology Regional Office XI, the Philippines  
- Flood Management in Namibia – Leonard Hango, Department of Water Affairs, Namibia  
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<tr>
<th>Time</th>
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<tr>
<td>13:00-14:00</td>
<td>Lunch</td>
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<tr>
<td>14:30-16:00</td>
<td><strong>Session 6: Asia-Africa Science Policy Dialogue on Building Resilience to Climate Change Risk and Vulnerability to Meet Water Security Challenges</strong>&lt;br&gt;Key Progress noted at the workshop&lt;br&gt;<em>Presented by Dr Aftab Ahmed, Murray Darling Basin Authority, Australia</em>&lt;br&gt;Panel Session to develop recommendations: Policy Makers, Managers and Scientists from the region (Australia, Indonesia, Iran, Malaysia, Namibia, Nepal, Nigeria, Pakistan, Philippines, Sudan)&lt;br&gt;<em>moderated by Prof Dr Shahbaz Khan</em></td>
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<tr>
<td>16:00-16:30</td>
<td>Coffee</td>
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<tr>
<td>16:30-17:30</td>
<td>Closing Ceremony</td>
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