

**Water Security
and Climate Change
Conference**

—
Nairobi 2018

**Book of
Abstracts**

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Foreword



The third international conference on (Water Security and Climate Change 2018) that has been organized by Kenyatta University and DAAD funded Excellence Centers; Centre for Water Management in Developing Countries (SWINDON) (Technische Universität Braunschweig), Centre for Natural Resources and Development (CNRD) Technische Hochschule Köln), and Centre for Food Security (FSC) (Universität Hohenheim) is the first to be held in Africa. The conference will spotlight the key role that universities can play in the achievement of the seventeen Sustainable Development Goals. The many papers and posters to be presented during the conference will mainly target Goal 2 of ending hunger, Goal 6, pertaining to universal access to water and sanitation and Goal 13 of taking urgent action to combat climate change and its impacts.

Africa continent has a low level of greenhouse gas (GHG) emission but has become a real victim of climate change. The continent is highly affected by severe changes in weather patterns leading to aridity with some regions experiencing an increase in droughts. Climate change is expected to result to the Africa's population living under water stress to increase from 47% as in year 2000 to 65% in year 2025. These effects are generally threatening the continent from achieving Sustainable Development Goals (SDGs).

The conference marks an important phase in the creation of an alliance of universities, research institutions, non government organizations and policy makers in identifying common solutions to overcoming challenges facing water and food security related issues in the face of climate change. When all is said and done, the strength of the alliances will depend on the capacity to assemble talent and create an environment of diversity in which men and women can work together to build a sustainable future.

Prof. Dr. Paul K. Wainaina, Vice Chancellor Kenyatta University

Preface



Climate change is one of the major challenges facing the world though there are a few people denying the reality. Climate change is exacerbating the situation of water stress, and threatens the economic development of many countries. The adverse impacts especially in developing countries are undermining the achievement of Sustainable Development Goals (SDGs). The increase in global temperature, sea level rise, ocean acidification, low agricultural yields and scarcity of water are affecting many communities especially in the coastal areas and low lying coastal countries. The impact is affecting mainly the least developed countries and small islands developing states, making the survival of many societies and of the biological systems of the planet be at risk. The impacts and consequences of climate change on the water cycle are related mainly to variations in the average and the geographical distribution of rains, the upsurge in droughts and heavy precipitations. Climate change directly impact on natural resources, ecosystems and societies. The water and related sectors in particular, is among the most affected, as it is confirmed by the observations and projections of scientific experts. The impacts of climate change on the water cycle are very complex and different for each region of the world, having very strong socio-economic and environmental impacts. Although many developing countries especially in Africa have a low level of greenhouse gas (GHG) emission, they have become a real victim of climate change. It is reported that the arid and dry subtropical parts of Africa are expected to be the region with the highest impact from climate change by 2100. Although the African continent is already affected by severe aridity and some regions such as Sahel are already expecting an increase in droughts. There is therefore urgent need to share mitigation strategies, strengthened resilience and adaptive strategies to climate related hazards and natural disasters in all countries. The 3rd International Conference on Water Security and Climate Change 2018 that is held in Nairobi and the first time in Africa provide an opportunity for researchers, policy makers, extension staff and development agents to learn from each other on the best strategies of tackling the challenges of water security and climate change. It encourages stakeholders to integrate climate change measures into their national policies, strategies and plans. The conference provides a roadmap of creating awareness and building institutional capacity for many stakeholders in the area of water security and climate change. It also provide an opportunity for researchers, policy makers, extension agents and development agents to partner and network in the future.

Conference Organization Committee

Selecting Committee

Prof. Dr. James B. Kung'u	Dean, School of Environmental Studies, Kenyatta University Nairobi
Prof. Dr. Andreas Haarstrick	Coordinator, Center for Sustainable Water Management in Developing Countries at Technische Universität Braunschweig
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Dr. Maina Mwangi	Department of Agricultural Science and Technology
Dr. Felix Mingate	Department of Environmental Studies and Community Development
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Water Security: From a Popular & Contested Concept to its Implementation

Anik Bhaduri

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The academic and political interest in the concept of water security has increased considerably over the past decade as reflected in numerous publications, research and funding initiatives, and conferences. This growing interest may reflect the explosive rise in concern of scientific and policy communities about the state of freshwater resources and the urgent need for sustainable water and land management in an era of rapid change and persistent water and food challenges including access issues. To improve policy and scholarly capacity in dealing with such problems, claims are made for changes in both science and policy to overcome evident gaps that include more interdisciplinary and comparative studies, for an improved understanding of factors that shape water governance and cause governance failures, for the bridging of levels from local to global, for more sectoral integration to get out of the water box, and for closing the policy implementation gap. This raises the question: Is a new concept required to improve our analytical capabilities and provide an imperative for policy to deal with these challenges? Does the concept of water security hold promise in this respect?

The keynote presentation will provide an overview of the quite fragmented landscape of contributions and approaches to water security, and address the following issues:

- a.) What is their theoretical understanding of the water security concept, what is its potential and limits? And does it provide a better framework for dealing with water governance challenges?
- b.) How can the concept be elaborated at the implementation level, and how such elaboration address water governance challenges?
- c.) What are the global implications of water 'security' challenges?

In short, the presentation will analyse whether and under what conditions the conceptualization of water security will enhance our understanding of water governance and requirements for successful water governance reform.



Anik Bhaduri is the Director of the Sustainable Water Future Programme (Water Future) of Future Earth. Water Future is a global platform facilitating international scientific collaboration to drive solutions to the world's water security problems. Anik coordinates this large network of more than 400 working group researchers. Anik also facilitates integration and synthesis exercises in collaboration with Water Future's fifteen international and interdisciplinary research groups.

He plays a key role in designing and developing key Water Future initiatives like COMPASS, a comprehensive assessment tool for near real time assessment of global water security, as well as the capacity building activities related to water security like 2030WaterSecure.

Anik is also an Associate Professor at the Australian River Institute, Griffith University, Australia and a senior fellow at the Centre of Development Research, University of Bonn, Germany where he works on several topics and projects, ranging from transboundary water sharing to adaptive water management under climate change.

Blanca JIMÉNEZ CISNEROS, Prof., PhD, Certified Environmental Engineer

35 years of professional experience in research and governmental positions, for instance coordinator of the Environmental Engineering Department at UNAM (1988-1989); coordinator of the Water Quality Department (1991) and of the Human and Institutional Capacity Building at the Mexican Institute of Water Technology (1991-1992); Deputy Director of the Hydraulics and Environmental Department at the Institute of Engineering (1991-2001); Project leader on sanitation and food security at the University of Pretoria (South Africa, 2005); Project leader for the Mexican Climate Change and Water Research Program at the National Ecological Institute of Mexico. Member of several international high scientific level groups and international consultant for governmental, UN and private organizations. Since 2012, Director of the Division Water Sciences of UNESCO and Secretary of the International Hydrological Programme, which is an intergovernmental programme in charge to promote water security worldwide. Received several honours and awards (three of them presented by different Mexican presidents) such as the Mexican National Science and Arts Prize in Technology and Design in 2009. At the international level, have received the Global Water Award granted by the International Water Association (IWA) in 2010 and in 2002 the Royal Polar Star presented by the King Gustaf of Sweden. Served on the Nominating Committee for the Stockholm Water Prize (2007-2012), considered as the Nobel Prize for Water. In 2017 was elected as the best Environmental engineer of Mexico.



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Tropical forests are a critical resource for water and food security in East Africa

Mariana Rufino
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Tropical forests are a key component of the water cycle and critical for water provisioning to both rural and urban populations. In East Africa, increasing human population, rising incomes and competing demands on the land have led to massive forest cover loss. In Kenya, the water towers are the headwaters of the rivers delivering drinking water to most towns in the country. The forests of the water towers are hotspots for biodiversity, and important carbon sinks, however they are under increasing pressure of human encroachment. Since 2014, our team quantifies the importance for water provisioning of the Mau forest, the largest water tower in Kenya. We focused on forests and water because water is a critical currency for most stakeholders: water can be a blessing and a curse, as evidenced by the impacts of drought and floods often observed in the same year. In areas of high rainfall, water can cause crop and infrastructure damage and soil losses leading to community conflicts. Understanding of the dynamics of water flows, water quality and land use is required to improve land management. Our research showed that the largest concerns related to forest and tree cover loss are the large amount of sediments in rivers and streams. The loss of fertile top-soil has direct impacts on food security with enormous consequences for future generations, reducing the amount of crop harvests, the quality of agricultural products and affecting rural incomes. Lack of forest and tree cover undermines water and food security and therefore supporting communities to monitor their water and soil resources is critical to create awareness and empower local decision-making. Our research used a citizen-science approach and demonstrated that communities can monitor their resources and use this information to design and implement sound management plans for forests, water and landscapes.



Mariana Rufino is Professor of Agricultural Systems at Lancaster University, and one of twelve chairs of the HEFCE-funded N8 Agri-food programme, a partnership between eight Northern England Universities. She leads interdisciplinary research in Sub-Saharan Africa dealing with production challenges and environmental impacts of agriculture. She made a significant contribution to new global assessments of the environmental impacts of agriculture and livestock production. Previously, she worked for the Centre for International Forestry Research (CIFOR), where she led the Climate Change Agriculture and Food Security (CCAFS) programme. Mariana held positions at Wageningen University and the International Livestock Research Institute (ILRI), based in Kenya. Her work on carbon and nitrogen cycles at field, farm and landscape levels aims to quantify how land use change relates to food insecurity, incomes and environmental problems such as water scarcity. She collaborates with scientists from several international institutions, and with the private sector (tea and dairy farming in Kenya and Tanzania and the leading Argentine farmers association AACREA).

Groundwater from water security and climate change perspective in Africa

Prof. Dr. Tamiru Abiye
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Groundwater is less understood, often considered as strategic resource in Africa, the continent that has clean water shortage for its vast population. Predominantly in the arid- and semi- arid regions, groundwater plays vital role in fulfilling an increasing water demand due to its resilient nature for climatic variations. In Africa, groundwater exploitation is unregulated and the storage and recharge history are unknown. The potential impact of climate change on groundwater has been researched in depth in different parts of the world with a prevalent interest in arid- and semi- arid regions due to scarcity of surface water. High evaporation and low rainfall obviously affect surface water availability, which leaves groundwater as a dependable choice. It is a known fact that an increasing global surface temperature leads to change in precipitation and atmospheric moisture and impacts the recharge to aquifers. Often, the extent of water supply aquifers and storage is not known that has essential contribution to the management of the resource in order to increase water security. In many areas, well fields are supplying water for big cities and irrigation schemes. Livelihood can be affected by seasonal stress, longer-term drought and flooding due to changing climatic variables that increase water insecurity. Declining access to food and water is a common in Africa. Although groundwater plays a vital role in buffering the effects of climate change, mismanagement of the resource through pollution and over-abstraction could cause difficulties in accessing freshwater has a knock-on effect on food production and environmental sustainability. A more common scenario is a spiral of water insecurity as shallow aquifers get dry or polluted, with additional demands on remaining sources.

The main water security features from groundwater point of view could be due to:

- High groundwater recharge and availability of groundwater at exploitable level: signify high water security
- High groundwater pollution sources and flooding: low water security
- Low rainfall/Low recharge/high ET/drought: low water security from shallow aquifers. High water security if we rely on a deeper aquifer.

Regular monitoring of groundwater availability, recharge and status of water quality could enhance water security in vulnerable areas to ensure early detection of impact of climate change. Above all, increasing the coverage of ground water–based rural water supplies, and ensuring that the design and siting of water points is informed by an understanding of hydrogeological conditions and user demand, can significantly increase the resilience of rural communities to climate variability.



Prof. Dr. Tamiru Abiye, Wits University, Johannesburg

I have got about 30 years of experience in the field of hydrogeology in East Africa and Southern Africa. I am currently based at the School of Geosciences, University of the Witwatersrand, Johannesburg. I have supervised more than 95 MSc and PhD students and published about 117 peer reviewed papers on International Journals, conference proceedings, chapters in books and books. I have actively participated in the establishment and management of Ethiopian Association of Hydrogeologist and Africa Groundwater network. I am a rated researcher by the South African National Research Foundation and am a registered Professional Natural Scientist in South Africa. I participated in different African level activities to advance sustainable use of groundwater to alleviate poverty and enhance economic development owing to the fact that Africa has huge groundwater reserve which is resilient to climate change.

Water Security and Climate Change - the Gender Dimension

Ursula Schäfer-Preuss

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Achieving water security and advancing climate resilience is not possible without addressing the special needs of fifty percent of mankind – women and girls. The gender dimension has to be properly integrated into the agenda of promoting economic and social development as well as resources sustainability.

The rich knowledge of men and women at the local level in preserving our habitat and helping to find pathways to support the SDG Agenda 2030 to be gathered.

Local best practice cases have to be scaled up, silo thinking and acting in isolated sectorial boxes has to be opened up. The gender specific data base needs to be strengthened across sectors, and the various inter-linkages between goals and targets of the SDG Agenda related to the transformative Gender Goal 5 and all other relevant goals have to be well documented.

Science has never been in a better position than right now making intelligent use of digitalized communication and information systems across the globe, not forgetting the voices and specific needs of vulnerable groups, including women and girls. By this the dialogue between science and political leaders and practitioners, including communities at the local level, can be opened up in a language we all are able to understand. It will be much easier to introduce innovative approaches on how to implement various pathways of Agenda 2030 aiming at a world that leaves no one behind.



Ursula Schäfer-Preuss

Dr. Schäfer-Preuss is an economist who has been engaged in the field of development policy for more than 35 years.

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Impact of ecosystem services on human health and well-being of the inhabitants along the white Volta basin in the Upper East Region of Ghana

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Upper East Region is a northern bordering area between Ghana and Burkina Faso and for that matter this region is at the water gate of the White Volta basin in the country. It is well established that existence of a stream always attracts population's settlement because of all the services and advantages that water provides. The region's population density of 104.1 hbt/Km² is higher than the national density of 79.3 Km² with 66.4% of them living from agriculture and related works and 69.4% people having never attended school. These factors induce waste management problems as well as intensive and improper use of natural resources such as water, land and forestry, with severe impacts on human health and environmental degradation leading to threat on the well-being of inhabitants and that of future generations.

This study seeks to facilitate water governance at the local level by highlighting issues on human health, socio-cultural, economic and environmental impacts of the ecosystem services on the inhabitants at the White Volta Basin in the Upper East Region.

The interdependence among different components of the ecosystem is described and a diagram shows all the stakeholders involved in water and environment management in the basin. In this way water governance is facilitated at the specific level. But it requires the implementation of the following recommendations:

-Promotion of literacy and health and environmental education: a) Government must assist local communities especially the youth to enrol in school ; b) Government should review previous educational intervention.

-Development of eco health programs targeted more to prevent water, health and environment problems from increasing. Government institutions, agencies, donors, and NGOs should provide technical and financial support for proper agricultural practices such as: Proper rearing of livestock, land conservation, tree planting and waste management within the White Volta basin.

Management of Watershed Based on Its Classification of Upper Cisadane Watershed (Cisadane Hulu and Cianteun)

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Cisadane watershed is classified as one of Indonesia government priorities in preserving the natural resources such as soil, water, and land especially for the upper watershed. It supports watershed capacity that is utilized to support human activities. The aim of this research was to classify Cisadane Hulu and Cianteun watershed, and to determine the management activity of watershed based on the classification of its watershed. The procedure of data analysis followed the decree of Ministry of Forestry No. 61, 2014 about criteria of watershed's classification. The used criteria are land condition, water management, social economic and institution, water building investment, and utilization of area.

Score of Cianteun watershed for land condition, water management, social economic and institution, water building investment and utilization of area were 37,50, 23,50, 23,50, 5,00, and 7,50 respectively, amounted 103,50 in total. Meanwhile score for Cisadane Hulu watershed are 42,50, 16,50, 28,25, 10,00, and 6,25 respectively, amounted 97,00 in total. Based on it's score, carrying capacity of Cisadane Hulu watershed should be restored to achieved score more than 100. Meanwhile, total score of Cianteun watershed is 97,00 (less than 100) and carrying capacity of Cianteun watershed could be still maintained.

The planned activities of watershed management that related to the result of watershed classification are optimization of land use based on the function and area's carrying capacity, and also the application of soil and water conservation technique. The activities are particularly implemented for Cisadane Hulu watershed's carrying capacity that should be restored. Meanwhile, management activities that could be proposed are sustainably preservation and maintenance of productivity and ecosystem of Cianteun watershed.

Institutional, policy and legal frameworks for comprehensive disaster management in Bangladesh

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The coastal communities in Bangladesh are frequently victims of water-borne disaster such as cyclones and storm surge, flood, riverbank erosion that threaten their livelihoods and food security. However, interventions from the government, non-government partners, and strategies of the communities themselves have helped to reduce disaster risk. Based on desk research and fieldwork, this study identifies the roles of institutional, policy and legal frameworks for disaster management in Bangladesh. The findings suggest that Bangladesh has shifted its disaster management emphasis from a response and relief focus to a more encompassing management framework for capacity building to reduce the risk. To do so, Bangladesh has developed a robust regulatory framework for disaster management that includes legislation, policy, plan and best practice frameworks under which the activities of disaster risk reduction (DRR) and emergency response is currently managed and implemented. The existing management frameworks emphasize the importance of working together with all stakeholders to build strategic, scientific and implementation partnerships with public, recognize combating climate change as a major challenge, and facilitate mainstreaming of climate change and DDR in the development process. In case of recovery and immediate rehabilitation, Bangladesh has a detailed system for quick and long-term need assessment at the grass-roots levels, where the local committees play a vital role in providing information. The 'Standing Order on Disaster' outlines the detailed roles and responsibilities regarding DRR and emergency response management for the public institution at all levels. Overall, the disaster management framework facilitates community-based decision making through early warning system support, helps to maintain a broader social safety net program, provide a legal basis for active and well organized NGO network up to grassroots level. All these steps collectively increase food security and make the communities more resilient against disaster risk in line with the Sustainable Development Goals 1,2,3,6 and 13.

KEYWORDS Disaster Management, Bangladesh, Climate Change, Sustainable Development Goals

Mapping the drought using Agricultural Stress Index: Case study of Ethiopia

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Drought is one of the frequent climate phenomena occurring across most part of the Africa including Ethiopia, causing serious consequences in food security of the region and country's economy. Due to El-Nino (2015-16) and Indian ocean dipole (2016-17) most parts of the Ethiopia experienced droughts, which led to emergency food assistance for around 6 million people in addition to other devastating consequences including disease outbreak and loss of livelihood. To implement the drought risk management plans, drought prone areas can be identified using probability of occurrence of drought. Recently, FAO developed a novel methodology (Agriculture Stress Index System, ASIS) to assess the probability of occurrence of drought and monitor the agricultural drought using the satellite data (Rogas, 2015). ASIS uses Normalised Difference Vegetation Index (NDVI) to derive the Vegetation Health Index (VHI), a key parameter to monitor the agricultural drought for sub-seasonal (10 days) and seasonal drought severity levels. In this research study, we have used time series of satellite-based vegetation index from AVHRR (Advanced Very High Resolution Radiometer) data by SPOT (Satellite Pour l'Observation de la Terre) to assess and map the (ASI) Ethiopian drought during 2015-16 and 2016-17.

KEYWORDS: Drought, AgricultureStress index

Securitisation of water resource management in Ghana: Debating an emerging paradigm

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An increasing volume of research has investigated water resource management approaches in Ghana and the effect on sustainability, delivery systems and access outcomes for different segments of society. However, little scholarship exists on how political actors' conception of water resource management has led to the securitisation of water. Additionally, there is a gap in research which offers an empirical investigation on how these actors' conceptions construct water security outcomes for broader society. Using documentary and content analysis, this study examines the conceptions of water security held by political actors in Ghana's water management space. On the basis of the analysis, it is argued that contrary to the dominant inter-state securitisation of water discourse in the literature, this study observes an emerging intrastate securitisation of water discourse in Ghana. An understanding of political actors' conception of water security is key as it shapes policy direction and sustainability outcomes.

KEYWORDS ater security, inter-state securitisation, intrastate securitisation, Ghana

Climate Variability And Change Trends, Impacts, Perceptions And Adaptation: Multiple Lessons From East And West Africa

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In several parts of east and west Sub Saharan Africa, climate variability and change have been associated with a complex web of direct and indirect impacts which have lead to variable perceptions and adaptations. With the different accessible data formats, types and ranges, the present paper demonstrates the occurrence of climate variability and change in Cassou, Southern Burkina Faso and Wote, Eastern Kenya. In both locations meteorological and satellite based data is used to show trends in rainfall and temperature as well as computing indicators such as annual rainfall. Findings show climate variation in terms of annual rainfall while cereal yields widely depict sensitivity to the length of the growing period and total dry days in the growing season around Cassou area. Statistical Models show Maize yields relate strongly to the rainfall amount variation ($R^2=51.8\%$) showing high moisture dependence. In Wote area findings indicated vulnerability as households have been exposed to calamities; drought, 100%: crop pests, 93%: crop diseases, 83%. A multiple regression model, $F(9,51)=2.655$, $p=0.013$, $R^2=0.319$, indicated that age, gender and acreage influenced adaptation significantly $p<.05 = 0.027, 0.043$ and 0.011 respectively. This work is highly significant as it demonstrates the need for adoption of efficient water utilization platforms especially those that have evidently increased yields in Cassou area. Further it is shown there is need to develop a mechanism of providing forecasts that include appropriate response mechanisms. In Wote area the study mainly shows a potential in adoption of alternative income activities, including on farm value addition to supplement farm based income and at the same time linking modern and indigenous adaptation. The studies also shows alternative approaches of understanding climate impacts and dynamics with available data in different locations.

KEYWORDS: Climate variability, Climate Impacts, Small Holder Farming, Perceptions, Adaptation, Sub Sahara Africa

An appreciation of the relationship between the water security index (WSI) and the Sustainable Development Goals (SDG) in Tropical Africa

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The economic loss from the inadequate delivery of water and sanitation was estimated to amount to 1.5 % of gross domestic product of the countries included in a world health organization study on meeting the millennium development goals. According to some estimates, over 80% of wastewater is discharged without treatment. Water-related disasters are the most economically and socially destructive of all natural disasters. Africa is endowed with vast water resources including but not limited to lakes, rivers, swamps and underground aquifers. However, the way of life in Africa does not reflect this kind of wealth owing majorly to degradation and underutilization of these water resources. This review discusses the centrality of water resources in Africa's pursuit of the Sustainable Development Goals. Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival itself. It is vital for reducing the global burden of disease and improving the health, welfare and productivity of populations. It is central to the production and preservation of a host of benefits and services for people. Water is also at the heart of adaptation to climate change, serving as the crucial link between the climate system, human society and the environment. Water is a finite and irreplaceable resource that is fundamental to human well-being. It is only renewable if well managed. **KEYWORDS** climate change, human health, vulnerability, adaptation

KEYWORDS: Appreciation, Water Security, Sustainable Development Goals (SDG), tropical Africa

Valuing Water Resource Users' Associations in the Peri-urban Drylands of Kenya: What is their Role in Water Access and Affordability?

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Water insecurity is a threat to pastoral livelihoods and sustainability. The Water Act of 2002 created the Water Resource Users' Associations (WRUAs) to enhance water resource conservation and enhance water access at the local level. Yet, not much has been documented on the effectiveness of the WRUAs in augmenting water access and affordability for resilient livestock production in the peri-urban drylands of Kenya. This study therefore sought to assess the role of WRUAs in enhancing water access and affordability through capacity building in Kajiado County, Kenya. Kiserian and Oloolua WRUA members were purposively sampled for this survey while non-WRUA members were randomly sampled for comparison. Household interviews were conducted using a semi-structured questionnaire and Focus group discussions and key informant interviews used to validate the data obtained from the household interviews. Chi-square analyses, t-tests and descriptive statistics were used to analyze the data using SPSS version 20. Results showed that access to information on water resource management was significantly associated ($\chi^2=0.56$, $p<0.05$) with membership to the WRUA. Besides, WRUA members accessed 20 litre gallons of water at an average of Kshs. 11.26, a significantly lower ($p<0.05$) cost compared to non-members (Kshs. 12.50). Most (79.5%) WRUA members had participated in catchment conservation. Half (50%) of the WRUA members were mainly motivated to join the association because of perceived benefits including improved access to water at lower prices and access to training. The main challenge facing the WRUA was lack of funds (93.2%). This study recommends awareness to increase WRUA membership and allocation of sufficient funding from the government and other related stakeholders to WRUA conservation activities, if catchment conservation for improved water access in the area is to be realized.

KEYWORDS: Kajiado, resilience, catchment conservation, water security, Aedes, breeding, Zika virus

Water Funds: Nature Based Solutions For Water Security in Developing Countries

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This presentation resumes the history and evolution of Water Funds, starting in Latin America and finishing in Africa. A Water Fund is a collective impact mechanism aimed at providing water security to metropolitan areas by investing in natural infrastructure, strengthening integrated watershed management and governance of water resources by financing long term conservation actions and bringing together relevant water management actors. Natural landscapes conservation and restoration activities produce benefits for water supply, and while this is well known today, from the total amount of funds invested to secure water access only a small fraction is invested in green infrastructure and natural ecosystems protection if compared with grey infrastructure. Since the first major investment in nature-based solutions documented, the Catskills watershed protection instead of building a new water treatment plant for New York city, the number of cities investing in source watershed protection is increasing in the world. The first financial mechanism created to systematically invest in green infrastructure protection and restoration using resources collected via water tariff from final users, the FONAG in Quito, Ecuador, is now 10 years old and has reached a USD 1 MM budget for nature-based solutions investment every year. This model have been promoted by The Nature Conservancy around the world, now reaching more than 40 similar projects, 22 in Latin America and 3 in Africa. This approach has also resonated with development banks since green infrastructure and nature-based solutions usually imply lower operative and maintenance costs for grey infrastructure associated with water treatment and management, being the Inter American Bank the first one to promote the replication of the Water Funds model in Latin America and requesting the integration of nature based solution approach for new loans in the water sector.

KEYWORDS: Water Security, Nature Based Solutions, Green Infrastructure, Latin America, Africa, Watershed Protection

Quest for regional water co-operation for building socio-economic resilience in the view of climate change impacts in the GBM basins

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The Ganges, Brahmaputra and Meghna (GBM) river basins are vulnerable to multiple climate change impacts such as glacier receding, change in hydrology, extreme events and climate variability. The lack of transboundary co-operation fuels the climate induced livelihood damages, food insecurity, human displacement, social vulnerability and death toll in the GBM basin. In this connection, the endeavor has been made in this study to evaluate climate change impacts and vulnerabilities, environmental and social stress, and identify the optimum framework for water co-operation in the GBM basin for large scale regional benefits. The study adopted multi-disciplinary lens to generate robust evidence and scientific knowledge on climate vulnerability, water co-operation and socio-economic resilience. It appears that, during 1980-89, 209 extreme events occurred in the GBM basin where 0.76 million people were affected directly and total cost of damages was counted USD 10,379 million. During 2000-2009, USD 37,476 million worth of damages were estimated by the impact of 365 extreme events along with 0.14 million death toll. Further, average hazard and vulnerability risk index, river health index and per capita flood induced damages are calculated 0.53, 0 and \$69 respectively in the GBM basin. The study will also address the water and climate stress in the GBM basin in the absence of regional water cooperation and find out the pathways to promote joint water resource and river basin management to mitigate the common problems faced by the poor and water stressed communities. As the GBM river system is the third largest freshwater outlet to the world's oceans, being exceeded only by the Amazon and the Congo river systems, It is highly recommended to better utilize and jointly manage the f GBM river basin for greater regional prosperity and socio-economic resilience.

KEYWORDS: Climate change, GBM basins, international co-operation, loss and damage, river health index, socio-economic resilience

Groundwater exploitation, rural livelihood and the role of governance efficiency in groundwater management

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Water resources in Iran's dry and semi-arid climate are one of the key elements in economic and social development. Shortage of surface water and disparate distribution of that in the whole country have caused excessive utilization of groundwater in the water-based civilization of Iran from the past and it has affected sustainable development and the environment. Agriculture is by far the dominant user of water in Iran and consumes close to 90 percent of all available water resources, whereas groundwater satisfies around 76 % of irrigation water needs. Also, the centralization about 17% of the country's employment is in this sector and agricultural livelihoods heavily depend on groundwater. Over-exploitation, groundwater storage depletion and drop in groundwater tables have been made aquifers more critical in recent years. So food security would have affected due to a close link between water resources and the agricultural sector. In recent decades, lack of drought management, over pumping of aquifers and negative implications of climate change have been led to strategic groundwater storage decline and expresses. So the poor groundwater governance can threaten development rate. In total, amount of over-exploitation of groundwater storage is more than 120 billion cubic meters, and this has led to visible and invisible outbreaks like land subsidence and loss of groundwater quality. Also, other factor such as deepening wells technology has helped this disaster. The Relative Water deficit (RWD) index shows moderate condition is just extend in less than 11% of area and semi-critical to extreme critical are extend from 21% and 68% of Iran. Also, groundwater operation in the agricultural sector has increased significantly in recent years. Therefore, the only way to save these conditions and restore balance to groundwater resources is to be found in the agricultural sector. But this is just possible if farmers' livelihoods and their rights are preserved. By approaching to the water governance, the role of people and public institutions should be more considered. This research has aimed to show the role of effective water governance on better water resources management of arid and semi-arid regions. **KEYWORDS** Nile, Grand Ethiopian Renaissance Dam, river basin simulation, hydropower, irrigation

KEYWORDS: Agriculture, Groundwater resources, Exploitation, RWD Index, Water governance

The Importance of Security of Water in Supplying Iran's Water Security

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Using common pool resources may lead to cooperation and/or conflict among states. Mismanagement as long as bad governance on the growing rate of natural shared resources may lead to a tragedy of commons in this regard. Undoubtedly, 'water' resources with political and security values can also be problematic for nations, in terms of policy, security and water being interrelated. Therefore, there are not only economic and environmental dimensions involved with the water resource system as a complex human-natural system, but also the social, political and security have to be considered. This system holds a dynamic and non-linear interaction with social, political and security factors in local, regional, national and international scales. Different schools of thought, including neorealism, neoliberal and Copenhagen have introduced a specific definition for security and its dimensions that will be discussed here in order to explain water security. The security of water is another term that requires acknowledgment. For example sea water desalination projects has gained high attention in order to maintain water security these days. The question is whether these systems can provide the security of water in addition to water security or not. This paper will be aiming to investigate this question while discussing the water security and security of water in Iran

keywords: water security, security of water, neoliberal, neorealism, copenhagen, desalination, Iran

Alternative Types of Organizations: Networks Case Study: International Water Security Network

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In order to address the complex challenges of environmental law&governance, it is currently required to comprehend new forms of policies, laws and institutions as possible remedies to those challenges. Environmental networks are one of those promising to be alternative ways of achieving environmental goals. Indeed, their settlement and functioning, with the basic principle of 'flexibility instead of strict formality' differentiating them from traditional organizations, can be used as a sample model for creating new forms of law&governance based on cooperation/ collaboration. In this respect, it is aimed to question whether networks can play a role in managing the various complexities differing across issue areas and different levels of environmental law&governance in this study. While doing its analysis, the study is based on the International Water Security Network (IWSN) as a case study of the research, as it raises as a good example of a network bringing together relevant stakeholders to investigate issues around 'water security' which is an ever more important global issue, of relevance and importance to diverse actors such as individuals, businesses, governments, organisations etc. For this purpose, firstly, environmental law&governance, environmental networks and their relationship are analyzed at the outset of the study. Secondly, the structure of the IWSN is examined, particularly focusing on the its ways/methods pursued for forging new collaborations and fostering new compelling law&governance. Thirdly, the strengths and weaknesses of its functioning are discussed on the basis of its some activities conducted in practice for dealing with the complexities, and so working and producing cooperatively for law&governance. Finally, based on the findings, concluding remarks are provided as a response to the main question of the research.

KEYWORDS: Environmental governance, environmental law, environmental network, International Water Security Network (IWSN).

Results-Based Management and Sustainability of Water Supply Projects in Informal Kettlement Areas in Nairobi City County, Kenya

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The sustainability of water supply projects has over the years become a key concern for the global community. The interest in project sustainability in this sector has resulted from water scarcity attributable to climate change and other anthropogenic factors. Development organizations and governments have therefore been working in tandem to formulate strategies for curbing water stress. The concerted efforts of water sector stakeholders led to the formulation of global and country-specific goals on water and sanitation. These goals have seen to, among other strategies, the implementation of water supply projects in affected countries. However the statistics show that these water supply projects have reported high failure rates with the existing systems failing to operate at full capacity. The sustainability problem is magnified in urban informal settlement areas which are characterized by large populations and poorly constructed dwellings that generate infrastructural and spatial challenges. Considering the criticality of water as an input in all other sectors of the economy, stakeholders in the water sector are now addressing issues related to the sustainability of water supply projects. Previous research has conceptualized sustainability as a managerial responsibility and should be ingrained in project management approaches. The general objective of this study is therefore to investigate the effect of Results-Based Management on sustainability of water supply projects in the informal settlement areas in Nairobi City County, Kenya. The specific objectives are to establish the effect of RBM principles namely: accountability, national ownership and inclusiveness on sustainability of water supply projects. The study will further investigate the moderating effect of regulatory policy on the relationship between RBM and sustainability of water supply projects. A sample of 260 projects implemented by the Nairobi City Water & Sewerage Company in informal settlement areas of Nairobi County obtained through stratified random sampling will be observed in this study.

KEYWORDS: Sustainability, Results-Based Management, Accountability, National Ownership, Inclusiveness, Regulatory Framework

Water sector development in Turkana: Filling the critical sectoral gaps

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Achieving water security and good sanitation has been a great challenge to many counties in Kenya. These challenges are attributed to by poor infrastructure, insufficient funds, poor storage, administrative and human resource issues and many more factors. This paper looks at the state of water sector development in Turkana County and recommends ways in which these gaps can be filled to achieve water security in the county. Turkana situation is characterized by water insecurity, including periodic occurrence of water borne diseases resulting from poor sanitation. As an ASAL region, it is more vulnerable to water insecurity and greatly suffer impacts of prolonged droughts that result to severe water shortage. Prolonged droughts also result to conflicts over water related resources. Some of the threats to water security in Turkana include: Weak political will and low institutional capacity to manage, water resources and water supply services; social and political exclusion; low community resilience to cope with stresses on water supplies; poverty; poor hygiene and sanitation; rapid population growth and urbanization; climate variability; complex hydrogeology and challenging terrain; climate change and poor siting, design and construction of water sources. By addressing water insecurity, access to water and good sanitation will be improved hence reduced incidences of water borne diseases and loss of lives related to water will be halted. In order to achieve these, institutions need to stop working in silos in addressing water security matters and establish how they can work together in eliminating water insecurity. The institutions should also design pro-poor models to ensure those who are poor and more vulnerable in the society are able to access good quality and quantity of water. Good governance structures, stable institutions and efficient policy instruments are vital for water sector development in Turkana.

KEYWORDS:

Ecosystem services of urban forests in the context of water security and climate change - a case study from the German metropolis Cologne

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The worldwide process of urbanization, with more than 50% of world's population already living in urban areas, leads to rapid climate and environmental changes in cities as well as on a global scale. Cities are a key contributor to climate change, as urban activities are major sources of greenhouse gas emissions. Estimates suggest that cities are responsible, directly and indirectly, for 80 percent of global greenhouse gas emissions. At the same time, cities are especially vulnerable to impacts of climate change. Therefore it is important not only to invest in climate protection, but also to make climate adaptation a priority in cities, to ensure the quality of life of citizens. In this regard ecosystem services of urban forests might play an essential role, but are not yet in the research focus. In addition to many other aspects, the water storage capacity of urban forests has a broad impact: floods after heavy rainfall events are mitigated, the stored water causes a microclimatic cooling effect via evapotranspiration and the forest floor filters pollutants from the water. Using the example of the city of Cologne, the ecosystem services of the city owned forests, which were created at the beginning of the twentieth century in the previously forest-free city, are highlighted, with a special focus on water storage capacity. The research results show that the city's afforestation efforts in the last century are fulfilling their intended purpose and are benefitting the population greatly. The outer green belt on the western side of the river Rhine is of particular importance as it provides all analyzed ecosystem services at the same time. The results may serve as a stimulus for other major cities to protect and, if possible expand their forest areas.

KEYWORDS: Ecosystem Services, Urban Forest, Water Security, Climate Change, Cologne

Sustainable solution for unconventional water in arid regions by promoting nature-based techniques with relatively low energy demanding solutions (constructed wetlands, CWs)

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The approach was accepted to be funded by the ERANETMED and was supported by the EXCEED-SWINDON_JRP in 2017. The main purpose of the project is to provide a sustainable solution regarding water management under arid climatic conditions by utilising decentralised, small scale natural treatment systems, i.e. CWs, for WW and polluted streams treatment. The decentralised approach is preferred, as there is no need for long, costly and maintenance intensive drainage-collection systems to a central treatment unit. Moreover, CWs are proposed as a sustainable solution mainly because of the minimum energy input needed, relatively low construction and operational costs. Regarding energy requirements, it is suggested that CWs need 7 times less energy than activated sludge systems. CWs will provide a natural habitat for several plants, fish, and can also contribute in turning arid areas into green areas. Apart from landscaping, the vegetation in CWs can provide additional benefits according to the species used; in Egypt Mangroves, salicornia will be used for these purposes and mitigation of climate change through absorbing greenhouse gases (mainly CO₂) and immobilizing organic matter in the ecosystem, and providing fodder. Attention will also be given to use vegetation tolerant in high salinity and extreme environmental conditions. In this way the polluted water source will be exploited further, considering that commercial products during treatment will be produced, thus increasing the socio-economic impact of the project and decreasing further the costs for treatment. An innovative concept regarding the exploitation of the CWs vegetation will be developed, by examining several possible scenarios and by developing potential business models. The purpose was to examine in lab scale different domestic plant species and different CW configurations (e.g. horizontal or vertical subsurface systems, surface systems, different bed materials and depth, etc.) and to define the most efficient system for each region.

KEYWORDS constructed wetlands, unconventional water, climate change, food production, energy saving

Evaluating Potential of Payment for Water Service a Nature based solution to challenges on Water security in Nairobi, Kenya.

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Payment for Environmental Services is a concept that is increasingly being adopted as incentive based approach in natural resource management. It links the suppliers and consumers of goods and services from a natural resource in a way that both parties contribute to improved delivery. Water is one of the main environmental goods and services traded in the market. However the main predominant attitude towards watershed management is that it will always flow from the catchment for free and so there is no urgency or incentive to institute sustainable use of land and water. As a result, farmers have inadequate knowledge, incentives and recognition of their role in provision of water to the rivers. Nairobi City has experienced serious water shortages in the past due to water levels in Thika dam subsiding to low levels and resulting in water rationing. The dam supplies 80% of water to Nairobi city but few of the residents are able to link availability of clean water in their pipes to conservation of water catchments areas. The objective of the study was to find out whether land owners and users of water from Thika dam could participate in watershed protection scheme through Payment for water Services. Specifically, study identified factors that could influence willingness of water users to pay for water services, environmental services the farmers were willing to adopt to improve quality and quantity of water and the economic incentives the buyers were willing to give to farmers in return for their conservation efforts. The study also reviewed policies and institutional framework necessary for PES. Primary and secondary data were collected through baseline survey and qualitative research approaches, interview schedules, questionnaires, focus group discussions and analysis of satellite imagery followed by ground truthing. Both parametric and non-parametric methods of data analysis were used. Farmers are willing to accept improved farming practices in return to incentives though their expected incentives were far above what the users were willing to give. A significant relationship between farmers' acceptance of conservation practice and incentives provided was established.

KEYWORDS: willingness to pay, willingness to accept, conservation, Payment

Transboundary Wetlands and International Environmental Security Case Study: Hamoon Wetland

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In Today's world, Human is facing water inaccessibility due to change in his lifestyle and growth in water demand. Increase in global warming and climate change has endangered water and food security. On the other hand, transboundary wetlands play a great role in regulation of local and global climate and also in providing water resources. Wise use of such ecosystems result in preventing change in ecological characters of wetlands and this will bring about safeguarding water security. The role of Ramsar Convention in operationalizing wise use concept as one of the most fundamental principles of international environmental law, and providing a ground for mutual cooperation among riparian states and international cooperation is very decisive that will lead to a win-win relationship between states and global environment. Hamoon Wetland as a shared resource between Iran and Afghanistan, is in danger of complete disappearance and destruction as a result of unwise utilization, lack of environmentally sound management, and exacerbation of climate change in the area which have unsecured life continuance for flora, fauna, and human population in both sides of the border. This study as an interdisciplinary one, intends to investigate wise use and similar concepts and their practical application along with other management tools such as ecosystem-based management to conserve wetlands and therefore to reduce adverse impacts of climate change and prevention of crisis in water and environmental security. The question raised here is 'what operational mechanisms is being provided by international environmental regime especially Ramsar Convention to realize wise use and thus sustainable development.' It is important to answer this question because it can help governments particularly those locating in transboundary wetlands to settle their arising disputes. We have used an analytical-document approach with a view to state practices, international judicial decisions, and doctrine.

KEYWORDS: Climate Change, Water Security, International Wetlands, Sustainable Development, Wise Use.

Assessment of public-domain and ensemble precipitation products for estimating the water balance of the Blue Nile Basin

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An efficient use of water requires better understanding of its availability, spatial and temporal variability and pattern of use. However, these information, especially for precipitation, are not always available. Public-domain Precipitation Products (PPPs) are valuable sources of information, especially for data-scarce regions. However, their performance and accuracy across various spatial and temporal domains are differing widely. In addition, there is a need to test simple merging methods to produce Ensemble Precipitation Products (EPPs) that benefit from the advantages of the several PPPs. In the current research, 18 PPPs from different sources were assessed for their applicability to be used for water balance (WB) estimation over the Blue Nile Basin (BNB) for the period 2005-2010. Using three ensemble methods, 15 EPPs were created for the BNB using the original 18 PPPs. Results of the current research showed that, the PPPs and EPPs differ considerably over the BNB spatially and temporally. Moreover, their performance in closing the WB is recognizable. Among all the PPPs considered in the current study, CMORPH and MSWEP 2.0, showed the best performance for WB estimation, with a difference between the estimated and measured discharge of -0.86% and 8.6% for CMORPH and MSWEP, respectively. The two EPPs created by averaging all the 18 PPPs and by averaging all the blended PPPs showed better performance in WB estimation compared to many original PPPs. The findings of this research are helpful for a better understanding of the PPPs performance. The outstanding performance of some EPPs indicates that, the practice of merging different PPPs using simple assimilation methods is very promising to produce new precipitation estimations with better performance. These results are useful to advance the usage of PPPs for water balance studies, and for a wide range of applications in water resources.

KEYWORDS: Public-domain precipitation products, Ensemble precipitation products, Blue Nile Basin, Water balance, Water accounting

Climate change, transboundary conflict and food insecurity in global south: implication for advancing water cooperation to attain SDG in South Asia

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The issue of transboundary river management is highly pertinent to South Asia with conflicts emerging in water resource management and utilization in the era of climate change impacts which indeed affect the beneficial uses of downstream region. The paper considers the situation of the Teesta river basin shared between India and Bangladesh to assess the cost of uneven water access of the downstream region from the upstream region and identify the mutual benefit of water collaboration in the view of SDG implementation. The study found that during 1995-2010, the annual mean discharge in the upper Teesta floodplain was 707 cumecs, where the downstream discharge was found 140 cumecs and during 2005-2010 the downstream region received less than 8% of the mean annual water discharge which may be attributed to reduced flow from the upstream region due to the intense operation of dams and barrage. Consequently, the water reliant 5000 villages and 12 subdistricts of lower Teesta basin of Bangladesh were found to be experiencing immense hydrological and agricultural impairment. Using marginal productivity method, the study estimates that, in Rangpur region, total loss and damage of Boro rice production is 15,08,020 metric ton during 2006-2015 due to water unavailability from upper Teesta basin, which has a market price nearly US\$367 million. Whereas, in Nilphamri total loss and damage is estimated at 9,83,054 metric tons during the same period, which incurs a total cost of US\$197 million. Here, the total computed economic loss for both the region is US\$564 million from 2006-07 to 2014-15 FY, which evidently trims down the overall regional food production and socio-economic situation of the marginal farmers in the lower Teesta region and fuel the hydro-economic and political tension between the close riparian. If the transboundary conflicts continue and upstream region withdraws the water at the same pace from the upper Teesta, the total agricultural cost of the downstream region will reach to US\$1584 million in 2030.

KEYWORDS: Climate change, cost of conflict, regional water co-operation, food insecurity, SDG

Impact of Water on Food Security

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The development of the principle of solidarity has been enhanced as an important tool in different areas of International Law and it has even been claimed to have reached "constitutional status". On the other side, these last two decades the importance of international water law has been reaffirmed with the decisions of the International Court of Justice (hereinafter the court). Moreover, International Water law is often being seen as counterproductive when it comes to solving transboundary problems, as it is being said to be reactive rather than setting a path towards peaceful and sustainable management of natural resources, on this sense, solidarity was also needed to strength the cooperation between riparian states. Furthermore, solidarity emerges as hydrosolidarity with the purpose of injecting a common understanding, based on collective action, interdependence and ethics, into (transboundary) water cooperation that will help frame the negotiations between riparians States.

Nevertheless, hydrosolidarity can challenge the self-interests of states whose legal regime will need to undergo a process of refinement in order to apply it and not so many States will be willing to implement it since this can affect their hegemony of a transboundary water resource. Moreover, in the absence of a binding treaty that encourage riparian states to implement hydrosolidarity, it remains the jurisprudence of the Court that can help to set up binding and effective implementation rules of hydrosolidarity. Consequently, after the innovative decisions of the Court regarding transboundary water conflicts there remain some questions, did the States need to apply hydrosolidarity in their regimes so they can implement properly the Court decision? Did the presence or absence of hydrosolidarity in the States regimes affect the implementation of the decision of the Court? The aim of this paper will be to answer this questions.

KEYWORDS: International Water Law, riparian states, water resource

Conjunctive transboundary aquifer-catchment management in the Shire basin between Malawi and Mozambique: Principles through fit-for-purpose practice

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Transboundary water management in the Southern African Development Community (SADC) is increasingly coordinated by river basin organisations (RBOs), with a focus on surface water. Groundwater is increasingly critical for dealing with increasing climate variability and for providing sustainable water access to people. While RBOs are beginning to address groundwater, they often treat surface and groundwater as two separate resources. However, these two resources are fundamentally linked through the hydrological cycle. Conjunctive water management, or water management that actively leverages the natural connection between surface and groundwater, presents an opportunity for riparian states to strategically manage water resources to deal with these challenges and capture major opportunities for resilient joint solutions. Examples of conjunctive management includes using aquifers upstream of floodplains to attenuate floods, using ground or surface water to supplement drinking water supply or irrigation during droughts, and employing managed aquifer recharge to store freshwater on top of saline groundwater for recovery. In addition to improved resilience, solutions under conjunctive management are often nature-based and distributed, making them more cost-effective than traditional schemes. A project in the aquifer-catchment system in Shire Basin, shared between Malawi and Mozambique, aims to contribute to sustainable water management in the SADC through transboundary cooperation on shared critical (surface and ground) water resources. To do so, a Transboundary Diagnostic Analysis (TDA) is underway to provide a baseline assessment of the shared water resources and surrounding context, leading to a Strategic Action Plan (SAP). The SAP is meant to address issues and opportunities identified in the TDA by generating a shared vision, goals, objectives and actions for conjunctive management. This process will also reflect upon critical uncertainties in the basin, including climate change. This presentation includes early findings at the mid-point of the project and emerging principles for conjunctive management in regions beyond the Shire.

Keywords: conjunctive management ; groundwater ; climate change ; transboundary ; SADC ; Shire

Water Resource Governance as Key Factor Sustainable Development in Morocco

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Water resource governance stands for the main key to secure sustainable development. Easy access and better quality of water are essential to promote socio-economical activities and better standard of life for population. Climatic changes prevailing in the last decades combined with unequal distribution of water resources have made Morocco under severe drought conditions. Potential of water resources tends towards the alarming threshold of scarcity. The quality of water has also degraded making the health of population and the environment under real risk.

To cope with this situation, Moroccan authorities tackle the issue via national strategy including best management of water and usage of non conventional water resources, mainly in agriculture. Official reactions have focused on maximizing water mobilization of surface water and improvement of supply drinking water for domestic, agricultural and industrial users through regional agencies and autonomous public authorities.

The strategy of management of water resources tends also to balance between water scarcity, the rise in cost of supplied water to different users and uses. Integrated approach includes reinforcement of institutional reforms by establishment of the High Council of Water and Environment (HCWE) in charge of the orientation and the general guidelines of water policy, the law of water that defines the role played by all actors in this field, long term national programs of mobilization (irrigation of 1.5 Million ha) and sanitation (National plan of liquid sanitation). More than 140 dams are currently operating, ensuring the storage of 14 Billion m³ and 98% sewer connection in urban zones.

NGOs (Non Governmental Organization) are also active involved in this effort. The experience of INDH "Initiative Nationale pour le Développement Humain", allowing participation of local population is very relevant. These strategies have allowed the achievement of 94% and 87% full access to water. Urban and rural zone respectively.

Keywords: water, sustainability, management, governance, scarcity, Morocco

Analysis of Local Water Governance Structure and Dynamics in Rusinga Island, Homabay County, Kenya.

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Water as a resource is significant in all forms of production, including agricultural and industrial production both of which remains at the centre of human economic development. Good governance is not only important for the national government but also for the various sectors especially in rural areas, in discharging service to the people. One such area is the provision of basic needs such as water which is critical for human survival and securing of livelihoods. Good governance frameworks are said to embrace the relationships between governments and societies, including laws, regulations, institutions, formal and informal interactions which affect the ways in which governance systems function, stressing the importance of involving more voices, responsibilities, transparency and accountability of formal and informal organizations associated in any process. To assess the current measures and attempts by the local government to achieve the constitutionally guaranteed right of access to clean and safe water in adequate amounts, the paper offers an overview and analysis of the provisions of Water Act 2016 in light of the international best practices in water governance and the sustainable development agenda. Governments, the public, donors, and development agencies have often neglected challenges in water governance. Some of these challenges are related to policies, access to water resources, participation and water information. In Kenya, a range of technical solutions for water problems could work with more relevant and efficient governance structures. The first section of the paper thus gives review addresses a review of Kenya's water supply and sanitation situation. The second section encompasses the local governance structure in the water sector, which includes the policies, and institutions set to address water problems and finally it looks at factors influencing the use of lake water by households for irrigation in Rusinga Island.

KEYWORDS: Water, Governance, Local, Access

Impacts of Water Crises on Agriculture Sector and Governance Challenges in Pakistan

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The study contributes to develop a framework to understand the water governance challenges for agriculture sector at subnational level in Pakistan. The country is facing severe water crises and it may run dry by 2025. According to the International Monetary Fund, Pakistan is the third most water-stressed country in the world. Pakistan has the world's fourth highest rate of water use. Agriculture is the major source of economy in the country. Pakistan uses 93% of its freshwater resources on agriculture. This suggests that no country's economy is more water-intensive than Pakistan's. Agriculture sector contributes 24 percent of Gross Domestic Product and accounts for almost half of employed labour force and is the largest source of foreign exchange earnings. However, agriculture sector is under stress due to population growth, increased demands for food, ever-growing competition for water and land, climate change, and less-participatory water resources governance. It is imperative to introduce improved water management in agriculture and adaptation of agricultural systems to enhance water use performance and water productivity, particularly to face water scarcity. This study is conducted to understand the water governance for agriculture sector at subnational level in Pakistan. This study focuses to explore the prominent initiatives towards water governance in the province of Punjab, Pakistan. It also identifies the key challenges in the way of effective water governance towards agriculture sector. More succinctly, the study contributes to establish a framework to tackle the risk of water scarcity based on preparedness rather than a crisis approach.

keywords: Water Scarcity, governance, subnational level, Pakistan

Towards a better understanding of resource management decisions

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Sustainable resource management decisions are key for achieving the Sustainable Development Goals. Decisions are taken by individuals in the context of institutions such as households, communities or user associations. The members of these institutions may or may not share the same vision on resource allocation e.g. on the allocation of land, water or labor. If visions on resource allocation diverge, decision outcomes depend on the prevailing interests and power positions of the various actors at different scales. Hence, researchers and development agents that aim to support individuals or institutions in sustainable resource management decisions must know about the matrix of actors as well as the underlying decision-making dynamics. Based on three years of work with smallholder farmers in Northern Ghana, I present a 3-step framework to assess the prevalence and interplay of interests and power positions shaping local resource allocation decisions: (1) a farm and farmer typology, using multivariate statistics and a Participatory Learning and Action Approach, (2) a stick-score method, to measure individual interests and power positions concerning land allocation decisions and (3) a serious game to unravel decision-making dynamics. We find that farms and farmers may be classified along a gradient of resource endowment. Within households, the male household head (HHH) owns the land and generally holds the greatest power position. In low resource endowed farms, we find a top-down decision-making structure, since food security is the role of the HHH and all farm resources are used towards this purpose. The more farm resources (land, livestock), the greater the opportunities but also the intra-household claims on sharing the resources, implying negotiations, often leading to more diverse and 'just' decision-outcomes. We conclude that a systematic assessment of the connections between actors and their resources is fundamental to understanding and effectively supporting sustainable resource management decisions..

KEYWORDS: Decision-making, households, typology, farm, Ghana

Local governance systems in managing the risks of climate extremes and water crisis: Discussions from the case of coastal Tamil Nadu, India.

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Climate change could have the significant influence on the intensity and frequency of climate-related extremes, and it will have severe impacts on the lives and livelihoods of marine fishing populations. Climate change impacts pose numerous challenges to the fishing populations across Southeastern coastal Tamil Nadu, India - which is one of the most vulnerable regions to climate change in South Asia. Besides, this particular coastal region was the most affected region to the 2004 Indian Ocean Tsunami disaster in the Indian mainland. The fishing villages across the coasts of this region are self-governing villages for generations - which make the local governance systems of this region unique in South Asia. Provided this background, this paper discusses some key challenges the marine fishing populations of this region regularly face the impacts of climate-related extremes including short-term water crisis by exploring their vulnerability and adaptive capacity to the weather and climate-related extremes for around the past one decade. This paper then discusses how the marine fishers and their local governance systems have responded to the vulnerability of climate-related extremes. Many key themes are examined against the background of this case, including local governance, vulnerabilities from climate-related extremes and livelihoods. Drawing on qualitative empirical evidence from the selected small fishing hamlets in the Southeastern coast of Tamil Nadu, this paper argues that informal local governance systems of the traditional marine fishing communities have the significant stake in building the collective action to respond to weather-related risks. However, the complexities of decision-making and distribution of power-sharing among the various stakeholders among the formal and informal local governance systems significantly reduce the local level adaptation interventions of the traditional marine fishing communities to respond to climate-related extremes..

KEYWORDS: Local governance systems, Marine fishers, Climate-related extremes, Water crisis, Local-level adaptation interventions

Investing In Water Security and Climate Resilient Projects

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On Monday, 8th of October 2018, the Intergovernmental Panel on Climate Change (IPCC: 2018/24/PR), in its Special Report, has emphasized that it is now more urgent than ever to limit global warming to 1.5°C compared with 2°C. The report shows that in order to achieve this objective, carbon dioxide (CO₂) emission caused by human activities should by fall 45% from its level in 2010 and this should be accomplished by 2030. This is on component of climate-compatible development, another equally important component is enhancing water security as reported by the Water Aid in their Briefing Note. According to this note, despite the availability of funds, water sector fails to fully use such funds to adapt to climate change through failing to support water security projects. It is found that developing countries are at high risk of climate change consequences on water cycle. In light of this, this paper aims to survey the determinants of investing in sustainable development projects and in particular, factors that drive green investment and financing in developing countries, and how this relates to circular economy. This has very important policy implications to government and policy makers to achieve water security and combat climate changes in countries that have been worst affected.

KEYWORDS Green Investment; Circular Economy; Climate Change; Food Security

Water Quality Management Scenarios for Rosetta Nile Branch, Egypt

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Egypt, as a developing country, faces growing challenges for providing an adequate water supply with good quality. Population growth, economic development and human activities contribute to reduce the quality status of surface water resources. Rosetta Branch is one of the two Nile River branches that is considered as the major source of fresh water for western Nile Delta. Agricultural drainage water of the main Delta drains, including Tala Drain, and industrial wastes from Kafr El-Zayat City are considered as the main sources of Rosetta Branch pollutants. The main objective of this study is investigating the effectiveness of applying some feasible water quality scenarios for Rosetta Branch, to achieve a better ecosystem. Six water quality management scenarios are investigated using a calibrated hydrodynamic and water quality model (MIKE 11) for the branch. Five water quality parameters: water temperature, salinity, dissolved oxygen (DO), biochemical oxygen demand (BOD) and fecal coliform (FC) are simulated and used to evaluate the effectiveness of the investigated scenarios. The simulation period was selected to be from November 2014 to August 2015, according to the available collected data. The results showed that the best water quality improvement can be achieved by diverting the effluent of Tala Drain into the nearest main drain. Moreover, this study confirms that the expected decrease in the discharge of the Nile River, due to climate change and/or the construction of the new Ethiopian dams, will cause a significant deterioration in the water quality status of Rosetta Branch. It is urgently recommended that a national water quality management plan for Rosetta Branch to be initiated.

KEYWORDS: Water Quality Modeling, MIKE11, Water Quality Management, Nile River, Rosetta Branch, Tala Drain

A Zone of Possible Effective Cooperation (ZOPEC) in Transboundary Water Cooperation

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Water is life. It has economic, environmental and social values, and is essential for sustainable development. However, unprecedented population growth, a changing climate, rapid urbanization, expansion of infrastructure, migration, land conversion and pollution are posing great dangers to the availability of both surface and ground water. In the past 10 years, Kenyatta University has experienced a surge in population growth, exacerbated by a demand for higher education, rising from about 9,000 students in 2006, to over 70,000 as of 2016. Due to lack of adequate accommodation services in the university halls of residence, more than $\frac{3}{4}$ of these students reside in the neighbouring towns of Ruiru, Kahawa Sukari, Kahawa Wendani and Kiwanja (KM) leading to a further increase in population of the affected centres. This has also triggered a further increase in the demand of water in these areas sometimes exceeding the one provided by the municipalities. A direct response to the shortage has been drilling of boreholes to meet the ever increasing water demand. A study was thus conducted to assess the socio economic aspects of the hydrogeology and the geochemistry of the groundwater systems in Kenyatta university and the emerging surrounding settlements. A total of 220 respondents were interviewed on various aspects of water supply and demand, environmental issues and water and health. This study found out that there are occasional water shortages in the affected areas and the problem has been getting worse with increase in student population. A majority of the respondents for instance reported that the problem is worse on periods when students are on session while gets slightly better when students are on vacation. Most hostels and apartments were also found to own boreholes to augment the seasonal fluctuations caused by increase in student population. For instance, 83% of the interviewed apartments caretakers indicated that they do not have underground water tanks with 75% of residents reporting water shortages during student peak sessions. With student population expected to continue rising or remain at its current high level, it is obvious that the hydrogeology and geochemistry of the groundwater in these areas will be affected if no intervening measures like water harvesting and recycling are put in place.

KEYWORDS: Kenyatta University, Groundwater, Geochemistry, Hydrogeology, Socioeconomic.

Climate Change Adaptation to Water Scarcity in Glacier-Dependent Town of the Indian Himalayas

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Current and anticipated impacts of climate change on water resources are expected to intensify the present as well as future threat of worldwide water scarcity. Societies of Glacier dependent are especially vulnerable to water scarcity due to more noticeable effects of climate change on glacial systems that oversee the water availability of their societies. In this research paper, water scarcity is examined as an impact of climate change in the glacier-dependent town of northern India, while recognizing that climate change is not the only factor causing reduction of water resources in this town. In order to show the linkage between climate change and water scarcity, evidence is presented on changes occurring in the town local climate parameters such as snowfall, rainfall, temperature as well as changes in the hydrology of the water bodies that make water available to this town. This establishes that water scarcity in town has been brought not only by growing demand, but also by diminishing supply of water.

In light of the water scarcity facing this town, an investigation of the measures taken by their local governments to address this issue is presented, which reveals that the primary adaptive response employed in town has been supply augmentation. The driver behind this response has been the pursuit of economic development to improve the standard of living of town. It is argued that economic development as a driver has not been effective in making holistic adaptive responses to water scarcity.

Furthermore, climate change considerations have been largely absent in the processes that administer water management in town. There are numerous technological, infrastructural, financial and political barriers to the inclusive climate centric strategies for adaptation to water scarcity in the town. Based on the study, recommendations are offered to enable the local governments of the town for water security..

KEYWORDS: GLACIER-DEPENDENT TOWN; WATER SCARCITY; WATER SECURITY; CLIMATE CHANGE AND CLIMATE CHANGE ADAPTATION

Remote Sensing Applications in Water Resources Management for Nile Delta, Egypt

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Kafr El-Sheikh is one of the most important governorates in the Nile Delta of Egypt, where it contributes 30% of the Republic's rice production and ranks first in the production of sugar beet at the level of the Republic. Egypt faces great challenges to secure its freshwater quota. So, the expected shortage in freshwater will significantly affect the Egyptian water and food security. A regular assessing of water security elements for each of the Egyptian governorates is essential. Therefore, the study of land use change is very important in describing the current state and predicting future changes. Remote sensing is one of the most modern methods that can be used in the management of the water resources because of its Numerous temporal and spatial data. The objective of this study is to evaluate the performance of the use of different satellite data in water resources management applications. Therefore, the performance of Landsat images in land use identification has been assessed, which has shown excellent representation. Since the value of actual evapotranspiration (Eta) is considered one of the most important values to achieve optimum management of water resources, Eta product from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite (MOD16A3) performance was evaluated in calculating the values of evapotranspiration at the governorate level, which also showed very good performance. After verifying the performance of the Landsat and Eta product from MODIS, the land use and actual evapotranspiration were calculated over the previous years. The results showed that there was an increase in the agricultural area of the governorate during the period from 1990 to 2010 and then the agricultural area started to gradually decrease.

KEYWORDS: KAFR EL-SHEIKH, REMOTE SENSING, LANDSAT, LAND USE, MODIS, EVAPOTRANSPIRATION, WRM

Drought monitoring as a key component for drought preparedness in Brazilian northeast.

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The semi-arid region (sertão) of Brazil has been experiencing an intense and prolonged drought since 2012, being the most intense and impactful in recent decades, thus a greater necessity of more efficient tools for drought monitoring emerged. In a period where climate change is a persistent and worrying issue, the semi-arid and arid regions are particularly exposed to its impacts on freshwater (Kundzewicz et al., 2007). The drought monitor is an approach which represents the first step for a profound paradigm shift, from a reactive emergency management to a proactive one. The drought monitor aims increasing the resilience of vulnerable and impacted areas, once the Brazilian semi-arid experiences recurrent drought events, notwithstanding without solid policies. This tool intends integrate technical and scientific knowledge to achieve a better understanding of drought severity, spatiotemporal evolution and impacts over the various actors involved. The implementation of it, showed itself already as an important apparatus to easily assist decision makers, especially supporting the mitigation of drought and recognition of states of emergency and public calamity.

KEYWORDS: Drought; Semi-arid; Mitigation; State of Emergency and Public Calamity

El Niño Effects on Rainfall Patterns and Behavior in Sudan

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In this research the effect of El Nino and La Nina was investigated on the behavior and pattern of the rainfall over Sudan. This research depend on time series of rainfall data. Dataset used are the monthly mean data (mm), from 14 weather stations in different regions of Sudan Spanning the years (2007-2017) accomplished by the Sudan Metrology Authority. For each rainfall station, the normal annual average rainfall data was calculated and then displayed on graphs compared to annual average rainfall during El Nino/La Nina episodes. Data was analyzed statistically for the number of rainy days, average monthly rainfall, mean, standard deviation and variance. The results showed that the rainfall behavior in most stations is affected by the ENSO episodes recording above or normal during El Nino conditions while recording below normal conditions or almost normal during La Nina conditions. Western Sudan station indicated two peaks of annual average rainfall in July and August, and change in annual average rainfall pattern during El Niño indicating above normal conditions over the rainfall pattern. In mid-west region stations, the annual average rainfall pattern also indicated increase above normal conditions during El Nino Episodes. The central region stations indicated positive change in the rainfall patterns, while stations along the Blue Nile and White Nile showed no change in the annual average rainfall behavior and pattern during El Nino years. Stations located in the north along River Atbara indicated no change as well as stations located in eastern Sudan along the Red Sea. In stations towards the east and south east there was significant positive change indicating increase above normal means. Results indicated that ENSO have positive effects on the annual rainfall average for some regions in Sudan which will lead to floods and further deterioration in sanitation and hygiene conditions, in Blue Nile regions and Kassala, that will affect the sustainable development of the rural areas located in these areas. Therefore it is important to understand how El Niño events typically behave once it is developed, and to place these typical features in the context of rainfall early warning system and disaster management in Sudan.

KEYWORDS: El Nino/La Nina episodes, rainfall, above normal conditions, floods, rural development, early warning

Climate Change Impact on Groundwater Pollution and Nitrate-N Transport: A Case Study of North Bihar, India

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Climatic variabilities significantly affect the groundwater flow regimes especially in shallow aquifer regions. The moisture flow and pollutant transport through partially saturated zone plays a crucial role under varying hydrogeological conditions. The objective of this study is to evaluate the vulnerability of groundwater resources due to climate change and Nitrate-N in Samastipur, Darbhanga and Madhubani district of north Bihar. Richard equation integrated with the classical advection dispersion equation is simulated using HYDRUS 1D by incorporating realistic site conditions. Further, a constant head and atmospheric boundary conditions are simulated for the study area by integrating long term climatic change. In which, the transient flux is estimated using soil types, land use cover, slope and from precipitation and evapotranspiration. The time taken to reach the Nitrate peak concentration at groundwater table is considered to estimate vulnerability index (VI) for target years. Results show a high risk in southern part dominated by Gangatic kankar (gravel) in subsurface. Further, high pollution risk is reported in eastern north part of balance area (Sandy river bed) having alluvial deposition in subsurface. The main causes of high risk are due to the low water table depths and low runoff due to change in rainfall pattern along with higher hydraulic conductivity of the subsurface media. Moreover, comparatively low vulnerability is observed in area having clay capping of 2-4 m from surface. This research may help in better implementation of agricultural, soil-water conservation practices and urban/industrial infrastructure development in and around study area..

KEYWORDS: Climate Change, Groundwater Pollution, Nitrate-N, Numerical Modeling

Impact of Syrian Refugee Camp on Water, Air and Soil Quality at Zaatari Refugee Camp / Jordan

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Evaluation of the environmental situation inside Zaatari Refugee Camp in terms of water, soil and air was done through classic monitoring as well as by the use of new technique (biofilm) to monitor heavy metal pollution in sewage system at Zaatari Camp. Major ionic composition was determined for surface runoff, groundwater and wastewater whereas six heavy metals Zn, Mn, Cd, Cr, Cu and Pb were evaluated for all samples. It was found that salinity of surface runoff decreased with rain events that the highest concentration was found at the beginning of the rainy season where the lowest was found at the end of the season. The salinity of wastewater was related to population density within the camp as it was highest in the oldest part of the camp where high population density exist and the lowest was in the new part of the camp with low population density. Heavy metals concentrations in groundwater were low indicating that pollution from the refugee camp did not reach the groundwater resources of the area. All biofilm sampling of the same of wastewater sampling sites was done and it was found to be more efficient in wastewater monitoring as it represent longer period of monitoring than traditional method. For heavy metals concentration in the upper soil showed much higher concentration than lower soil indicating that the source of heavy metals are from the activities within the camp. For air concentration of all heavy metals were very low indicating that there is no source of heavy metals pollution in the area as the camp is located in a desert area and relatively far from major cities.

KEYWORDS: ZAATARI CAMP, HEAVY METALS, BIOFILM, WASTEWATER

Laboratory Study to Determine Runoff Coefficients of Two Types of Permeable Pavements

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Green stormwater Infrastructure (GSI) is among the most effective stormwater management tools that mitigates the adverse effects of climate change by reducing generated stormwater discharge volumes and promoting infiltration and ground water recharge. In this study, a laboratory study was conducted to assess the hydrological performance of two types of green stormwater infrastructure (GSI) systems: permeable interlocking concrete pavers (PICP), and permeable concrete (PC). The two systems were constructed using two rainfall simulators equipped with laboratory plot scales. Several rainfall-runoff events were simulated under different plot slopes to develop runoff coefficient values, C , that describe the runoff characteristics of each surface. C values of 0.68-0.74 were determined for PICP under dry antecedent water content (AWC) of subgrade. On the other hand, high infiltration rates and no measurable runoff were observed on PC surface under dry AWC of subgrade. While under wet AWC, C values of 0.88-0.92 were determined. Through the determined C values, this paper demonstrates the expected impact of AWC of subgrade on the hydrological performance of permeable pavement systems. These results highlight the importance of considering this parameter for an appropriate design of GSI systems.

KEYWORDS: Green stormwater infrastructure, Runoff coefficient, PICP, Permeable concrete (PC), Rainfall simulator, Antecedent water content

Suitability Analysis for Managed Aquifer Recharge through Runoff Water Harvesting in Eastern Badia of Jordan

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Groundwater is considered the major source of fresh water in the eastern desert (Badia) of Jordan. The arid climate with low rainfall and high evaporation rate, coupled with population growth and growing water demand, which amplified by migration from politically unstable countries, have put additional strains on this limited resource. Consequently, the regional aquifers are exposed to over-abstraction that exceeds the natural recharge causing ongoing groundwater depletion. Hence, Managed Aquifer Recharge (MAR) is selected as a valuable counter-measure to overcome this issue. In this study, ArcGIS is used to identify and provide a graphical assessment of suitable locations for MAR through surface infiltration of Runoff Water Harvesting (RWH) in eastern Jordan Badia, by assessing their physical suitability. Parameters such as topography, hydro-geology, proximity to water resources, and groundwater quality are considered determinant factors for MAR site selection. Each parameter is processed individually to a thematic layer and combined with others to form a final MAR suitability map using Multi-Criteria Analysis tools (MCA). Based on the resulted map, seven dams are proposed to be implemented downstream of the main wadis, in sites with a very good to good suitability within the study area. As a result, site suitability is proved very good, good, and moderate over 23%, 30%, and 8% of the effective drainage area (EDA) respectively; while low potential areas represent only less than 1%. Whereas the estimated groundwater recharge via surface infiltration in the suggested catchments is found to be on average 4.15 MCM/year. The surface runoff that could be annually utilized for water harvesting is estimated to be 2.17 MCM, which could increase the groundwater recharge budget up to 6.32 MCM/year. Therefore, MAR is imperative to ensure the sustainability of this water source for future water supply, improve the socio-economic situation and the sustainable development in that region.

KEYWORDS Jordan Badia, Managed Aquifer Recharge, Multi-Criteria Analysis, Sustainable development

High Aswan Dam Reservoir Management in Case of Ethiopian Renaissance Dam Failures

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Dams provide many benefits to humanity such as water supply, hydropower, and flood protection. However, dam failures worldwide produced many catastrophic and destructive disasters; in the forms of loss of lives and widespread damages. The dam break parameters prediction, the understanding of dam break mechanics, and predicting the propagation of unsteady flow wave downstream constitute essential factors in the dam break analysis to eventually determine the volume and extend of damage. A separate flood routing model, based on level pool hydrologic routing, was developed to simulate the GERD break and rout the flood hydrograph coming from the upper Blue Nile catchments and the reservoir storage through break. The hydraulic routing of the resulting flood wave through the river downstream of the GERD was investigated using 1-D Hydrodynamic model that was used to model breach formation and to solve the unsteady flow equations of flood wave propagation. The resulted flood wave from the breaching had a catastrophic effect on the downstream Nile reach with a flood extent over few kilometers on both sides of the main channel until reaching AHDR reservoir upstream entrance. Another hydrologic routing model, based on level pool routing technique, was developed to rout the arriving flood hydrograph reaching the entrance of AHDR and study its impact on water levels in the reservoir. The level pool routing was simulated assuming different outflow alternatives from AHD normal summer peak release, future planned maximum release and maximum turbines outflow capacity. The flood wave impact on AHDR were simulated against different assumed water levels in AHDR at the start of the simulation. From the simulation it was found that the maximum AHDR level that should be maintained if the GERD failure occurred to avoid AHD overtopping or any damage to the downstream Main Nile reach was then estimated.

KEYWORDS: GERD, Dam failure, 1-D hydrodynamic simulation, Nile River, Blue Nile, AHDR.

Groundwater Management and Hydrogeological Modeling of the Sminja-Oued Rmel Aquifer in the Zaghuan district (north-eastern Tunisia)

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Hydrogeological modeling is a tool for the efficient management of groundwater resources. The Sminja-Oued Rmel aquifer system is located in Northeastern Tunisia. It consists mainly of continental detritic deposits of Quaternary age and formed of clays and sands. The two aquifers have a hydrogeological continuity, from west to the east forming a monolayer unconfined aquifer. The use of modflow software and Geographic Information Systems (GIS) aims to evaluate the hydrodynamics and geometry of the Sminja- Oued Rmel aquifer system as well as to test the response of the water level of the aquifer under different exploitation conditions and predictive simulations. The application of the Modflow model in steady state, considering that the piezometry of the aquifer system is invariable over time, with an equality of incoming and outgoing water flows, has made it possible to refine the spatial distribution of transmissivity, with values varying from $0.8 \cdot 10^{-3}$ to $32 \cdot 10^{-3} \text{ m}^2/\text{s}$. The satisfactory concordance between the piezometric levels calculated and those measured reflects the reliability of the model, despite the inadequacy of the hydrogeological information in some parts of the aquifer system. The model also made it possible to estimate the inflow and outflow, which is estimated at 477 l/s, and to evaluate the renewable resources of the aquifer system. On the other hand, the calibration of the model in transient state has made it possible to determine the piezometric drawdown during the period 1982-2015 in response to increasing exploitation. The largest drawdowns ($> 3\text{m}$) are recorded at the eastern and southwestern part of the aquifer, where the majority of water points that are well exploited. The predictive simulations show that increasing operating rates leads to a significant drawdown. Indeed, a first scenario, with samplings identical to those of 2015, shows drawdowns of the order of 5 m. The duplication of exploitation, in a second scenario, increases the drawdown up to 9 m. For both simulations, the highest drawdowns are recorded in the eastern and southwestern part of the aquifer.

keywords: hydrogeological modeling, sminja-oued rmel aquifer system, modflow, water resource management, zaghuan, tunisia

Distribution of nitrate and fecal bacterial indicators in urban groundwater under stress at the end of dry season

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The contamination of groundwater by pit-toilet leachate is a major environmental concern in Cameroon as it sources a major proportion of potable water from aquifers. Water resources might spread diarrheal disease if they are microbiologically polluted. In Yaounde, the capital City of Cameroon, groundwater plays a fundamental role in the water supply with less than 50 % of households having direct access to piped supply. This study assessed the prevalence of nitrate and fecal indicators in 39 different groundwater points selected in of urban area of tropical countries taking Yaounde (Cameroon) as case study. The concentration of nitrates, *Escherichia coli*, total coliforms, physicochemical parameters such as pH, Electrical conductivity (EC) and the main inorganic components (K^+ , Ca^{2+} , Na^+ , Mg^{2+} , Cl^- , SO_4^{2-} , HCO_3^-) were determined in water samples following standard protocols of water analysis. The statistical interpretation and relationships between analyzed parameters was done as well as the map showing the geographical distribution along the streamline of the City. Globally, the groundwater samples were highly mineralized with EC ranging from 33 to 1412 $\mu S/cm$. Most samples exhibited acidic pH was ranging from 4.62 to 7.23 Units. All samples had detectable concentration of nitrates with values ranging from 0.25 to 161 mg/L, exceeding the WHO drinking water limit of 50 mg/L in samples from dug wells in more than 50 % of samples. More than 69 % of the total samples exhibited the detectable values of fecal indicators placing the users under the risks of fecal-oral diseases. It can be concluding that the groundwater resources in Yaounde is strongly affected by anthropogenic inputs, thus the higher pollution in nitrate, EC, and fecal indicator microorganisms display with the area with higher density population. The streamline of the town was also found to be favorable to the groundwater pollution, placing groundwater resources of Yaounde under continuous degradation.

KEYWORDS: anthropogenic activity, groundwater contamination, nitrate, fecal indicators, dry season, Yaounde

Interactions between freshwater ecosystem services and land cover changes in southern Bangladesh: a perspective from short term (seasonal) and long-term (1973-2014) scale

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We aimed to assess the long-term (1973-2014) and short-term (pre and post-monsoon) quantities, values and changes of freshwater ecosystem services (FES) in the wetland areas of Southern Bangladesh using land cover change as a proxy indicator. Bangladesh is a sub-tropical country that receives more than 80% of its annual rainfall during the monsoon and post-monsoon periods, between the months of June and November. Therefore, it could be hypothesized that the monsoon and post-monsoon rainfalls significantly contribute to altering the local land cover, and consequently change the FES. Our multi-stage methodology, among others, included; (i) participatory FES identification (ii) long-term and seasonal land cover analysis using Remote Sensing and GIS, and (iii) assessing FES quantities and values using an expert-developed FES Matrix. The results identified 14 major FES; seven provisioning, six regulating and one cultural service. The results showed that over the last 40 years, significant land cover transformations occurred in the study area e.g. increase of agricultural land, rural vegetation with settlement (RVS) in exchange of wetlands, along with significant seasonal variations include increase of wetland in the post-monsoon seasons and agricultural land in the pre-monsoon seasons. Such changes contributed to the decrease of total long-term FES quantities and economic values including a significant reduction of regulating and provisioning services. Post-monsoon seasons experienced increased quantities of regulating services (e.g. soil fertility, water purification and biodiversity), mainly as a result of additional rainfall, although its overall quantities considerably decreased over the long-term. The results of the study highlighted the importance of prudent land management policies at rural scales for better ecosystem services and conservation.

KEYWORDS:

Young's bargaining model for optimal design of groundwater in-situ bioremediation

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Optimization problem with groundwater quality issues can be considered with different objective functions. These objectives cause conflicts between different stakeholders that have conflicting goals. Young's bargaining model is one of the game theories that can be used to find the best design from a set of optimal solutions. In this paper, the optimal in-situ bioremediation design for contaminated groundwater is obtained by minimizing the total cost and the square of cleanup standard violation (SCSV). After the optimal solutions were extracted by applying the non-dominated sorting genetic algorithm (NSGA) II, Young bargaining model was used to select the best alternative. Results show that the selected solution by Young's model is the most optimal combination of two objective functions considered in this study. This solution decrease the cost of project as much as 78.85%. This cost reduction will increase the SCSV as much as 25.86%.

Hydrodynamic Numerical modeling for groundwater management in Jeffara of Medenine (South-Eastern Tunisia)

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As water quality parameters and study of their spatiotemporal changes, quantification of reserves and their variations according to natural and anthropogenic forcing is necessary to establish an adequate management plans for groundwater resources. For this purpose and for optimal and sustainable exploitation of groundwater resources, the modelling approach is an effective tool allowing, after calibration phase and verification of simulation, and under different scenarios of forcing and operational changes, to estimate and to control the groundwater quantity and quality. For this study, the main objective was to collect all available data in a model that simulates the Jeffara of Medenine aquifer system functioning and serves as a tool for sustainable management of the resource. To achieve this goal, first a conceptual model is established based on previous studies and hydrogeological investigations. The calibration of the mathematical model in steady state (piezometry of 1973 as reference state), helped to refine the spatial distribution of transmissivity, with values ranging from 10^{-4} to $6 \cdot 10^{-2}$ and to restore the piezometric level at each point and determine the groundwater balance in steady state. The good concordance between the simulated levels and those measured reflects the reliability of the model.

KEYWORDS: Groundwater, flow model, modelflow, steady state, piezometric, Tunisia,

Research on Contribution Ratio of Large Upstream Reservoirs for Minimum flow in Vugia-Thubon River System

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Hydropower development in the upstream have a great impact on downstream flows. According to the Operational rule of Reservoir System (Operational Rule 1537) in Vu Gia - Thu Bon river basin, four large upstream reservoirs must discharge certain flow during dry season to increase water levels at downstream hydrological stations named Ai Nghia and Giao Thuy. These stations were used as the control points for the downstream water supply. This study seeks reasonable minimum discharging flows of reservoirs to maximize total electricity production and to ensure minimum flow at downstream as required. An integrated river basin model was developed in Excel and solved by Crystal Ball Optquest. Thousand combinations of the reservoir inflows were generated by Monte Carlo simulation, considering the correlation between tributaries. Then, the scatter search algorithm available in the Optquest module was used to find the optimal outflows from the reservoirs. The optimizing-simulation based results show that the current Operational rule 1537 can be improved for more efficient water resources management

KEYWORDS Reservoir system operation, Crystal Ball Optquest, optimization, Monte Carlo simulation

Application of forecast information and near real time rainfall monitoring to support mitigate salinity intrusion in Vu Gia Thu Bon river basin – VietNam

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Vu Gia Thu Bon (VG-TB) river basin in central of Vietnam is characterized by a complex exchange between Vu Gia and Thu Bon flows. Quang Hue connecting river branch between Vu Gia and Thu Bon rivers has been continuously eroded and changed in flow dynamics, thus increasingly shifted flow from the Vu Gia to the Thu Bon river causing serious flooding in Hoi An city in flood season and lack of water for Da Nang city in dry season. After the construction of the large reservoirs system, especially for the transfer of water from Dak Mi 4 hydropower plant, there have been significant consequences for the downstream area regarding the environmental impacts and salinity intrusion. Due to the dynamic water flow on the system of VG-TB, without integrating the reservoir operation and the weather forecast for the forecast water balance scenario, it is almost impossible for the city of Da Nang to operate its water intake system to meet the water quality requirement during the dry season. An operational support system digesting 10 days meteorological forecasts data of the Global Forecast System (GFS) from NCEP-NOAA National Prediction Centers (USA) and the GSMAP real-time rainfall as the initial conditions for the reservoir water balance model has been developed. The system couples the entire downstream detailed Mike 11 AD + HD models (calibrated and validated for water level and flow from 1976 to 2016) and the reservoir water balancing with forecast rainfall was able to simulate both the water level, discharge and salinity intrusion has been validated and show high agreement at the observed points for the dry season of 2015 and 2016.

KEYWORDS: SALINITY INTRUSION, RESERVOIR OPERATION, REAL-TIME RAINFALL, WATER BALANCE

Numerical Modeling of Climate Change Impacts on Water Quality Characteristics of Lake Burullus, Egypt

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Egyptian Mediterranean coast hosts five shallow coastal lagoons which play a vital role in the national economy. These lagoons face significant environmental challenges which limits its functions, climate change is expected to significantly affects their characteristics. Lake Burullus, the case study of this work, is the second largest Egyptian lagoon which is located in the Nile Delta and connected to the Mediterranean by a narrow outlet. The prime objective of this study is investigating the impacts of climate change (CC) on its physical, hydrodynamic and water quality characteristics. So, a 2-D hydro-ecological model for the lagoon was developed, using MIKE21. The proposed model was calibrated and validated against water quality records, for two successive years (2011-2013), at twelve monitoring stations throughout the lagoon. The simulations were executed for various parameters, such as: water depth, salinity, DO and nutrients components. The model results showed that the developed model is an effective tool to simulate Lake Burullus characteristics under observed hydrological and meteorological conditions. Six different Regional Climate Models (RCMs) were used to extract the most accurate future climatic conditions for the lagoon. These climatic estimates cover three Representative Concentration Pathways (RCP) scenarios, according to the IPCC 5th Assessment Report (AR5). The validated model was modified with these future estimates for different years covering the near, mid and long-term future of the 21st Century. The results showed that CC has the potential to radically alter the physical and chemical structure of Lake Burullus ecosystem. The results emphasized that the Lagoon is expected to be warmer and more saline for all scenarios. CC will increase the risk of oxygen depletion with significant spatial differences of DO decreasing. A prolonged residence time will be resulted accompanied by increasing trend of phosphate PO₄, decreasing trend of nitrate NO₃ and significant increase in the concentrations of chlorophyll-a. Climate change impacts on the lagoon characteristics should be considered in Lake Burullus management plans.

KEYWORDS: AR5, Climate Change, Lake Burullus, MIKE 21, Nile Delta, RCM, Water Quality Model.

Variation of nitrate and faecal bacterial indicators in groundwater of a tropical urban area

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This study assessed the nitrate and fecal indicators in groundwater source of urban area taking Yaounde as case study. A total of 39 groundwater samples distribute at 21 dug wells, 4 production wells and 14 springs were sampled in dry season. The concentration of nitrates, *Escherichia coli*, total coliforms and some physicochemical parameters such as pH, Electrical conductivity (EC) and the main inorganic components (K^+ , Ca^{2+} , Na^+ , Mg^{2+} , Cl^- , SO_4^{2-} , HCO_3^-) were determined in water samples according to standard protocols of drinking water analysis. The relationships between physicochemical parameters and their distribution in the study area are studied using the descriptive analysis, a spatial distribution of EC and pH along a streamline in an urban watershed, the Pearson correlation test, cumulative density function and factors analysis. Groundwater samples were characterized by a high mineralization with EC between 33 and 1412 $\mu S/cm$. The weighted mean value of EC for urban groundwater in Yaounde is 498.9 $\mu S/cm$. The EC of samples correlates positively with all inorganic compounds considered. The pH of samples was acidic ranging from 4.62 to 7.23 Units. All samples had detectable concentration between 0.25 and 161 mg/L with a median of 51 mg/L, exceeding the WHO drinking water limit. Total Coliforms and *E. coli* in urban groundwater ranged from 0 to 2400 CFU/100 ml and 0 to 144.5 CFU/100 mL respectively. Moreover, in 69 % of all samples, bacteriological contamination was found. The reduction in pollution sources as well as health risks associated to water quality is a need, for example, through constructing latrines and the respect of protection area between latrines and water sources. A combination of improved water supply and effective health education programs could help in reducing the negative aspects associated with the use of contaminated water.

KEYWORDS Anthropogenic activity, groundwater contamination, nitrate, fecal indicators, dry season, Yaounde, tropical urban area

Bacteriological Safety of Sachet Drinking Water Sold in Benin City, Nigeria

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Access to safe drinking water remains a major challenge in Nigeria, and where available, the quality of the water is often in doubt. An alternative to the inadequate clean drinking water is being found in treated drinking water packaged in electrically heated sealed nylon and commonly referred to as “sachet water”. “Sachet water” is a common thing in Nigeria as the selling price is within the reach of members of the low socio- economic class and the setting up of a production unit does not require huge capital input. The purity of the water and the hygienic condition under which they are produced is often in doubt. The bacteriological quality of selected “sachet water” stored at room temperature over a period of 56 days was determined to evaluate the safety of the sachet drinking water. Test for the detection of coliform bacteria was performed and the result showed no coliform bacteria that indicates the absence of fecal contamination throughout the 56 days. Heterotrophic plate count (HPC) was done at an interval of 14 days, and the samples showed HPC between 0 cfu/mL and 64 cfu/mL. The highest count was observed on day 1. The count decreased between day 1 and 28, while no growths were observed between day 42 and 56. The decrease in HPC suggested the presence of residual disinfectant in the water. The microorganisms isolated were identified as *Staphylococcus epidermidis* and *Staphylococcus aureus*. The presence of these microorganisms in sachet water is indicative for contamination during processing and handling.

KEYWORDS: Coliform, heterotrophic plate count, sachet water, *Staphylococcus aureus*, *Staphylococcus epidermidis*

Smart Cities, Access to Safe Drinking Water and SDGs: Evidences from Indian Cities

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Access to water is one of the primary requirements, both in urban and rural settlements, whereas most of the Indian cities are encountering looming water scarcity. Over the years, several policies have been undertaken at the individual city level, and of late, the national government has launched three flagship programs to rejuvenate urban regions, particularly to address three sustainable development goals such as good health and wellbeing for people (Goal 3), clean water and sanitation (goal 6) and reduced inequalities (goal 10). These policies are: Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Smart Cities Mission (SCM) and Housing for all (HFA). While providing adequate clean water across the income strata is a major policy challenge, a large number of studies have emerged to look into various aspects of this at the city level. Nevertheless, there is a dearth of studies to evaluate coping costs of urban water, and cross-cutting issues across the smart cities. This study, therefore, aims to identify various issues and challenges faced by the smart cities in India in regard to water supply. Initial list of 20 smart cities were selected for the empirical analysis and the information were collected since late 1990s. Various indicators associated with urban water are reported for different years across the cities, and hence, we grouped the data into two distinct periods, i.e., 1999-2005 and 2006-2014. Based on the available information, this study discussed on several issues associated with urban water supply, accessibility and status of water, demand and supply gap and water pricing. Major discrepancies observed across the cities with respect to access to treated water, dependency on groundwater, lack of uniform water pricing and inefficient revenue collection. Such analysis could assist the policy makers in the context of enhanced efficiency in equitable distribution of water, setting a price for urban water supply and redesigning the policy for maximizing benefit to weaker section households.

KEYWORDS: Urban water supply, Informal water market, Water tariff, Coping cost, Smart cities

ITTSmartSense: a cost effective and flexible technology for environmental monitoring

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Traditional commercial based environmental monitoring is costly, time consuming and often restricted with the tailor-made demand and less flexible in terms of choices of sensors to be deployed in the field. Wireless sensor network (WSN), in this regard, enable a new scope for application and research in environmental monitoring particularly in the field of agricultural, water and land management activities, due to the increased spatial, dynamic resolution and remote accessibility. However, very often this may lead to suboptimal flexibility, power consumption and therefore cost of the system. This paper presents a new flexible environmental monitoring solution to be used in any places in the world and reveals its usefulness by highlighting some of the key features. In comparison to typical commercial or industrial environmental monitoring solutions, our system architecture referred to as "ITTSmartSense" provide wide range of features, such as opportunistic data dissemination, flexible choices of multiple sensors in one system, long distance deployment and localization of information to meet the requirement of most of the typical environmental monitoring system around the world, particularly in the developing countries. ITTSmartSense is an intelligent cloud-based system for monitoring of the different environmental parameters in the field of agricultural, weather, soil, and water. It is an end-to-end solution for intelligent, energy efficient and modernized sensing technology capable of both, real-time and offline monitoring of typical environmental parameters e.g., soil moisture, temperature, rainfall, water quality, solar radiation and relevant parameter. Besides describing some of the important requirements for the sensor equipment to be used in ITTSmartsense settings, we present the main features and experiments conducted using the cloud-based Internet of Things (IoT) as one of the wireless sensor deployment platforms that meet these requirements. Furthermore, building upon IoT, we present an application to forest-hydrological monitoring in the Atlantic rainforest in Brazil as one of the first step towards building WSN in the developing world using different sensor equipment.

KEYWORDS: ITTSmartSense, Environmental Monitoring, Internet of Things (IoT), Sensors, Wireless Sensor Network (WSN)

Assessment of Groundwater Quality for Drinking Purposes in Omdurman Area, Khartoum State, Sudan

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This study was carried out to test the quality of drinking water in Omdurman Althawra, this study area was selected because the newspapers and other media sources reported in many occasions the complains of the communities about the drinking water quality, the households indicate that they suffer from water related diseases. The overall objective of this research was to assess the quality of the drinking water; the specific objectives were to identify the chemical, physical and biological components of drinking water, also to investigate users' satisfaction regarding water quality and to check the existence of water related diseases. The primary data was collected by means of collecting water samples from boreholes and distribution of predesigned questionnaires. The secondary data for this research was gathered from previous books, articles and written papers. According to the findings the households were not satisfied with the quality of drinking water and they used nothing to improve the water quality. According to the comparison that was made between the collected water samples and the WHO maximum limits, the chemical, physical and biological results showed that there is no contamination detected in the five groundwater samples , but the hospital data showed that there is a large number of people suffer from water related diseases ,the research revealed that the problem of the water quality does not come from the water provided from the source by Omdurman water corporation but mostly the problems are related to the damaged pipelines (leakages) or unhygienic practices at household level such improper storage or lack of awareness with regards to hygiene practices, therefore it is recommended that: Water authority should carry out regular monitoring on water quality and they should increases the level of awareness and develop a plan for replacement of the existing water pipes to reduce water leakages.

keywords: Drinking Water Quality ,Water Related Diseases , Unhygienic Practices .

Tracing the sources of groundwater nitrate in the Plateaux Region of Togo, using hydrochemistry and dual isotopic approach

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Groundwater contamination by nutrients especially nitrate, due to anthropogenic activities is a major global concern. This present study focuses on the intensive agricultural areas of the Plateaux Region of Togo where drinking water supply rely on low productive hard rock aquifer system which is also vulnerable to nitrate pollution. It aims at identifying the sources and processes of nitrate contamination. An approach combining hydrochemistry and a dual isotope ($^{15}\text{N-NO}_3$ and $^{18}\text{O-NO}_3$) monitoring approach was used for the first time in the region, to understand the evolution of nitrate pollution. The hydrochemical results have indicated contaminated groundwater with NO_3^- concentration high as 422 mg/L at the beginning of the dry season (December 2015) and as 364 mg/L at the beginning of the rainy season (May 2016). The $\text{NO}_3^-/\text{Cl}^-$ ratio, $^{15}\text{N-NO}_3$ and $^{18}\text{O-NO}_3$ data show that NO_3^- originates mainly from anthropogenic sources which are human and animal wastes, fertilizers and land clearance. The $^{15}\text{N-NO}_3$ vs $[\text{NO}_3^-]$ and $^{15}\text{N-NO}_3$ vs $^{18}\text{O-NO}_3$ plots suggest that nitrate concentration is controlled by the interference of nitrogen input homogenization, waters mixing and denitrification processes. The monitoring of chemical constituents, and water table level support roughly a potential nitrification and transfer of contaminant from the surface or from the shallow weathered zone during infiltration while the extent of nitrate attenuation in groundwater is probably controlled by the history and the level of nitrogen input, the geo-environmental conditions and the availability of electron donors. This study appear relevant to establish appropriate strategies for the sustainable management of groundwater resources in the study area.

KEYWORDS: Groundwater nitrate, hydrochemistry, $^{15}\text{N-NO}_3$ and $^{18}\text{O-NO}_3$, Plateaux Region, Togo

Drinking Water Security via HydroInformatics: a review of the potential with situational analysis of water supply and quality monitoring in Lekhnath-Pokhara Metropolitan City, Nepal.

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Availability and accessibility of safe drinking water remain some of the main challenges in many parts of the world, especially in developing countries. Despite of safe water sources in the majority of cases, high concentration of E-Coli can be found in household levels. In Nepal, about 80% of prevalent communicable diseases are due to poor sanitation and lack of access to quality water. There is a big gap between the coverage and functionality of the water supply system owing to the degraded quality of water. Citizens are still fighting with water quality issues, which are overshadowing the importance of water quality for community people, institutions and authorities. In fact, there is no data available on water quality. The WSP (Water Safety Plan) tool has been helping the government strategy but the data accuracy and consistency of CBM (Citizen Based Monitoring) needs to be checked. There isn't any efficient way ("easy to use" and practical tools) to engage technicians and local community (especially Youth) in assessing, collecting, transferring and visualizing water quality data. In order to evaluate existing situation in water supply system and to assess the possibility of integrating ICTs (Information and Communication Technologies) in the system, semi-structured interviews, experts' consultation, small workshops and focus group discussions were conducted. A specific methodological approach has been designed for the selected area, Lekhnath-Pokhara Metropolitan City, Nepal. The approach focuses mainly on the selection of HydroInformatics tools (ICTs like mobile applications, smart water quality sensors) in combination with stakeholders' participation/ Citizen Science (through water user's committees, local schools/universities and authorities) including co-learning interfaces (mobile e-learning), which in conjunction aims to provide a suitable data management system: Techno-Social-Institutional (TSI) Model towards drinking water security.

KEYWORDS Drinking Water Security; HydroInformatics-ICTs, Citizen Science; Water Supply; Water Quality Monitoring; Safe Drinking Water

Application of water quality model in studying natural attenuation of pollutants to support the environmental zoning and protection plan for Vu Gia Thu Bon river basin - VietNam

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Vu Gia Thu Bon (VG-TB) river basin in central of Vietnam is characterized by a complex exchange between Vu Gia and Thu Bon flows. In addition to a complex water resources system, the basin is also characterized with complex social-economic development including many anthropogenic sources of pollutants discharge to the water body (mining, industry, agriculture, untreated wastewater, ...). Recent years, the water quality index of the basin has continuously deteriorated. Traditional method of environmental zoning and planning was based on Water Quality Index (WQI) with monitoring data and categorize different reaches of the river system based on the pollutant level and the intended usage of the water on the reach to develop the environmental zoning and protection. The WQI index is a static method and heavily based on monitoring data. However, a hydrological-hydraulic model based on Mike suite of models has been set up, calibrated and validated with historical water level and flow from 1976 to 2016 period coupling with the environmental processes of pollutants in the river system has been proposed and developed. Other than the hydrological data, the model also uses environmental monitoring data from 32 stations on the basin. The system was able to capture the environmental hot spots near Da Nang cities and upstream areas sites with discharges from resident areas (high organic loading) and mining areas (high TSS loading) respectively. The model offers the environmental protection agency from 3 provinces on the basin a dynamic system to assess the status of the water environment system to do the planning and studying the relationship between reservoir operation, pollutant discharge points and environmental quality downstream for proper management of both water and environment systems.

KEYWORDS: Salinity intrusion, reservoir operation, real-time rainfall, water balance

Assessment of Drinking Water Quality in Al-Riyadh and Al-Taif Areas (Khartoum, Sudan)

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This research assesses the drinking water quality in Al-Riyadh and Al-Taif, in Khartoum. Khartoum State lies in the central part of the Sudan. The aims are to test the water quality and also compare it with the international standards namely, the World Health Organization's (WHO) Guidelines for Drinking Water Quality (GDWQ). These areas were selected as they are first class residential areas and should have high standard drinking water quality. The study areas are highly populated as they are both residential and market areas. Hence, there are a lot of people in this area at all times and so this can cause a strain on the water being supplied. The objectives are; to conduct chemical, physical and biological analysis of the drinking water supply, to assess the household's satisfaction, to examine the reliability and efficiency of water supply services and water authorities. To find out if there are any vulnerabilities to water borne diseases. Secondary data was obtained from various literature. Primary data was collected in two parts. Firstly, samples from three wells in the study area where the tests were carried out. These results were compared to the WHO's GDWQ. The findings show that the samples met almost all the guidelines however, coliform bacteria were detected in one of the wells. Secondly, questionnaires distributed to residents of the study areas. The responses were analyzed using Statistical Package for the Social Sciences (SPSS). According to the findings, it shows that most of the residents are satisfied with the drinking water quality. However, some have suffered from water borne diseases. In regards to the findings some recommendations were made; the water authorities need to be more vigilant and carry out periodical analysis. Also, they should shut down the contaminated well and nearby wells in order to solve the coliform bacteria issue.

KEYWORDS: WHO, GDWQ, COLIFORM BACTERIA, AL-RİYADH, AL-TAIF, DRINKING WATER QUALITY.

Impact of Kulfo River Stream on the Sustainability of Aquatic Life in Chamo Lake

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Over the last two decades, most of the water bodies in Ethiopia have become increasingly threatened due to pollution from different sources. Recently many died and floated fish on the surface of Chamo Lake at ArbaMinch city, indicated that lake water quality and ecosystem health had been deteriorated. The deteriorating quality of the lake or river systems is directly linked to the inadequacy of the existing sewage and city waste disposal systems and untreated wastewater discharged from domestic, agricultural and industrial sources in ArbaMinch, Ethiopia. This paper examines 16 water quality parameters to ascertain the water quality of Kulfo river stream as well as Chamo lake and the impact of Kulfo river stream on Chamo lake. Analysis of the data revealed that the concentration of Turbidity(21NTU), TDS(111.3 mg/l), PO₄- P (0.285 mg/l), Phosphates (18.9 mg/l), Iron (0.76mg/l), Total Coliform bacteria (646), pH (9.142) and Electrical Conductivity (1778 mho's) are above the permissible limits. Besides, the dissolved oxygen levels were also very low. As per the field observations and laboratory analyses, the dissolved oxygen content in the lake was very low and the temperature was very high. The impending climate change is projected to further increase water temperatures in Chamo lake, stressing the aquatic life including fish.

KEYWORDS Kulfo river, Chamo lake, Water Quality Index, Dissolved Oxygen, Temperature, Dead fishes

An analysis of the economic impact of agricultural runoff and nutrient pollution in the Chesapeake Bay

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The premise of this case study involving water quality in the Chesapeake Bay watershed is to analyze current environmental policy and compare results to determine if current action is the most effective option to manage the externalities created by agricultural runoff and nutrient pollution into the Bay's waters. The current policy, as described in section 3, is that of the Total Maximum Daily Load (TMDL). This limits the nutrient load inputs to create a cap and trade system to manage the marginal external damage attributed to water pollution. However, based on the analysis of the slopes of the Marginal Partial Net Benefit vs. Marginal External Damage graph, it is obvious that the use of a cap and trade system is ineffective. Since the slope of the MED curve is nearly horizontal, a tax policy would be the most effective in managing pollution in the Chesapeake Bay watershed area. Realistically, there is a high likelihood that such a drastic change in policy will take a long period of time to take effect if such a policy is even implemented at all. Many years have gone by since the initial Chesapeake Bay Agreement in 1983. In the time since the first action to combat water pollution and environmental damage in the Bay area, only vague and lofty goals were set for the first 20 years. After that, the current Total Maximum Daily Load policy was passed which is still in effect today. Data evidence shows that the current policy has helped to lessen pollution inputs into the Bay, but our project's analysis has determined that the cap and trade policy in place is by no means the most effective course of action. In contrast, a tax policy would be much more effective in making further progress toward cleaning the Bay. Our group's project contribution shows that current legislative policy in the Chesapeake Bay area is ineffective in adequately controlling pollution and is an impractical method in achieving the goals set forth by states in the region with regard to cleaning the Bay.

KEYWORDS: CHESAPEAKE BAY NUTRIENT POLLUTION TMDL POLICY ECONOMIC ANALYSIS

Assessment of groundwater quality variation in Lodwar during wet and dry periods using Water Quality Index method

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In arid and semi-arid areas groundwater is the major source of drinking water. Lodwar town in Turkana County is no exception depending on groundwater for its water supply through boreholes sunk along the banks of Turkwel River. This study aimed at using water quality index (WQI) to evaluate the groundwater quality during dry and wet periods (February and May, respectively) for public use in Lodwar town. A total of fifteen physico-chemical parameters were selected, namely pH, turbidity, electrical conductivity, total dissolved solids, major anions (Ca, Mg, Na, K, Fe and Mn) and major cations (SO₄, HCO₃, Cl, F and NO₃). The observed values of each parameter were compared against the Kenya Bureau of Standards (KEBS) and World Health Organization (WHO) standards for drinking water to determine the groundwater quality in Lodwar. The concentrations of Ca²⁺, Mg²⁺ and Fe²⁺ anions were observed to increase during the dry period while Na⁺, K⁺, and Mn²⁺ were higher in the wet period. The concentrations of HCO₃, Cl⁻ and NO₃⁻ also increase during the wet period while that of SO₄²⁻ and F⁻ increase during the dry period. The water quality index has revealed that the drinking water quality of groundwater in Lodwar town is highly variable and ranges from very poor to excellent. In particular, Lolupe Hp, Napuu 1 and Bh 2C were observed to have poor water quality in both periods and urgent measures are required to enhance the water quality of these sources.

KEYWORDS:

Assessing drought vulnerability and adaptation in peri-urban agriculture in São Paulo city: a socio-ecological approach

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São Paulo is south-America's largest metropolitan region, and has been experiencing severe water shortages since 2010, raising concerns about the future of water supply. Fresh water reservoirs reached its lowest levels during 2013/2014, due to the lack of rain accompanied by a heat wave, reaching the warmest summer in 55 years in 2015. This events are a relevant example of increased vulnerability to extreme weather events in cities; specific impacts of drought are expected to increase the vulnerability of agricultural systems and reinforce factors affecting them like rising demand for food and the decrease on yields due to the changes on rainfall patterns and extreme temperatures, conflicts over scarce resources (land tenure, water, biofuels, etc.), and chronic poverty. Facing these challenges there is a strong need on finding strategies that enhance the resilience and adaptive capacity of these systems, through and integrative understanding of the climate change dynamics and impacts at the local level. In this sense it is important to note the critical relevance of Urban and Peri-urban Agriculture (UPA) in the city's context, since is one of the major strategies that is being adopted in the tropics to address urban poverty and improve wellbeing of city dwellers. In order to develop functional mitigation and adaptation plans, it is necessary to assess the vulnerability and impacts of drought in UPA systems in the cities, in this sense this research aims to assess the drought vulnerability of UPA agriculture in Sao Paulo city and its potential for adaptation within the context of One Health identifying the impacts of drought on UPA agriculture in São Paulo, city, analyzing the level of vulnerability of UPA in São Paulo, Brazil and identifying the adaptation strategies and technologies available to enhance resilience and reduce vulnerability to drought.

KEYWORDS: Dought, vulnerability, climate change, adaptation, peri-urban agriculture

Water Resources Status in Bihar (India): Current and Future Challenges and Research Direction

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Water being a basic resource plays a vital role in the development of an area whereas the population growth and growth of industries and socio-economic development have influenced the water resource potentialities in the Bihar. Land-use and climatic changes are the other major concerns because of their potential impacts. Bihar state is one of India's most populous and poorest states which primarily dependent on its agricultural output which is highly dependent on rain which it gets from South –West monsoon rains. Mainly rains occur during the months between June to September and about 20 days of incessant rains, 300 to 400% over and above normal trends in second half of July, had been unprecedented. The climate of the state is somewhat extreme in nature and associated uncertainties have serious direct and indirect consequences for agricultural output and food security. Bihar state has got average annual rainfall of about 1326 mm. Total flood prone area of the State is about 68.80 lakh hectares which accounts for 73.06 percent of its total geographical area. The state has irrigation potential of 2.6 million ha (Medium and Major Irrigation Schemes). Water table in the state varies from as low as 5M in the North Eastern region to 20M in the Southern districts. The water quality mapping of the whole state indicates that the drinking water sources in rural areas are not safe in most of the area and the health of the rural population is at risk. The study helps to develop site-specific adaptation, flood plain management, and mitigation options that minimize the negative effects of climate change while maximizing the opportunities..

KEYWORDS: Bihar; Water Resource; Agriculture; Flood Prone; Climate change

Morphological Deformities in Chironomidae (Diptera: Insecta) as indicators of Urban Pollution in River Mezam, North West Region, Cameroon.

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In this study, we examine the combine effect of urban pollution and high metal concentration in sediment on Chironomidae by recording the different mouth parts deformities in this organisms. By calculating the morphological percentage deformity of the organisms, we realized 19 % mentum deformity against 8% mandible deformity. Base on the Organic Pollution Indice (OPI), this urban town present a moderate to highly pollution. Sampling was done in rivers for a period of six months (January 2017– June 2017). Physico-chemically, we noted a relatively higher water temperature, low dissolved oxygen with a moderate organic pollutants concentration. Eight chironomid genera were identified representing 18 species; *Chironomus stigmaterus*, *Chironomus plumosus*, *Chironomus riparus*, *Chironomus staegeris*, *Chironomus crassicaudatus*, *Polypedilum illinoeuse*, *Polypedilum laetum*, *Polypedilum beckae*, *Polypedilum sp.*, *Dicrotendipes neonodestus*, *Micropsectra sp.*, *Radotanypus florens*, *Cantopelopia gesta*, *Brundiniella eumorpha*, *Procladius bellus*, *Tanytus sp.* *Zalutschia sp.* and *Eukiefferiella sp.* were identified amongst which several deformities where noted. The mouth parts deformities in *Chironomus* spp. larvae differed among the different streams; the source, nature and concentration of pollutant in these streams differed as well. For example, the highest incidence of deformities in larval *Chironomus* spp. was observed at Fumuki stream followed by Ayabah stream. None of the deformities was seen in the mufueh stream. *Chironomus* and *Polypedilum* which are generally considered resistant to organic pollution. Consequently, these aquatic communities were ecologically disordered by organic pollution that caused a decreased in the different genus and loss of sensible species and the abundance of tolerant species. We found several significant correlations ($p < 0.05$), but most of them were low. We can only highlight those that were higher ($r > 0.5$). There were significant positive correlations between temperature and a number of chironomus species ($r = 0.270$) and for the taxa we found a significant negative correlation between electrical conductivity, Total Dissolved Solids and *Procladius bellus* ($r = -0.267$), ($r = -0.267$).

KEYWORDS: Chironomid larvae; mouth parts deformities; Mezam River; Bamenda; physicochemical parameters; multivariate analysis.

A landscape level analysis of urbanization, lake level change and water security impacts in Mwanza, Tanzania

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The area around Mwanza Gulf, off of Lake Victoria in northern Tanzania, has experienced rapid and sustained urbanization during the past several decades. Anecdotal evidence from the ground indicates this urban growth on the landscape has significantly changed the nature of the lake, which is supported by a handful of localized ecological studies. Less attention has been given to a landscape-level study of change across the entire gulf. This study explores the nature of change on the landscape and associated impacts, exploring urban growth and lake change since 1984, using remote sensing techniques paired with qualitative interview data. The roughly 2300 square kilometer area of the gulf and its surrounding shores were examined utilizing Landsat imagery from 1984-2017. Change detection analysis, including NDVI and NDBI, was utilized across this landscape, producing both cartographic and statistical outputs of the locations and degree of changes occurring across this region. These outputs are cross-referenced with climatic data to draw final conclusions about the nature of change occurring since 1984, and results highlight the significant and rapid increase in urban cover across the time period and the changes in lake level and lake blooms as a direct result of these modifications. Interviews with local stakeholders reveal the implications of these landscape changes and lake fluctuations on water security of local communities, highlighting a conflict between urban and rural areas on the landscape as the urbanized area has grown.

keywords: Lake Victoria, Mwanza, urbanization, landscape, water security

Groundwater Quality Assessment of Unnao District, Uttar Pradesh, India

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The current study deals with groundwater quality assessment of Unnao district which is located in the alluvial plain of River Ganges. A data set of physiochemical parameters such as pH, Cl⁻, NO₃⁻, F⁻, SO₄²⁻, TH, Ca²⁺, Mg²⁺, TDS, TA and Fe were obtained from 16 ground water samples of the study area and were further employed in computation of Groundwater Quality Index (GWQI). Another parameter, Cr (VI) was also taken in order to examine its suitability for drinking purpose as Unnao district is a hub of numerous industries which increases the possibility of discharging effluents containing Cr (VI). . In the present study, concentration of selected water quality parameters were compared with standard limits prescribed by Bureau of Indian Standards (BIS). The overall study concluded that none of regions in the study area were having water that belongs to the category of Excellent quality while only 25% area belongs to the good water quality domain, 31.25% and 18.75% of the region were in the scale of poor and very poor water quality respectively and 25% of the area were detected where water is highly unsuitable for drinking. Cr (VI) was detected above its limit in 12.5% of the total samples that were taken for analysis. The presence of Cr (VI) in two blocks above the permissible limit viz 0.92 mg L⁻¹ and 0.1 mg L⁻¹. The finding of this study will help the policymakers to decide how the water quality can be improved for human welfare and society, on a regional basis.

KEYWORDS Bureau of Indian Standards, Chromium (VI), Groundwater Quality Index, Physiochemical Parameter, Unnao District.

Valuing Water Resource Users' Associations in the Peri-urban Drylands of Kenya: What is their Role in Water Access and Affordability?

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Water insecurity is a threat to pastoral livelihoods and sustainability. The Water Act of 2002 created the Water Resource Users' Associations (WRUAs) to enhance water resource conservation and enhance water access at the local level. Yet, not much has been documented on the effectiveness of the WRUAs in augmenting water access and affordability for resilient livestock production in the peri-urban drylands of Kenya. This study therefore sought to assess the role of WRUAs in enhancing water access and affordability through capacity building in Kajiado County, Kenya. Kiserian and Oloolua WRUA members were purposively sampled for this survey while non-WRUA members were randomly sampled for comparison. Household interviews were conducted using a semi-structured questionnaire and Focus group discussions and key informant interviews used to validate the data obtained from the household interviews. Chi-square analyses, t-tests and descriptive statistics were used to analyze the data using SPSS version 20. Results showed that access to information on water resource management was significantly associated ($\chi^2=0.56$, $p<0.05$) with membership to the WRUA. Besides, WRUA members accessed 20 litre gallons of water at an average of Kshs. 11.26, a significantly lower ($p<0.05$) cost compared to non-members Kshs. 12.50). Most (79.5%) WRUA members had participated in catchment conservation. Half (50%) of the WRUA members were mainly motivated to join the association because of perceived benefits including improved access to water at lower prices and access to training. The main challenge facing the WRUA was lack of funds (93.2%). This study recommends awareness to increase WRUA membership and allocation of sufficient funding from the government and other related stakeholders to WRUA conservation activities, if catchment conservation for improved water access in the area is to be realized.

keywords: Kajiado, resilience, catchment conservation

Assessing the Performances and Strategies of the Improvement of the Potable Water Distribution Network in a Subsaharan Urban Environment, Kribi-Cameroon, West Africa

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This study aimed at contributing to the improvement of the quality of community water services of the city of Kribi, South Cameroon. More specifically to evaluate the global efficiency (R) and losses in the water distribution network; to determine the causes and consequences associated with the loss of water and to suggest solutions to improve its performance. For this purpose, the methodological approach consisted of direct observations of hydraulic equipments; the assessment of the volumes of water produced and the volumes of water commercialized from 2010 to 2017. Besides, representative water samples collected from high leak stations were analyzed (pH, temperature, turbidity, colour, Cl, Mn and Fe concentration) according to standard procedures. Results of the assessment of the efficiency of water system (R) from 2010 to 2017, showed that the drinking water distribution network of Kribi is qualified "defective", indicated by a low value of R (69.54 <80%). The total losses on the distribution network in the same period were estimated at 618824 cubic meters which represents 30.46 % of the water volume introduced into the distribution network. These significant amount of losses were associated to (i) archaic network equipments constructed during colonial period and causing leaks at the level of the joins, valves; and to (ii) fraud in the subscriber's meters (illegal connections) and breaks of pipes. These financial consequences due to water losses, evaluated from 2010 to 2017 were 214 331 936 FCFA (326 747 Euros). The water quality showed that the temperature (T) ($T = 27.34 \pm 0.12 > 27.0$ °C), turbidity ($2.53 \pm 0.2 > 1$ UTN), Mn (0.07 ± 0.1 mg/l > 0.05), Cl ($0.31 \pm 0.02 > 0.2$ g/l) and Fe (6.82 ± 2.21 mg/l > 0.02) all exceeding WHO norms, except pH ($6.8 \pm 0.10 < 7.0$) and the colour (14.62 ± 1.3 HU) < 15 . Keeping all these constraints in view, it was suggested to rehabilitating pipelines, to strengthening and improving anti-fraud schemes.

KEYWORDS: Urban water supply, losses index, water quality, maintenance of hydraulic infrastructures

Water Security in La Pila, San Luis Potosí, México

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Cities are the dominant form of human habitat, and most of the world's resources are either directly or indirectly consumed in cities (Moore, Kissinger, & Rees, 2013). In this context, water, which is essential for life, is one of the resources under current pressure. "Ensure availability and sustainable management of water and sanitation for all" is one of the Sustainable Development Goals from the United Nations (United Nations, 2015). As water is essential for all life, the importance of providing clean water and sanitation for people outgrows importance. However, building Water Security for cities –considering them as Urban Socio-Ecological Systems (USES)- is not such as an easy task, because of cities' dynamic interactions. Therefore, the following questions raise: How can water security be built? Can we build water security without the help of the community? This paper starts with an introduction about the essentialness of water. After that, the concept of water-security is explained and cities are defined as urban socio-ecological systems with complex dynamics. In order to analyze the current water-security context, we present the four-dimension Water-Security Framework, which assesses availability, access, utility and stability. Then, in order to answer the research question, we use such framework in order to look into the status of the community of 'La Pila', which is located in San Luis Potosi, Mexico. After having an overview of the community's status based on the Water-Security Framework, social participation is analyzed as a strategy that might help to increase Water Security for this Urban Socio-Ecological System. Finally, conclusions and recommendations are drawn from the application of the four-dimension framework and the social participation approach.

keywords: Water Security, Urban-Socio-Ecological Systems, Social Participation

Ensuring Domestic Water Security in Rural India: Role of Technologies and Institutions

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India has made huge strides in improving households' access to drinking water sources and sanitation facilities in rural areas. More than 90% of the rural water supply schemes are based on groundwater. With almost 75% of the country (most of the peninsular India) underlain by hard rock formations having limited storage potential and water yield, large number of groundwater based schemes fail to provide water during summer months resulting in seasonal water scarcity. The paper, through a case study on the rural water supply schemes in one of the states in peninsular India, analyse type of techno-institutional model that may work better in hard rock areas from the source sustainability point of view. For the purpose, a total of twelve schemes were analyzed on their performance. Out of these, seven were individual piped water supply schemes (mainly based on groundwater) and five were regional piped water supply schemes (mainly based on surface water). The analyses indicate that overall physical, financial and economic performance of water supply schemes based on surface reservoirs (both single village and multi-village) is better than that of schemes based on groundwater. Though, the degree of decentralization in scheme management was found to be comparatively better for the groundwater based single village schemes, this has come at the cost of sustainability of water supplies in terms of providing year-round sufficient quantity of water and the cost effectiveness. If source sustainability has to become a priority and the fact that around 2,000 million cubic metres of water remain unutilized in the surface storage systems at the end of the irrigation season every year in the state, the study recommends that the existing strategy has to change from groundwater based individual supply schemes to reservoir based regional supply schemes, unless proper enforcement of groundwater regulation is done.

KEYWORDS Water Scarcity, Techno-Institutional Model, Source Sustainability, Surface Water, Groundwater Regulation

Potable Water Crisis amidst abundant Fresh Water Resources: Interrogating Options for Effective Water Management in Urban and Peri-urban areas in Cameroon

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Although available natural water resources and annual rainfall in Cameroon is unevenly distributed as one moves from South to North, the country is generally well-watered. Existing water resources are estimated at 322 billion m³. This figure amounts to an annual available water volume of 21000m³ per inhabitant, which is three times higher than the 7000 m³ world average. The main wet season lasts about seven months, with the wettest area receiving up to 10000 mm of annual rainfall. Unfortunately, more than 60% of rural and urban dwellers in Cameroon still do not have access to potable water. This paper examines macro water management policy in Cameroon within the context of abundant water resources as it affects access to water. It interrogates opportunities and linkages between state, private, and community water management actors for an effective and increased access to potable water for rural and urban dwellers. The study is framed within the Sustainable Development Goal 6-of ensuring access to water and sanitation for all, and the neoliberal argument for the privatization of public goods/services. It analyzes primary data collected between 2015 and 2017 and official national statistics on water production and consumption in Cameroon. It observes that although availability of fresh water resources is important for poor countries to reduce the proportion of person without access to potable water, good water governance is a key determinant in the provision of water for all. The constant situation of high water pricing, alongside water shortages, rationing, poor national coverage, and threats from climate change on natural water sources calls for effective and responsive water management options. Such option does not only require more investments in the water sector but smart water governance that also integrates an effective public-private-community partnership that can guarantee affordable and efficient water production and distribution in Cameroon.

keywords: water crisis, water governance, privatization , community water management, Cameroon

Some indigenous knowledges and approaches in water resources management in Africa

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According to UNESCO 2016 global Education monitoring ED/GERM/MRT/2016/PI/20 report, indigenous knowledge (IK) is essential for sustainable development. In addition, Sustainable development Goals 1 and 2 enhances the right to IK, while Goal 6 connects the IK to water resource management. Indigenous Knowledge Systems are potential transformative tools if they are effectively integrated in water conservation and management systems not only as a matter of redress but also to enrich the current water management systems (Mahlangu and Garutsa, 2014). In order to effectively contribute to sustainable water management, in particular at community level in rural area, academicians and researchers in water sector, should incorporate existing indigenous ways of water management, and contribute, if needed to, for an improvement. The introduction of new or existing techniques to a community, even adequate, may encounter some barriers for the implementation if a local approach exists already. Indigenous water management, in term of the importance of water within an identified community, water harvesting, water transportation and storage, water treatment etc. are key aspect to be take into account by scientists and practitioners dealing with water resource management in order to achieve water security. Therefore, this presentation aimed to highlighted some indigenous knowledges in water management in the context of climate change in Africa, with a focus on Burkina Faso.

KEYWORDS: Water management, Water harvesting, Indigenous knowledge, Water storage, Africa

Assessing Household Water Insecurity in a Rural setting in Wamba, Samburu County, Kenya: Development of a Household Water Insecurity Scale

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Background: Water security is a global challenge with significant impact on communities in sub-saharan Africa. Pastoralist households in ASAL and semi-ASAL areas of Kenya are especially vulnerable. A measure for household water insecurity is needed to assess this vulnerability and could be used for targeting interventions.

Methods: the objective of the study was to adapt and test a household water insecurity scale. A 26-item scale developed for use in Western Kenya was adapted to a pastoralist setting. The scale items were validated against results from an earlier qualitative study conducted in the same community. The scale was included in a household survey questionnaire with questions related to household demographics, livelihoods and asset ownership, water supply, social capital, household participation in water governance. 2- stage sampling was used to select a study sample. Purposive sampling was used to identify study locations. A representative sample size was calculated from census figures and allocated proportionately to study locations. Household selection was based on random walk methods and interviews were conducted with household heads or their spouses. Data was collected from 331 households and entered into STATA for analysis. Cronbach's alpha was used to test for item-test correlation, average inter-item covariance and scale reliability coefficient. A scale was generated as a new variable to provide a score for each individual observation.

Results: item test correlations varied between 0.18 and 0.71, an average interitem covariance of 0.21 was obtained and a scale reliability coefficient of 0.89. Individual scores on the scale ranged between 1.31 and 3.73.

Conclusions: the resultant scale is a valid and reliable measure of household water insecurity in the study setting and will be used to test a range of hypotheses relating to how various independent variables (including gender, social capital and water governance, water quality) relate to household water insecurity.

Exploring the challenges, opportunities and approaches for private sector engagement to address water security in cities of Nepal

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There is increasingly recognized role of private sector in fulfilling the sustainable development goals. Micro, small and medium private and social enterprises are emerging in the water, sanitation and hygiene sector. Private sector interventions can be one of the ways which can tackle with emerging water related problems. However, there remains a challenge on finding out the appropriate ways in which private sector will be interested to get engaged, invest, contribute or make business out of water challenges. This paper highlights about the challenges of private sectors to get engaged on water security. The paper also synthesizes the experiences of the action research on two rapidly urbanizing cities of Nepal on how the private sector can be engaged to address water and sanitation related issues. The research found out that due to lack of municipal water supplies the private sector is dependent on other alternatives. There is lack of awareness about the appropriate technologies, fear of financial burden, lack of conducive policies, financial services and lack of knowledge on water management. Larger water users—specifically the private sectors can adopt efficient technologies, rain and gray water harvesting to minimize the risk for business viability, maintain competitiveness and have comparative advantage. The policy intervention and financial access are two ways through which the private sector can be attracted for new business ideas and motivated to adopt water efficient tools and technologies. In Dharan city, the mandatory policy to construct recharge pits in new houses by local government which has started boosting up the small scale construction enterprise. In Dhulikhel city, the mechanism of the soft water loan has been recognized to be allocated as a “revolving fund” that can be used for the low interest loan to the private sector to enhanced of resilient and equitable water management systems.

KEYWORDS: Private sector, sustainable development, urban, water and sanitation

Smart Management of Urban Water Systems under Changing Climate

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Water resources, which are unevenly distributed across the Earth's surface, are under pressure due to climate change and growing demand. Herewith, sustainable management of water resources has become even more important. Urban water systems play an important role in sustainable management of water resources and sustainable development, in which the fundamental needs of communities such as access to safe water are met. Ensuring the resilience of urban water supplies and optimizing urban water demand have become more crucial due to increasing impacts of climate change. In addition to the management of water quantity, supplying water to the consumers in adequate quality is also one of the main responsibilities of water authorities. Recently, there is a growing demand for smart and sustainable ways to manage resources. Information and communication technologies (ICTs) have an integral part in everyday life of many people. Therefore, implementation and integration of ICTs, which can be helpful for improving water sustainability and enhancing resilience of urban water systems, have attracted an attention. Smart water management utilizes ICT for system monitoring data and to achieve greater efficiency in allocation of resources. Smart water management aims to overcome challenges in water sector and promotes sustainable management of water resources by integration of ICT tools. This study aims to provide brief information on smart and sustainable management of urban water systems. Furthermore, case studies for smart management of urban water systems are going to be presented and discussed in detail.

keywords: Climate change, smart water, sustainable water management, urban water systems.

Sustainable Technologies And Strategies For Integrated Freshwater Resource Management: Understand The Dynamic Interactions Across The Water-Energy-Food Nexus

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Freshwater is one of the important natural resources where agricultural sector is consuming large amount of surface water along with energy. When water demand becomes more crucial, agricultural irrigation consume more energy for the production food. Moreover, freshwater and its management play key role in the dynamic interactions and functions across the water-energy-food nexus that affect on climate change, human health, socio-economic conditions, etc. Sustainable development and environmental conservation would be achieved only through dynamic understanding of nexus of water with other domains. The present study reveals the dynamic interactions across the water-energy-food by considering the important sustainable strategies for integrated freshwater resource management at agricultural and catchment area of Cauvery river basin, Karnataka, India. Optimal freshwater usage and pollution remediation in real-time irrigation management using sustainable technologies integrated water-energy-food nexus modeling approaches and strategies were demonstrated. Important factors, which affect on crop yields, were laid for development of integrated water-energy-food nexus models using real-time data and practices in the study area. The results clearly show that utilization of freshwater and associated energy for irrigation can play important role on the production of crop yield and quality. It also show that over consumption of water including associated factors such as soil conditions, crop type, fresh water source, etc., significantly affect on the food production rate and water quality. The water-energy-food nexus shows that efficient investments and investigations on technology based integrated water resource management at agricultural sectors are essentially required to reduce the water pollution and energy consumption which apparently affect on food production.

KEYWORDS Freshwater; Agricultural sector; Water-energy-food nexus; Cauvery river; Crop patterns; Sustainable development; Integrated Freshwater Resource Management

Sustainability Assessment of two selected Hydropower generating system in Nigeria

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Hydropower is the most commonly used and largest renewable energy source for electricity generation today and depends on river flows. Hydroelectricity has several advantages over most other sources of electrical power, including a high level of reliability, proven technology, high efficiency, very low operating and maintenance costs, flexibility and large storage capacity. The Nigerian hydropower generation system comprises of large and small hydropower plants and the large hydropower plants currently accounts for 33% of total installed commercial power capacity in Nigeria. Also there are about 278 unexploited sites locations of small hydropower plant (< 10MW) with a potential of 734.3 MW and eight (8) small hydropower plants with aggregate capacity of 37MW which has been installed in the country by both government and private companies. This study utilizes the hydropower sustainability assessment protocol to review the operations of two of the major hydropower plants in the country – Kainji and Jebba power plants which has been in operation for over 30years from an environmental, social and technical perspective. The study examines the broad areas of hydrological resources, downstream flow regime, reservoir management; project affected communities as well as environmental and social issues management. The hydropower sustainability assessment protocol is a tool that promotes and guides more sustainable hydropower projects and offers criteria to assess the performance of hydropower projects across 20 sustainability issues. The protocol provides a common language for evaluate sustainability issues and makes it easy to see how existing facilities are performing and how well new projects are being developed. Preliminary study results show that the two major hydropower plants are in need of major infrastructural and operational rehabilitation, and has affected the communities around there areas of operations both positively and negatively. Climate change has also affected the hydrological resources of the dam reservoirs and their operational outputs.

KEYWORDS: Sustainability Assessment, Hydropower, Nigeria

Assessment of Agricultural Solid Waste Management and Potential of Compost Production and Use in Agriculture: The Case of Wadi al-Far'a Watershed in the West Bank-Palestine.

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Agricultural activities can generate considerable amount of organic waste that represents an environmental problem if not managed properly. In Palestine, two problems are associated with agricultural solid waste (ASW) management: 1) disposal of the waste in open dumps where decomposed waste biomass emits methane and leachate, and 2) burning the waste, which produces acidifying and greenhouse gases. Composting is considered one of the most proper and efficient way for organic waste treatment and emission reduction. Besides alleviating environmental degradation and climate change, composting provides organic soil fertilizer (compost) that can be used, instead of chemical fertilizers, to improve soil fertility and water storage capacity. Despite its promise, composting has not been implemented in Palestine at a national scale. Besides political, institutional, and financial constraints, farmers' unwillingness to produce compost from their agricultural waste hinders success of Palestinian composting projects. The aim of this study is to assess the current ASW management practices and the potential of compost production and use in Palestine. This potential is assessed through i) examining farmers' perceived economic, agricultural, health, environmental, and institutional barriers of compost production and use, and ii) assessing suitability of the characteristics of the raw organic waste for compost production. The case of Wadi al-Far'a watershed, as a significant agricultural area in Palestine, is selected for investigation. The data is collected in 2017 through 409 semi-structured interviews with farmers in the watershed, and analyzed using statistical and econometric methods. Findings reveal high acceptance level among farmers for compost production and use in agriculture. Farmers' perceived economic benefits from compost production, land ownership, and use of pesticides are proved significant in shaping their acceptance. Methods of waste disposal and reuse, such as burning plant waste and using untreated animal manure as a soil fertilizer, are also proved significant. Unexpectedly, socio-economic and demographic variables are found insignificant.

Keywords: Compost, agricultural waste, organic waste, perceptions, Palestine

Transboundary management of day-to-day variations in discharge and water levels in the Blue Nile Basin: a water-energy nexus perspective

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Day-to-day variations in river discharge and water levels are quintessential components that influence the livelihoods of the populations that reside along river banks. Though the construction of mega dams on rivers creates a variety of benefits, they alter the natural day-to-day variation patterns of river discharge and water levels based on the dam function/s, the hydrological condition, and/or the water volume available in the reservoir. The construction of Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile River in Ethiopia triggered several studies and debates on its possible impacts on the downstream countries. This study sets out to demonstrate the long-term implications of the GERD for the day-to-day change in the Blue Nile discharge and water levels. To this end, a daily 30-year hydro-policy model is developed using RiverWare, a river and reservoir simulation tool, to include major water fluxes, storage dams, significant water users, and stage and discharge river gages. The implications of the GERD for discharge and water levels are analysed at two locations in two cooperation scenarios: unilateral action in which the GERD is operated to maximize energy generation; collaboration in which a higher priority is given to keeping the absolute day-to-day change in the dam outflow below 100 MCM/day whenever possible. The results show a decrease in the annual energy generation from the GERD when shifting from unilateral action to collaboration. However, the extreme day-to-day variations in river discharge and water levels decrease with raising the cooperation level. Moreover, a decrease is noted in the probability of exceedance of the number of events with an absolute day-to-day change in river discharge of above 100 MCM/day. The present analysis is imperative to improve transboundary management of floods in the context of dam operation in the quest for maximizing the benefits from water and energy resources.

KEYWORDS: Day-to-day variation; hydropower; RiverWare; HEC-HMS; cooperation levels

Aquatic agriculture for lakes in Africa: A proposal

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Concerned with growing water limitations to agriculture, we and others in the world have advanced clean and eco-friendly aquatic primary-food production techniques for the sea and lakes. While several of these techniques need applied research to be fully implementable, some very valuable ones for lakes are already past proof of concept and can be implemented after local adaptation. Using land crops (like bean, maize, tomato, rice) and aquatic plants, these floating production options may prove to be an essential adaptation to growing resource scarcity and climate change. Considering Sub-Saharan Africa's vast and many lakes (to which area of dams and floodplains can be added), we propose here a course of action based on these techniques to begin establishing a floating aquatic agriculture that can be high-yielding and basically does not spend water from the lakes because crop evapotranspiration is equivalent to the water that anyway evaporates from the surface. In this manner, and applicable to both small-scale low-cost production by fishers and their families, as well as large-scale operations, to use just a fraction of the lakes' surface represents increasing many times what several countries currently have in irrigated area, making available extensive areas that provide massive amounts of water at a much lower cost than developing irrigation infrastructure, in case water for irrigation were available. If only 5% or ca. 15,000 km² of the lakes' surface area were to be cultivated in this manner, 1.5 million hectares of farming area fully provided with water at the crop level will be added to these countries' food production capacity. This represents an addition of 20 x 10¹² L of new- and controlled-water use per year. Besides describing techniques being proposed, the efforts needed to begin such endeavor and achieve priority goals are presented as the basis for discussion on this proposal.

KEYWORDS: Climate change, food security, plant aquaculture, water

Drought Impacts in a Changing Climate in North Africa: The Case of Tunisia

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The North Africa (NA) region seems to be one of the most vulnerable regions in the world regarding its water resources.

In Tunisia, agriculture is the largest water user accounting for 83 percent of annual consumption, with an irrigable area of nearly 400 000 hectares. Agriculture employs 20 percent of the workforce. Rainfall is characterised by its scarcity and spatial and temporal variability. Temperatures are high and this leads to high evaporation from water resources and Farmlands. The effects of climate change could significantly increase the relevance of water development policies, given that economic growth of the majority of Maghreb countries is closely related to water resources and contributes strongly to the socio-economic balance and gross domestic product. Over the last decades, Tunisia have tried to overcome water stress and scarcity by improving water policy and strategy, infrastructure development, economy of water use, wastewater, and desalinization, among others. However, the great challenge for Tunisia and within the Maghreb region in general is mainstreaming climate change issues into development planning in the contextual framework of the water–energy–food security nexus, whose components are strongly interdependent. The present study assesses the occurrence and impacts of drought, the current policies underlying drought management as well as the mitigation measures and responses adopted in the NA region, with a focus on the Agriculture Sector. The objective is shedding light on drought effects, sensitizing policy-makers for the much needed paradigm shift to pro-active drought management planning and providing guidance for the development of such policies.

KEYWORDS: Water scarcity, Climate change, Sustainable Agriculture

Water sustainability indicators in the Water-Energy-Food nexus: A case study in coastal zone

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Extremely exceeding concentrations of seawater-related pollutants have been found in groundwater periodic monitoring samples in the west coast of Taiwan. This study sought to establish a set of water sustainability indicators in the water-energy-food interconnection under the influences of complexity activities along coastline. This study was conducted in Changhua coast, in which have been impacted by natural condition associated with human activities. After considering the availability of data, these indicators were set up, and covered the relationships in water-energy-food nexus as well as relevant fields affecting to their water sustainability. Subsequently, these indicators were categorized according to DPSIR (Driving forces – Pressures – State – Impacts – Responses) framework. Among relationships between the indicators as defined interactions of the framework, the authors were of opinion to select scores larger than 4, which were evaluated by experienced experts. Consequently, the study established a set of 25 indicators of water sustainability allocated to D, P, S, I and R factors. While “land-use extension” was the indicator of D factor impacting all of the four indicators in P factor, “agricultural production” and “water consumption” were indicators most impacted by D factors. “Groundwater reserves” in S was highly affected by “water supply”, “agricultural production”, and “water consumption” of P. In turn “groundwater reserves” have an influence on “water poverty index”, “agricultural output value”, and “replenishment” of I. “Water poverty index” should be considered in the response of “reforestation”, “water use efficiency”, and “environmental education”. All of the six indicators of R had high impact on “environmental awareness” of D or, in the opposite way, the higher “environmental awareness”, the higher effective of these responses. In summary, the indicators of water sustainability were established according to the water-energy-food nexus associated with relevant sectors that would be a significant strategy to manage water resources, especially in coastal comprehensive system.

KEYWORDS: WATER SUSTAINABILITY INDICATORS, WATER-ENERGY-FOOD NEXUS, DPSIR FRAMEWORK, SCORING MODEL, LAND-USE EXTENSION, AGRICULTURAL PRODUCTION, WATER CONSUMPTION, ENVIRONMENTAL AWARENESS.

Gynandropsis gynandra as a drought resistance, nutrient dense crop in Sub-Saharan Africa

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Gynandropsis gynandra a C4 plant that combines efficient water utilization with high photosynthetic capacity at high temperatures making it tolerant to both high and low temperature. We examined the variation in morphological traits and levels of different vitamins in 34 accessions in east-south Africa. The vitamins levels in the leaves varied significantly across accessions. The detected carotenoids in the leaves included lutein, violaxanthin, β -carotene and α -carotene. Chlorophylls a and b which provided a reliable measure of the "greenness" of the leaves. The main carotenoids accumulated in the leaves included lutein (up to 33.9 $\mu\text{g/g}$ fr. wt.), β -carotene (up to 20.9 $\mu\text{g/g}$ fr. wt.), α -carotene (up to 4.6 $\mu\text{g/g}$ fr. wt.) and violaxanthin (up to 0.9 $\mu\text{g/g}$ fr. wt.). The main tocopherols detected were γ -tocopherol (up to 10.6 $\mu\text{g/g}$ fr. wt.) and α -tocopherol (up to 0.1 $\mu\text{g/g}$ fr. wt.). Significantly positive correlations were observed between levels of carotenoids and chlorophylls and plant height, leaflet length, petiole length, filament length, gynophore length, pod length and 1000 seeds weight, suggesting that taller and bigger accessions with dark green leaves are likely to have higher carotenoids content. Therefore, East-southern African accessions were characterized by tall plants with high carotenoids and chlorophylls content.

KEYWORDS: CAROTENOIDS, TOCOPHEROL, ACCESSIONS

Irrigation water use charge to reduce climate change impact on water resources

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Water and food security are the key challenges under climate change as both are highly vulnerable to continuously changing climatic patterns. Studies have predicted that the average global temperature may increase by 1.5 – 6.0 °C and there would be substantial reduction in fresh water resources and agricultural yield by the end of the 21st century. In Africa (Sub-Saharan Africa) by 2050 the rainfall could drop by 10%, which would reduce drainage by 17%. This paper presents irrigation water use charges to ensure water and food security under climate change and recommend formation of effective adaptation and mitigation policies and strategies to minimizing the impact of climate change on water resources and irrigation. The study area is Awash River basin. Awash River Basin is one of the most utilized river basins in Ethiopia. It serves as a source of drinking water, hydropower, industrial consumption, irrigation and disposal of waste water. A major user and consumer of the surface water in the Basin is irrigated agriculture through numerous private and government irrigation farms and small holders. The irrigation in the Basin is characterized in general by low level technology and water management, low irrigation efficiency and low land and water productivity levels. As a possible solution to the problem mentioned above, Awash Basin Authority has rolled out a study to set an appropriate charge for irrigation water abstraction in the Awash Basin considering the different irrigation schemes with different technologies, farm types and socio-economic conditions. Ideally, water charges should send economic signals about the value and increasing scarcity of water for agriculture, provide revenue for water-related infrastructure and provide incentives to use water more efficiently. However, the success of charging relies on the proper setting of water charges, on the metering of water use and on the collection of user charges.

KEYWORDS Climate change; Water security; Food security; Adaptation & mitigation techniques

Understanding Climate Change Induced Vulnerability to Food Insecurity: Applying the Livelihood Vulnerability Index in Pastoral Area of Afar Region, Ethiopia

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This paper develops and tests the application of a Livelihood Vulnerability Index (LVI) to assess climate change-induced vulnerability to food insecurity for pastoral and agro-pastoral communities in Ethiopia. The index is applied in a comparative study of the two pastoral communities of Afar region, a region that is expected to bear some of the most severe impacts of climate change. The climate change-induced vulnerability to food insecurity was assessed as the function of exposure, sensitivity, and adaptive capacity based on pragmatic livelihoods approach. The sensitivity assessment was based on food, health, water and pasture. Exposure was expressed by the livelihood exposure index and supported by temperature and precipitation changes, while the adaptive capacity includes socio-demographic characteristics, livelihood strategies, institutions and social networks. About 33 socio-economic and environmental indicators have been identified to point out the three components of vulnerability: considering food insecurity impacts of climate change. The overall LVI-IPCC scores indicate that settled agro-pastoralists in Chifra district were more vulnerable than mobile pure pastoralists of Ewa district (0.118 versus 0.005, respectively). The highest levels of vulnerability among agro-pastoralists of Chifra district were documented in relation to increasing exposure to climate induced food security shocks (0.720), water/pasture access (0.628) and limited livelihood option (0.629). Therefore, food security and climate change adaptation programs should consider the unique vulnerability context of pastoral livelihoods and efforts should focus on improving access to water and pasture as well as supporting viable livelihood diversification to reduce the risk of increasing exposure to climate-induced food security shocks.

KEYWORDS: livelihood vulnerability; food security; climate change; exposure; sensitivity; and adaptive capacity.

Water security insights associated to food security: A case study of the Iranian virtual water trade of agricultural crops 2004-2014

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Getting more arid, Iran is confronting severe water scarcity. However, the food security policies contradict the adaptation requirements in terms of sustainability. Although virtual water trade can improve the national water balance, economic benefits usually dominate trading policies. Calculating virtual water for 19 selected crops, this paper aims to evaluate Iranian virtual water trading in the period of 2004-2014 in terms of both the volume and the economic values. The results show that, except in 2010, Iran was mainly a virtual water importer. Analyses indicated that the economic value of traded virtual water per unit had an ascending trend during the period. However, in the second half of the period, the value of imported virtual water per unit exceeded that of exported, comparing with the first half. It means that the net value of virtual water got more expensive in the recent years. More than 58'000 MCM blue water would be required annually to produce the agricultural products at the same level of year 2014. Maximizing the imported virtual water and economic benefits, while minimizing the water needed to produce the commodities domestically, we found that, among the selected crops, it would be optimal to import all products except saffron and forage corn, which are of high values corresponding to their virtual water. To fulfill the agricultural self-sufficiency targets in the sixth national development plan for the period of 2017 to 2021, the required yearly blue water will increase to more than 79'000 MCM, which is controversial due to climate change effects in Iran. As a conclusion, supposing to acknowledge water resources sustainability criteria, Iran will not be able to produce all the essential crops domestically to meet the self-sufficiency targets. Moreover, in terms of economic efficiency, the paper suggests that the priority be to import all essential agricultural products.

KEYWORDS:

Mitigating Climate Change Impact for Sustainable Agriculture in Southwestern Nigeria Using Crop Models

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Global food security is hindered by uncertainties of climate change and population increase which affects water availability. Solution to these uncertainties require robust and dynamic multidisciplinary approach. The potential consequences caused by climate change and population growth on crop production can be assessed and managed using crop models, which combines biophysical or empirical models in estimating yield variations due to changes in crop water requirement and application rate, with evapotranspiration as the determining factor. The study was carried out in Ibadan, southwestern Nigeria in West Africa. The objective of this study was to determine the impact of climate change on crop production considering evapotranspiration and crop water use in achieving water and food security over a 10-year period, and to test the reliability of selected crop model in achieving cost effective water management technique and optimum yield. Meteorological characteristics of the study area were determined using an automatic weather station, soil and crop growth parameters were obtained using standard procedures. FAO approved simulation model (CROPWAT) was used in simulating the effect of these uncertainties on crop yield for proper decision making and profitability which is key in achieving food security. The simulated results of crop growth coefficient ranges from 0.44-0.92, actual crop water use had mean values ranging from 1.53-2.68mm/day, and irrigation requirement had a range of 6.5-26.8mm/week to achieve water use efficiency with yield increasing from 4.23t/ha to 5.07t/ha. The results obtained from CROPWAT model were like field values showing high level of accuracy and reliability.

KEYWORDS disaster, cyclone preparedness, early warning, evacuation response

Water Accounting as an Efficient Tool for Sustainable Water Governance (Case study: Urmia Lake Basin)

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The challenge of sustainable water management in semi-arid countries like Iran for sustainable food production and water security is magnified by the country's geography, hydrology, climate and trans-boundary issues. A tenfold increase in population coupled with extensive industrial growth and economic development have placed a continuous and growing demand on Iran's limited water resources. Urmia Lake Basin located in northwestern Iran as a hot spot has encountered dramatic condition due to climatic fluctuations accentuated by periodic drought, sectorial pressures from urban development, heavy industries and agriculture. Water governance is considered as an efficient way for integrated water resources management for sustainability purposes and services. The current cumulative deficit in renewable water resources of the Basin, has also led to the qualitative deterioration of potable aquifer water resources and salt water intrusion to the neighboring agricultural lands. Therefore, water use efficiency and economics of water resources allocated for each activity becomes more and more important to maintain the sustainable water and food security in the region. The current research has aimed to consider water accounting as an effective and practical tool to develop sustainable land management systems considering the importance of maintaining water security in food production and farming end products of the region. The finding revealed the degree of pressure caused by each activity on water resources of the basin which should be reduced by different ways such as pricing and decision making tools. By considering the share of each product in the value chains of different agricultural and industrial activities in the region, we proposed some alternative solution and possible ways not only to reduce the losses of agricultural products but also to provide major opportunities in terms of land and water sustainable management for additional value creation by increasing water use efficiency.

KEYWORDS: Water accounting, integrated water resources management, Urmia Lake Basin, Adaptive management

In Situ Rainwater Harvesting and Conservation Technologies Increase Soil Water, Sweet Potato (*Ipomoea batatas*) Growth and Yields on Upland Gravelly Soils in Sierra Leone

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Field experiments were conducted to determine the effectiveness of six rainwater harvesting and conservation technologies (RWHCT) to increase soil water, sweet potato growth and yield on upland gravelly soils in Sierra Leone during five continuous cropping seasons (2014 second to 2016 second cropping seasons). The RWHCTs were designed using a factorial combination of two levels of mulch (mulch and no mulch) and three levels of ridge types (arch ridge, tied ridge and open ridge). Data were collected on total soil water, vine length, aboveground biomass, root weight per plant and root yield. Averaged across the five cropping seasons, the total water stored in the soil profile was significantly increased ($P < 0.0001$) by the RWHCTs with mulch (43.2-64.7%) and without mulch (11.8-16.2%) when compared to the control (open ridge without mulch). In comparison to the control, the arch ridge with mulch (AR+M) had the highest significant increase ($P < 0.0001$) in vine length (68.1%), aboveground biomass (214.2%) and root weight per plant (464.5%), whilst the tied ridge with mulch (TR+M) had the highest significant increase ($P < 0.0001$) in root yield (182.8%). In the fifth cropping season, the root yield produced by the TR+M and the AR+M was 59.0% and 11.5% higher than the best root yield of the control in the first season. The mulched tied and arch ridge technologies show high promise as adaptable farming systems for vine production and root yield on upland gravelly soils as Sierra Leone's rainfall pattern increasingly becomes erratic. Further research is required to determine the efficiency of these technologies.

KEYWORDS: RAINWATER HARVESTING AND CONSERVATION, SOIL WATER CONTENT, SWEET POTATO GROWTH AND YIELD, GRAVELLY SOILS

Sustainable Adaptation Practices in Ensuring Food Security in highly water stressed Southern Coast of Bangladesh

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The aim of this study is to illustrate sustainable adaptation practices that have been adopted by the farmers to address the food security in highly water stressed south coast of Bangladesh. A field visit, questionnaire survey, a FGD (focused group discussion) and a PRA (participatory rural appraisal) were conducted in Mongla, Bagerhat to examine the gravity of prevailing food insecurity and also to understand their survival as well as coping measures against the salinity and fresh water scarcity. It was found that around 95% of the south coast people have been combating against fresh water scarcity due to salinity and extreme climate. Saline water intrusion in fresh agricultural land made the crisis more acute by decreasing soil fertility. Local farmers are motivated and adapted enough in practicing cultivation of drought, flood tolerant and short lived cash crops and vegetable and like rice, wheat, maize, lentil, sesame eggplant, tomato, potato, cucumber and bean. Such species of crops certainly play key role in helping farmers not only to adapt their farming practices against the adverse climatic conditions but also to ensure food security. Farmers' adaptation measures demonstrate effective in achieving food security in the face of climate induced water stressed and saline prone coastal regions. Farmers are practicing zero or minimum tillage farming option to cultivate potato and groundnut with water hyacinth and straw mulch. Floating bed vegetable cultivation is very common in water logged areas. Year-round homestead vegetable cultivation, relay cropping of sprouted seeds of aman rice in jute fields are very common practice in coastal community. Vertical agriculture, Pond-water harvesting for irrigation to cultivate Rabi vegetables, fish-duck-rice cultivation in the same crop land are also practiced here. Reshaping the food access and consumption patterns to ensure basic nutritional needs are thereby met to foster sustainable food safety.

KEYWORDS: Coastal community, water scarcity, salinity, food security, sustainable adaptation practices

Edible insects as a chance to achieve better Nutrition Security in Sub-sahran Africa

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Edible insects are gaining attention as an alternative food source to fish and livestock with respect to protein and some micronutrients, as they need fewer natural resources, therefore showing high potential in helping to alleviate nutrition insecurities caused by water scarcity and climate change. Therefore edible insects commonly consumed in Kenya and Uganda, two countries showing a high risk to suffer from Climate Change induced nutrition insecurity, were collected. Samples included long horned grasshoppers (*R. differens*), crickets (*Gryllus bimaculatus*) and several kinds of caterpillars (*Imbrasia zambesina*, *Cirina forda*). If available, samples were collected fresh and processed e.g. boiled or fried. As the micronutrient content of edible insects is far less studied than their protein content, samples were analyzed for selected (pro)vitamins (riboflavin, carotenoids) and dietary minerals (e.g. iron and zinc). To ensure consumer safety, levels of heavy metals were also analyzed.

All samples showed high contents of riboflavin (1.18-3.11 mg/100 g dried sample material). Grasshoppers analyzed with their wings on, contained remarkably higher amounts of lutein, zeaxanthin and beta-cryptoxanthin, compared to their plucked counterparts. Beta-carotene was contained within all samples, ranging from 1.82 mg/100 g sample material to 49.70 mg/100 g dried sample material contained in crickets. All analyzed samples contained substantial amounts of iron (33.05-1078.57 mg/kg dried sample material) and zinc (49.91-131.88 mg/kg dried sample material), but also calcium (223.30-1458.99 mg/kg dried sample material). While all samples showed negligible levels of cadmium and mercury some had elevated levels of lead (0.10-3.15 mg/kg dried sample material).

Therefore insects, consumed in Kenya and Uganda show great potential for delivering high levels of micronutrients in particular those which are related to hidden hunger.

KEYWORDS Insects, sustainable food sources, micronutrients, nutrition security

Aquacrop model assessment in simulating bitter-gourd (*Momordica charantia* L.) water use efficiency in semi arid region

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The Dong Nai river basin is one of the most important watersheds in the south of Vietnam, with a plentiful water resource and a diversified ecosystem of the Asian tropical rainforest zone. Recently, this river basin has been affected by global climate changes. This has affected water utilities and has determined different terms of daily living activities and livelihood in the area. The study aimed to evaluate and analyze observed hydro-meteorological data (i.e. precipitation, evapotranspiration, temperature, sunshine hours) in order to create appropriate Budyko Curves of the influences of climate change on mean annual runoff in the Dong Nai river catchment. Moreover, this paper presents estimations of percentage changes in mean annual runoff in the future, based on the current national climate change scenarios, and the developed Budyko curves. As a result, the annual quantity of the Dong Nai river basin streamflow is considerably increased in the scenarios developed. It is significant to develop illustrative ecological models for the catchment area. However, a disadvantage of integrated water resource management arises if there is no effective water governance at all, such as water shortages in dry seasons and downstream flooding in rainy times.

KEYWORDS climate change, river basin runoff, Budyko curves

Artisanal small-scale mining and the threat to the environment, water quality and ecosystems, health and food security: the case of Burundi

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Artisanal Small-scale mining in Burundi affect the environment, water quality and therefore human life and ecosystems. Moreover, the chemical processing of gold ore using mercury and cyanide, which is slowly taking place in artisanal mining in Burundi, enhance this threat.

The purpose of this topic is to show the extent of the threat posed by this type of uncontrolled exploitation to the quality of the environment in general, but particularly to the quality of water and ecosystems. In fact, the rudimentary mining techniques, the lack of know-how and the lack of rigorous management of the law's requirements in the mining sector cause permanent risks to the environment and reduce the chances of food security.

In conclusion, solutions are proposed in the sense of practicing environmentally friendly operations and sustainable management of ore deposits.

KEYWORDS: ARTISANAL SMALL-SCALE MINING, ENVIRONMENT, WATER QUALITY, ECOSYSTEMS, FOOD SECURITY, MERCURY, CYANIDE, TURBIDITY, DEFORESTATION.

Constraints Of Stormwater Sanitation Of Cities Of Burkina Faso: Case Of The Commune Of Ouagadougou

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The Ouagadougou Commune, like the other cities of Burkina Faso, is confronted with the problem of sanitation globally and with stormwater sanitation in a specific way. The subsector suffers from a lack of planning tools such as the master plan for stormwater drainage dating back to 2000, and at the same time proposes design parameters that are not consistent with the urbanization of the city but also the phenomenon of climate change. In order to remain realistic, the designers resort to an approximation by referring to the existing master plan being updated. Therefore, some parameters determination for flood appraisal remains a challenge in urban hydrology. Indeed, with the effects of climate change, the components of the water cycle such as rainfall, evapotranspiration and discharge at the outlet are subject to large variations depending on the period of return.

According to the Ouagadougou stormwater drainage plan processed in 2000, the average runoff coefficient for the study area was 0,6. However, a preliminary design studies carried out in 2009 with a return period of 5 years made it possible to construct canals that have experienced flooding at least three times during the last five years due to the section of the canals which is found under dimensioned. An analysis of the situation reveals a variation in the coefficient of runoff in Manning Strickler's formula which should avoid a recurring flood of 0.75. Also, the rainfall used nowadays is found as a rainfall with an annual return period instead of five-year.

So, it should be noticed that these variations imply significant financial implications for investment in the construction of the infrastructures. In view of the above, it is important to reconsider the formulas used for flood flows estimating in urban planning. The review of required parameters should seriously take into account climate change.

KEYWORDS: Stormwater, Sanitation, Runoff coefficient, Climate change

Assessment of Low-Cost Lab-Base Leachate Treatment Plant and Effluent Toxicity Testing

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Municipal and industrial solid waste management is a major problem in Africa and Nigeria in particular. Wastes are daily deposited in dumpsites without prior sorting leading to the formation of leachates that contaminates surface and ground water. This study was aimed at testing the efficacy of a locally made leachate treatment plant and assessing the toxicity of the treated leachate. Fifty litres, each of raw leachate from seven dumpsites in Oyo, Ogun and Lagos States were collected. Physical and chemical parameters and heavy metals of both raw and treated leachates were analyzed using standard procedures. The toxicity effects of treated leachate were carried out using sub-adult *Clarias gariepinus*. After 96 hours of exposure, the blood and tissues (gills, kidneys and livers) of fish samples were analyzed. The average percentage removal for heavy metals ranged from 63.9 to 83.2 %. The toxicity assessment showed that leachate contained some macro-nutrient that that contributed to increase in blood parameters measured. The treated leachate resulted in physiological changes like whitish skin, irregular and erratic swimming pattern and aberration of secondary lamellae and death in fish samples. It can be concluded that the treatment process needs further optimization for better performance and deployment at dumpsites for leachate treatment.

KEYWORDS: Leachate, Heavy Metals, Lab base treatment, Toxicity, *Clarias gariepinus*

Caffeine and Ciprofloxacin Adsorption from water onto natural zeolite: isothermal, kinetics and thermodynamic studies

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In this study, a natural zeolite (clinoptilolite) was used for adsorption of ciprofloxacin (CIP) and caffeine (CAF) from aqueous media using batch equilibration method under different environmental conditions of contact time, pH, initial concentration, temperature and adsorbent dosage. The adsorption rate was best described by the pseudo second-order model well and intra-particle diffusion was not the sole operative rate-controlling step. The equilibrium data were modeled using three linear forms of Langmuir equation and Freundlich model and was best fitted by the type-1 Langmuir equation. The thermodynamic parameters indicated the adsorption process is exothermic, spontaneous and physical in nature. The adsorption mechanism of CIP is strongly controlled by electrostatic interactions while CAF adsorption is weakly affected by changes in pH. The findings demonstrate that natural zeolite present excellent low-cost adsorbent for removal of pharmaceuticals from water..

KEYWORDS: CAFFEINE, CIPROFLOXACIN, ADSORPTION, NATURAL ZEOLITE

Impact of stabilized leachate residues from the controlled landfill of Mohammedia city on the "Oued Nifika" river and on the soil

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The evaluation of pollution generated by residues of the controlled landfill of Mohammedia city at the level of the river "Oued Nifika", nearby soil and puddles of leachate from their percolation in the soil, show that the river and the surrounding sheet are still threatened by non-biodegradable inorganic pollution despite the closure of this landfill more than six years ago. These leachate puddles have very high electrical conductivities ranging from 42 to 46 mS / cm and that obtained at the river is about 2.2 mS / cm. These high values are due to the presence of high concentrations of mineral salts, K⁺, Na⁺, Mg²⁺, Ca²⁺ responsible for salinity and hardness, and various metals with varied forms. The concentrations of these salts in the stabilized leachate, as well as the metals As, Cd, Cr, Cu, Ni, Pb, Zn, Cr, Mn and Ni are higher than those of the river water. Total nitrogen concentrations are very high in the river water samples compared to the leachate samples. For the same landfill, the results obtained for the metals, compared with those obtained by some previous studies shows that the metallic pollution generated by these metals decreased of the landfill closure. The high COD content (46000 to 48000 mg O₂ / l) and BOD (36050 mgO₂/l) in the leachate samples reflect the introduction of biodegradable into the puddles of leachate, as well as the removal of biodegradable organic pollutants as the original leachate percolates into the soil before reaching the river edges. The metal analysis of soil samples near and far from puddles indicates that the soil seems to be less contaminated by leachate residues.

KEYWORDS: Pollution, Landfill, Leachate, metals, surface water, organic load

CLASSIFIED HOTELS APPLICATION OF THE 4RS TO WATER AND WASTEWATER MANAGEMENT IN BAUCHI STATE OF NIGERIA

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Water is crucial for sustaining life. The global water crisis necessitates the need both for prudent use of portable water as well as evolving ways of safe wastewater reuse. The hotel sub sector of the hospitality industry is a heavy user of water in food and beverage production, guest rooms, laundry and other use, creating high volumes of wastewater during the process which traditionally is released to the environment one way or the other. This study proposes that just like solid waste, the 4Rs are applicable to water and wastewater management as means of mitigating portable water scarcity as well as the adverse effect of wastewater on the environment. For hotels operators to purposefully engage water Resource efficiency, wastewater Reduce, Reuse and Recycle in their everyday hotel operations, it is fundamental that they incorporate these in their hotels water and wastewater management policies. The objectives of this study were to determine the level to which the different classes of hotels operators are cognizant of both the global water crisis as well as effect of wastewater on the environment and to find out the level to which the hotels apply the 4Rs to water and wastewater management in their operations. This was achieved using cross sectional descriptive survey design. Forty nine hotels classified into 5 categories were involved in this study from where 185 respondents comprising 49 hotels managers and 136 departmental heads were drawn using stratified and purposive sampling techniques. Scheduled interview for the managers and a semi-structured ten-item Likart scaled questionnaire administered to departmental heads were used to obtain data, analysed using the Chi-square. This study discovered that hotels operators are aware of global water crisis and the effect of wastewater on environment to a large extent, and that hygiene considerations, lack of technological knowhow as well as desire to satisfy guests' demands are parts of reasons why hotels are constrained to practice wastewater Reduce, Reuse or Recycle. This study recommends that awareness drive be carried out for hotels operators on the need for and how to innovatively incorporate the 4Rs in water and wastewater management in hotels operations.

keywords: 4Rs, Water, Wastewater, Classified Hotels

Water Quality Assessment of Drinking Water Intakes on the Nile River, Egypt

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Rosetta Branch is one of the two main branches of the Nile River in Egypt. It is considered as the main, and approximately the lone, freshwater resource for drinking, agricultural and industrial activities for five of the Nile Delta governorates. This study aims to assess the water quality status of the Rosetta Branch using the water quality index (WQI) and the statistical assessment approaches, in addition to determine the most appropriate WQI for the Nile River in Egypt. Four water intake stations have been chosen for this study, they are located on Rosetta Branch, for two years 2014 and 2015. Thirty-five of water quality parameters were analyzed by descriptive analysis. Three of the most widely used WQIs have been applied in this study (NSF-WQI, CCME-WQI and Bascarón WQI) based on the Egyptian guidelines of law No. 48/1982 (update No. 92/2013). Correlation matrix, factor analysis and principal components analysis, have been applied to investigate the main pollution factors and sources. The results indicated the critical water quality status of the Rosetta Branch at the four intakes. CCME-WQI is considered as the most appropriate WQI which can be applied for the Nile River in Egypt due to its flexibility and using of the Egyptian water quality standards. The statistical assessment approach estimated the main pollution sources, mainly are the agricultural drainage and domestic wastes. A water quality management plan for the Nile River, particularly at drinking water intakes should be implemented.

KEYWORDS: Bascarón WQI, CCME-WQI, Nile River, NSF-WQI, PCA, Rosetta Branch, Statistical Analysis

Mechanized rainfed agriculture in eastern Sudan: Food security under wet and dry conditions or perhaps not?

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Sudan's economy, livelihood and food security are mainly relying on agricultural activities. In the arid and semi-arid parts of eastern Sudan, farming is heavily practiced under mechanized rainfed agriculture despite the existence of several irrigated schemes. Sorghum represents the major crop grown in the region. However, little is known about the status quo of performance of this sector of the farming system of the region in general and under wet and dry conditions in particular. In this study, data on climate over 1941-2015 and sorghum statistics over 1970-2016 are considered for six states in the region, namely Khartoum, Gezira, Kassala, El Gedaref, Sennar and Blue Nile, occupying an area of 235852 sq. km. The data area aggregated to develop regional multi-criteria drought index and sorghum 'climatic' yield to classify the system vulnerability and resilience to dry and wet conditions. Regime shift detection analysis is performed to shed light on sustainability of sorghum production under the mechanized system and the recent climate state. The results show that there were 23 mild to extreme droughts and 17 mild to extreme wet cases during the June-October growing seasons of 1970-2015. It is also found that the mechanized system is highly variable in terms of vulnerability and resilience of sorghum production to dry and wet conditions. Notwithstanding that significant extensification of sorghum cultivation area has taken place, a loss of the area at harvest has increased drastically. The sorghum production shows significant increase over time interrupted by a significant decline during the first decade of this century. However, a steady decline of sorghum yield by one-third is noticeable with a significant drop in mean yield since 1982. The above results have profound implications for policymaking to enable improving the performance of, develop alternatives for, and achieve food security through the mechanized sorghum farming system.

KEYWORDS: Mechanized rainfed agriculture; Sorghum production; Agricultural extensification; Food security; Sustainability; Drought; Sudan

Catechol and Resorcinol removal in wastewater by Activated Carbon prepared from sunflower (*helianthus annuus*) seed hulls

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Catechol and resorcinol are two dihydroxybenzene isomers widely distributed due to their variety sources and are important environmental pollutants because they are toxic to humans and difficult to degrade in the ecological environment. Phenol and its derivatives are the commonly encountered organic pollutants in the industrial effluents that have caused severe environmental problems. Our aim in this work is study the efficiency of some phenolic compounds removal on activated carbon prepared from sunflower (*helianthus annuus*) seed hull and to study the effect of some parameters on those phenolic compounds removal on activated carbon in aqueous media. Batch experiments were performed to determine the equilibrium time, the kinetic, adsorption isotherms and the adsorption thermodynamic. The concentration of the pollutants in the aqueous solution was measured using UV-VIS spectrophotometer T90+ UV/VIS Spectrometer (PG instruments Ltd) at a wavelength of maximum absorbance of 760 nm according to the method of Sahu & Saxena (2013). The results show a maximum adsorbate adsorbed of 220 and 270 mg/g respectively for catechol and resorcinol. The equilibrium has been reached at 150 min and Langmuir isotherm and second order kinetic fit well the adsorption of the two pollutants while the thermodynamic show that the adsorption is exothermic. Pollutants concentration and adsorbent amount influence the adsorption of catechol and resorcinol in aqueous media. The activated carbon prepared from sunflower seeds hulls by zinc chloride activation is a good adsorbent for phenolic compounds removal.

KEYWORDS: PHENOLIC COMPOUNDS, ADSORPTION EFFICIENCY, ISOTHERM, KINETIC AND THERMODYNAMIC

Electrocoagulation-flotation as a possibility for domestic wastewater treatment and reuse

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Wastewater collection, treatment and reuse are key elements to achieve the water security. Therefore, the United Nations' Sustainable Development Goal number 6 includes reducing the untreated wastewater proportion and substantially increasing its reuse to improve the water quality and reduce the pollution. In Brazil, inadequate sewage disposal is the main source of surface water contamination, with 50.2% of the Brazilian people not having access to sewage collection and 59.2% to sewage treatment. In parallel to this, about half of the Brazilian municipalities have already decreed Emergency Situation or State of Public Calamity due to drought events in the last decade. For these reasons, the objective in this study was to evaluate the possibility of using an electrocoagulation-flotation (ECF) system for the domestic wastewater treatment and reuse. To achieve this, the best conditions of initial pH, electric current and electrolysis time of an ECF system for domestic wastewater treatment were defined, by means a central compound design, based on turbidity and final pH variables. After obtaining the best treatment conditions, a monitoring of the ECF system was performed, evaluating the treated wastewater quality (turbidity and final pH) and the system inputs demand (electric energy, electrode mass and acid volume) for a period of 4 months. The best conditions of electric current, initial pH and electrolysis time obtained were 1.65 A, 6.0 and 25 min, respectively. The mean values of turbidity (4.7 NTU) and final pH (7.6) of treated wastewater were in agreement with the Brazilian standards for reuse in residential and urban environments. The mean demand of electric energy, electrode mass and acid volume were 11.2 kWh·m⁻³, 366.8 g·m⁻³ and 5.2 L·m⁻³, being the decentralized reuse a possibility for treatment costs reduction. Thus, the ECF system proved to be an important alternative for the decentralized treatment and reuse of domestic wastewater.

KEYWORDS: Water security; Electrochemical treatment; Domestic wastewater; Reuse.

The Evaluation of Bioremediation Treatment System in Heglig-Sudan

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In the oil industry production there are several types of waste produced during the production process. One of the major wastes is produced water which needs actions because it has high potential risks on the environment. There are different management strategies to treat produced water which depends on its physical, chemical and biological properties. There are different locations that produce oil nowadays, Heglig is considered to be the biggest oil field which is located in the south-west region of Sudan. Bioremediation is a biological treatment system to clean up produced water to meet water quality standards before discharging it to the open environment, or other uses. It is important to treat this water as it is generated in a large amount therefore, regular evaluation should be taken in order to monitor the performance of the treatment system. The data which has been analyzed in this research has been previously collected by Greater Nile Petroleum Operating Company (GNPOC) and has undergone chemical analysis by Oceaneesu Global Environmental Solutions Company. To evaluate the treatment system three parameters were used; oil content, pH and electrical conductivity through categories based on international standards to assess the treated water quality in the selected years (2005, 2010, 2015). The calculations of the values and scoring the results has been done using Microsoft Excel 2013 and Statistical Package for the Social Sciences. According to the findings there is degradation in the treatment system efficiency through time and this was found to be significant. Some recommendations were made, these include; the treatment system should not depend on a single treatment process, oil companies should take immediate measures to improve the existing treatment process so that the quality meets international standards..

KEYWORDS: PRODUCED WATER , BIOREMEDIATION , WASTE.

Evaluation of pollutants removal in microcosms of artificial wetlands using ornamental plants.

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The evaluation of pollutants removal in municipal wastewater was carried out using ornamental plants, such as *Spathiphyllum* (Peace lily) *Zantedeschia aethiopica* (Calla lily) and *Anthurium* (Flamingo flower), the experiment was developed in 2 phases. In the first one, plants were installed in containers, simulating microcosms of artificial wetlands, supplied by a container with a total volume of 1100 L of municipal wastewater, distributed by hydraulic pipes to each microcosm. In the second phase, containers were divided in four different groups, with a total of 21 microcosms, 8 of them contained volcanic rock as a substrate, 8 PET, 8 more contained river rock and 3 functioned as a control, containing only the substrate. This first phase was identified as a period of stabilization and adaptation to the conditions of the microcosm and wastewater, after that, it was determined which plants survived and overcome the adaptation period. The species that best removed pollutants in form of BOD₅ were *Spathiphyllum* in the volcanic rock substrate and PET, followed by the species of *Zantedeschia aethiopica* on the same substrates. In the second phase of the artificial wetland, the selected plants in the first phase were used, in this case, the species *Spathiphyllum* (Peace lily), *Zantedeschia aethiopica* (Calla lily), as well as the substrates of volcanic stone and PET, because they presented the best pollutants removal and plants growth, then 10 microcosms divided in three groups were used, 4 of them contained volcanic rock substrate, 4 more contained PET and 2 microcosms were used as control. In this phase, the parameters of BOD₅, COD, nitrates, phosphates, alkalinity and plant growth were evaluated. According to the data obtained, the plant with the best COD removal is Calla lily, the results showed an average of 43 mg L⁻¹.

KEYWORDS: Domestic wastewater, artificial wetlands, ornamental plants

Paracetamol removal by vertical flow constructed wetland from domestic wastewater

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Water security can be achieved with the wastewater collection, treatment and reuse, to improve the quality of life of the population, reducing costs with hospitalizations for diseases transmitted by contaminated water. Therefore, the United Nations' Sustainable Development Goal number 6 includes reducing the untreated wastewater proportion and substantially increasing its reuse to improve the water quality and reduce the pollution. In Brazil, inadequate sewage disposal is the main source of surface water contamination, with 50.2% of the population not having access to sewage collection and 59.2% to sewage treatment. It is known that conventional sewage treatment plants do not achieve satisfactory removal of micropollutants. In Brazil, there is still no legislation to regulate the release of emerging pollutants such as anti-inflammatories and antibiotics, despite the important consumption of these drugs and their release in the sewage system. For these reasons, the objective in this study was to evaluate the removal of paracetamol by a system with a septic tank (ST) and a vertical flow constructed wetland (WCFV) for the domestic wastewater treatment, with 50% recirculation back to the ST. The constructed wetland has gravel as fill material and *Canna indica* and *Canna x generalis* were planted, two flowers that add the landscaping embellishment to the system. The experimental WWTP treated 1.500 L/dia (10 PE). Fifteen wastewater samples were collected to evaluate the removal of paracetamol. The average removal rate was 86.3% (on organic load, with hydraulic application rate = 90 mm/d), which can be attributed to the microbial degradation process and the plant uptake. Thus, decentralized systems using constructed wetlands can be an important alternative for the treatment of paracetamol in domestic wastewater, avoiding the discharge into the rivers and health protection.

KEYWORDS: WATER SECURITY; WASTEWATER TREATMENT; PHARMACEUTICALS; MICROPOLLUTANTS.

Biochar Effect on Biodegradation of free cyanide by bacterial species isolated from cyanide contaminated artisanal gold mining catchment area in Burkina Faso

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Artisanal small scale gold mining (ASGM) in Burkina Faso has contributed to the economical and societal development of this country, in spite of its unlawful characteristics. Nevertheless, rudimentary tools and technics were used in ASGM activity that induces a highly environmental degradation throughout the inappropriate aspect of the activity and the use of the hazardous chemical compounds as cyanide. In precedent study, the presence of cyanide degrading bacteria (CDB) in polluted Soil and water samples were confirmed and isolated in a selective medium in the laboratory scale. The isolated CDB species had degraded 99 % of the CNL within 24 h with bacterial growth and ammonium production (Razanmahandry et al 2016). But the pollution in the ASGM area still increase (Razanmahandry et al 2018). On the other hand, many study have shown that Microbial biomass in most cases increases in the presence of biochar (Lehman et al 2011). In this part we aim to study the effect of biochar on CDB and cyanide biodegradation. Biochars produced from balanites pyrolised in improved focus on burkina Faso were characterized and investigated as adsorbents for the removal of cyanide from aqueous solution. The adsorption data were well described by a Langmuir isotherm, with maximum adsorption capacities of 109 mg/g and cyanide removal about 85%. Using CDB and Biochar shown that cyanide removal is about 99% in 20 hours (24 hours without biochar) with bacterial growth more important than test without biochar.

KEYWORDS: Cyanide; Artisanal scale gold mining, Biochars

Antimicrobial properties of plants extracts for water treatment

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Plant extracts are used in various preparations for a multitude of applications. Plants rich in bioactive molecules present interest as natural disinfectants materials. They could be used for water decontamination from various microorganisms ranging from bacteria, protozoa, worms, fungi.

Many research studies focused on phytochemistry of plants extracts in relation to their antimicrobial potential for water disinfection. For bacterial investigation selected protocols are used for antimicrobial screening as Spread plate method or Well Diffusion method. Extracts of plants: *Ocimum sanctum*, *Azadirachta indica*, *Triticum aestivum*, *Phyllanthus emblica* and *Strychnos potatorum*, *Cleome gynandra*, *Cassia nigricans* significantly decrease the total bacteria in control water sample.

Chemical screening methods as phenolic compounds evaluation and antioxidant measurement of *Cleome gynandra*, *Cassia nigricans* extracts are used to justify antimicrobial properties.

This poster will show that application of plant extracts can be highly recommended for domestic drinking water purification in developing countries, where people used to drink dam, well and surface water which are contaminated. We will highlight the importance of multiple use approach of plants as a way which could be applied in many situations for natural product's valorization.

Potential Of Aerobic Granular Sludge As Treatment Measure For Small Decentralized Factory In Viet Nam

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In Thua Thien Hue Province, Viet Nam, there are many small factories which are located in residential area and their wastewater directly discharge into environment without any appropriated treatment measure. They are identified as a decentralized pollution sources that should be solved to minimize the negative impact to local community. Because of its decentralized characteristics, the criteria of treatment measure should be easy and low-cost efficiency operation, contaminants simultaneously removed involving one reactor only for saving construction area. Sequential Batch Reactor (SBR) requires less area for function, easy and cost-effective operation. Aerobic Granular Sludge (AGS) is finding several advantages: good settling property, the self-immobilized active micro-organisms in the reactor, and be able to withstand fluctuation of pollution loading. Especially, it is possible to cultivate aerobic granular sludge by adjusting operational condition of SBR. Therefore, the combination of SBR and AGS process could be the solution for decentralized wastewater treatment with cost-effective operation.

This paper is to present the assessment of ability as well as examine the contaminant removal efficiency of AGS process in waste water treatment of small factory in Thua Thien Hue, Viet Nam. Experiments show that aerobic granular sludge was cultivated successfully in SBR and had some advantages characteristics: short time to start up (just 35 day in SBR); good settling property (SVI value is just 43 mL/g); good biomass and high bioactivity (VSS/SS rate in range of 88-90%). After granules formation, SBR was continued operating with wastewater collected from a small aquatic products processing factory. Although, input concentration of COD and ammonium (N-NH₄) were fluctuated during, COD and N-NH₄ removal efficiency were still stable and reach to around 95-96% and 94-95% respectively. The data results show that the nitrification process has completely developed and the simultaneous of nitrification and de-nitrification could be occurred in SBR system during operation in real wastewater. After treatment by aerobic granular sludge, outputs are met limited value in Vietnam National Regulation for Aquatic processing product wastewater (QCVN 11:2008/BTNMT). This result presents the capability and stable efficiency of application of AGS process in treatment of waste water from small aquatic product processing factory.

KEYWORDS Aerobic granular sludge, decentralized waste water treatment, SBR technology, nutrient removal, nitrification.

Assessment of nutrients and heavy metals constitutes in raw organic agricultural waste and ready compost: The case of Wadi Al-Far'a Watershed, Palestine

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Agricultural activities can generate considerable amount of a wide variety of organic wastes, which represents an environmental problem if not managed properly.

Wadi Al-Far'a Watershed (WFW) is one the most important agricultural areas in Palestine. Yet, random disposal in open dumps and/or burning of agricultural waste are prevalent practices in the watershed, resulting in emissions of acidifying and greenhouse gases and water pollution due to production of leachate. To encourage compost production in WFW as an efficient way for organic waste treatment and emission reduction, this study aims at 1) assessing the characteristics of raw organic agricultural waste for the purpose of potential compost production, and 2) assessing quality of the compost used by some farmers in the area including locally- produced or imported compost.

To achieve the study objectives, 34 samples were collected from different agricultural villages in WFW including 19 samples of raw organic agricultural waste and 15 samples of compost. The analysis of the raw organic waste showed good potential for compost production due to its high content of organic matter and other nutrients like nitrogen and phosphorous. The analysis of the compost samples, however, showed that the compost quality is relatively low due to high electric conductivity and humidity as well as high sodium, chloride, and potassium content. Using this compost in agriculture may, therefore, result in adverse impacts on the soil and plant. Heavy metals analysis showed that both raw waste and compost samples contents are less than the limits specified by the Palestinian standard.

KEYWORDS compost, organic materials, fertilizers, manure, agricultural waste

Removal Of Crude Oil From Wastewater By Sorption On Carbonized Yam Peels (*Dioscorea Rotundata*): Kinetic Equilibrium And Thermodynamic Studies

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Yam peels (*Discorea rotundata*) from West Africa were used as absorbent to remove crude oil from wastewater. Carbon was produced from these peels and a comparative was carried out between inactivated and activated carbon. The absorption's efficiencies of crude oil from water were investigated through batch adsorption studies using readings from UV-Visible spectrophotometer. The crude oil obtained was characterized and properties such as viscosity (Kinematics and dynamic), pH, density, specific gravity and API gravity, heat of combustion, thermal conductivity, specific heat capacity and latent heat of vaporization were determined. Proximate analysis was carried out on the raw yam peels and the physicochemical properties were examined after carbonization. Some of the carbonized yam peels were activated with $ZnCl_2$ and comparatively studied with the raw carbon. The activated carbon was found to be better absorbent than the inactivated carbon at removing using batch adsorption after varying pH (3-13), oil concentration in water (2.0-5.0g/l), absorbent dosage (0.2- 1.4g), contact time (0-80 minutes). The conditions for maximum adsorption capacity for inactivated carbon (285mg/g) and activated carbon (316mg/g) were pH (7); contact time (40 minutes); adsorbent dosage-activated carbon (0.4g) and inactivated carbon (1.4g). The equilibrium adsorption test conducted showed that the Langmuir isotherm is a better fit for the adsorption of the crude oil on the activated carbon and the Freundlich isotherm is a better fit for the inactivated carbon as indicated by their high R^2 values at 0.6698 and 0.7569 respectively. The kinetic studies showed that the pseudo second order model is a better fit for the adsorption experiment with R^2 values of 0.994 and 0.9693 for the activated and inactivated carbon respectively. The intra-particle diffusion experiment revealed the influence of film diffusion and external mass transfer. Hence, activated yam peels are better adsorbent and can be used for oil spillage control.

KEYWORDS: Activated and inactivated carbons, absorbent, Freundlich isotherm, Langmuir isotherm, proximate analysis, oil spillage, yam peels,

Assessment of treated wastewater quality under different climate change Scenarios in Jordan

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In investigation was done in Jordan to evaluate impact of climate change on soil and treated wastewater quality in terms of salinity and PAHs content under different climatic conditions. Evaluation was done by sampling soil and treated wastewater flowing from Karak wastewater treatment plants passing sites of different climatic conditions.

Results indicated that there was a slight change in water salinity between the sampling location as lower concentrations were observed upstream where mild climatic conditions prevailed and higher concentrations were found downstream at lower altitude where warmer climatic conditions prevails. However, the wastewater quality in term of its suitability for irrigation was found to be safe at all climatic conditions.

For soil there was an increase in salinity was observed by moving from mild to hotter and drier climatic conditions as it increased from 506 mS/cm to 772mS/cm which is due to higher evaporation with increasing temperature. For PAHs, limited variation was observed in wastewater along sampling sites which is due to short period of transportation of wastewater from source to the mouth of the effluent streams making photo degradation, volatilization and biodegradation very limited. The individual distribution of various PAHs compounds were dominated by low molecular weight compounds as Fluorine and Phenanthrenes made more than 86% of total concentration of all PAHs. For soil, PAHs lower concentration of total PAHs were found at mild climatic conditions than those located at hotter and drier climatic conditions which was interpreted by that high temperature and high irradiation rate enhances volatilization of PAHs with low molecular weight indicating that with increasing temperature the treated wastewater would be of better quality in terms of its PAHs content. The result of this work showed that there was a slight impact on soil and wastewater quality in terms of PAHs and salinity

KEYWORDS Wastewater, Climate change, PAHs, Jordan

Facing Microplastic Pollution in Wastewater Treatment

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The worldwide plastic production increases every year. Since 1950 8.3 billion tons of plastic were fabricated, mostly polypropylene and polyethylene. The resulting plastic waste causes a serious threat to the aquatic ecosystems. Plastic pollution does not only have a negative impact on aquatic biota through entanglement or ingestion by animals. Pollutants and pathogens adhere to microplastics and thereby enter the food chain, such as seafood sold for human consumption. According to Van Cauwenberghe et al., consuming large quantities of mussels could present an exposure pathway. It is uncertain whether plastics that are ingested by humans can be transported into tissues. Once inside, it is theoretically possible for plastic to interact with biological tissue in a toxic manner. Therefore, the occurrence of smaller pieces of plastic debris has become a pressing concern in recent years. The term microplastic (MP) is usually defined as particles smaller than 5 mm and can be characterized as primary and secondary MP. Granular used in many consumer facial cleansers, textile laundering facilities and sandblasting are major sources of primary MPs. Secondary MP is generated from larger plastic items by chemical-physical impact or UV degradation. According to previous studies, MPs can be classified into three types: granular, fibrous, and fragment. According to 5 Gyres Institute, it is estimated that a total of 15-51 trillion MP particles have accumulated in the ocean, weighing between 93 and 236 thousand metric tons. To reduce the amount of microplastic which is discharged through wastewater into the aquatic system, multiple technical solutions as mechanical treatment, filtration, flocculation, and adsorption are conceivable and need further investigation. First studies on fate of MP in wastewater treatment plants have, however, shown that the common treatment plants, based on mechanical and biological treatment, are already highly efficient in eliminating MP, mainly by sedimentation and skimming.

KEYWORDS: Wastewater, microplastics, filtration, flocculation, adsorption

Wastewater Treatment by Photocalyse, Fenton Oxidation Process and Adsorption.

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The main objective of this study falls within the wastewater management of textile industries. The specific objectives are dual: (i) to evaluate the purification efficiency of trois wastewater treatment methods: photocatalysis, oxidation process Fenton and adsorption, (ii) to determine the most efficient method for the development of rural world's appropriate system. The first studied method is an advanced oxidation process: the photocatalysis. This method was achieved with honeycomb shaped material composed of silicon carbide β -SiC coated with nanoparticles of TiO_2 by sol-gel processes ($\text{TiO}_2 / \beta\text{-SiC}$). The pollutant studied is a Rhodamine B solution. The degradation was carried out in a photoreactor composed of a coaxial quartz tube disposed in a glass cylinder. The studied parameters are the number of lamps switched on, the quantity of materials (foams) used and the temperature. The results obtained are stated for a degradation of 90% and an initial pollutant concentration of 10 mg.L⁻¹ and we obtain 4 foams, 2 lamps and the working temperature (30°C). The oxidation process Fenton is the subject of our second investigation and is was carried out in batch by using the "laterite granite" as iron source. The physicochemical parameters such as the Rhodamine B concentration, the quantity in laterite granite, the hydrogen peroxide volume, the temperature and pH were studied. The results present an optimum value of respectively 4 g, 10 mg.L⁻¹, 2 mL, 30°C and pH=5 for a degradation of 56%. The last method analyzed is the adsorption on an adsorbent material based on rônier's shell. The experiments were carried out in batch and the studied parameters are the quantity of adsorbent the pollutant concentration, the temperature and pH. The optimum values were respectively 2 g, 10 mg.L⁻¹, 30°C and pH=6, in order to obtain an elimination of 90%. The most promising method for an applicability in our villages seems to be the adsorption for its high elimination rate and its ease of implementation.

KEYWORDS: Advanced oxidation process, Rhodamine B, Adsorption, wastewater treatment

Abundance evaluation of flagellated protozoan cysts in waste water used for urban wetland agricultural practices: case of Yaoundé urban city (Cameroon)

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To reduce hunger, people of certain African metropolises practice urban wetland agricultural. In order to evaluate the abundance of environmental forms of flagellated protozoan in waste water that is exploited for urban wetland agricultural practices in Yaoundé, a study was carried out from November 2013 to April 2014 in the waters of some localities in Yaoundé. Samplings were done in the water and on plants (*Lactuca sativa* and *Solanum nigrum*) and these plants were cleaned using distilled water. The flagellated protozoan cysts were identified following the method of flotation using zinc sulphate (Beugnet, 2000). The physico-chemical analysis showed that these waters have pH close to neutrality ($6,84 \pm 0,14$ U.C), highly mineralized ($357,18 \pm 68,26 \mu\text{S}/\text{cm}$) and rich in suspended solids ($61,41 \pm 21,44$ mg/L). Biological analysis showed the presence of *Giardia intestinalis* (101 ± 70 cysts/L), *Chilomastix mesnili* (34 ± 20 cysts/L), *Retortamonas intestinalis* (3 ± 6 cysts/L) and *Enteromonas hominis* (1 ± 3 cysts/L). Biological analysis on the crops reveal that these crops are contaminated with the cysts of flagellated protozoans at an average concentrations of 38.31 ± 47.25 cysts/100g for *Giardia intestinalis*, 12.87 ± 15.17 cysts/100g for *Chilomastix mesnili*, 1 ± 2.71 cysts/100g for *Retortamonas intestinalis* and 1 ± 2.71 cysts/100g for *Enteromonas hominis*. Appropriate environmental measures together with proper cleaning and cooking of the plants before consumption have to be respected in order to reduce sanitary risks.

KEYWORDS Cyst, flagellated protozoan, shallows and urban area

Developing a Model for the Evaluation of the Impacts of MSW Management on Water

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The management of Municipal Solid Waste (MSW) definitively has significant impacts on water, both quantitatively (water consumption) and qualitatively (water contamination). Though, these impacts are not yet evaluated. Apart from landfill leachate assessment, a review on the relevant literature results in a water footprint (WFP) study of food waste in the UK (Chapagain and James 2011) and life cycle assessment (LCA) studies, in which water related impact categories are considered. Maimoun (2015) mentioned that the impacts of waste management on water are yet neglected or not fully considered and studied the water footprint for the most commonly used MSW management practices in the USA.

The present study aims at developing a model that evaluates the quantitative and qualitative impacts of selected MSW management scenarios on water. The model should be adaptable to local conditions, and hence applicable for different regions. For this study, the LCA method in accordance to ISO 14040 - 14044 is applied. The functional unit is the treatment of 1 ton of MSW, focusing on the fractions bio-waste and paper. Other MSW fractions can be included in the model later. Nine treatment scenarios are selected for evaluation including a baseline scenario "no treatment". The system boundaries are set to only include treatment processes after MSW collection. The construction of MSW management facilities is excluded. For its wide accessibility and user friendly interface design, MS-Excel is chosen to work with.

In this paper, the status quo of the study and the progress in the model will be presented. The main challenges facing the study arise from the heterogeneous and complex composition of the considered MSW fractions, the big number of parameters affecting the treatment processes, the big number of process combinations, and the high dependency on the local conditions. These challenges and solution approaches will be presented by means of an example scenario.

KEYWORDS MSW management, impacts of MSW management, Water protection, life cycle assessment

Assessing the value of resource recovery and reuse: Social, environmental and economic costs and benefits for value creation and human wellbeing

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Resource recovery and reuse (RRR) contributes to a range of social, economic and environmental benefits that affect human wellbeing in developing and emerging economies. Energy, nutrients and water can be recovered and reused in domestic wastewater treatment and reuse for agriculture or industry, agroindustrial waste management, organic municipal solid waste (MSW) management and on-site sanitation of fecal sludge. There is a need to understanding the full value of RRR to justify action, demanding a systematic assessment approach that balances complexity with practicality. Cost-benefit analysis (CBA) is a well-established tool for weighing social, economic and environmental costs and benefits based on a common economic metric. This presentation highlights the methods available for quantifying and valuing social, environmental and economic costs and benefits of RRR, focusing on CBA as the primary framework. Rather than prescribing a standardized technique for conducting CBA for RRR, this presentation introduces frameworks and several examples that can be catered to individual contexts. This results in a suggested 8-step process accompanied with suggested assessment techniques. Examples of CBAs conducted in RRR sectors communicate environmental value to decision makers, quantify long-term and indirect cost savings, and incorporate complex social costs associated with human health and lifestyle, leading to various key insights. While CBA is useful in decision making, its limitations are well documented. The concept of human wellbeing encompasses a broader set of metrics, including security, basic needs for a decent life, health, good social relations, and freedom and choice of action, allowing for more robust reflection of the implications of RRR on society. This presentation also explores the relationship between RRR and human well-being to help decision-makers reflect upon the limitations of CBA and to suggest human well-being should be further explored as an assessment metric for justifying action in RRR.

KEYWORDS: resource recovery and reuse / wastewater / value / human wellbeing / cost-benefit analysis

Negative externalities of urban waste on the water resources in tropical Africa

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Urban waste continues to evolve in quantity, harmfulness and complexity. Waste management includes collection, transport, treatment and disposal of waste together with monitoring and regulation. It also encompasses the legal and regulatory framework that relates to waste management encompassing guidance on recycling. Waste management normally deals with all types of waste whether it was created in forms that are industrial, biological, household, and special cases where it may pose a threat to human health. It is produced due to human activity such as when factories extract and process raw materials. But waste management practices are not uniform among, regions (urban and rural areas), and sectors (residential and industrial). A large portion of waste management practices deal with municipal solid waste which is waste that is created by household, industrial, and commercial activity. Unfortunately, municipal structures in developing countries, particularly those in sub-Saharan Africa, are failing to cope adequately with the problem of urban sanitation. Populations are not aware of the negative impacts of waste in this case on public health and the environment. However, urban waste contains much diversified materials and is thrown on the ground, on the edges of streets, and rivers, on public squares... Wastewater is not treated but it is poured everywhere. Then after the rains, urban wastes are found in water while they are nests of parasites and vectors of waterborne diseases. Similarly, the burning of solid waste emits chemical micro pollutants that also end up in water. Urban waste is therefore a source of chemical and bacteriological pollution that reduces the quality of water resources.

In developing countries, in order to guarantee the safety of water and food, it is important to prevent this waste-related pollution by setting up a system of adequate management of urban waste: collection, treatment, recovery, reuse.

Keywords: externalities, waste, pollution, water resources

The main objective of the work is to search for relevant indicators for assessing the impact of waste on water quality of Kpondjo River.

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The lixiviation test applied allowed accelerated access to the water-soluble material that can be mobilized in the various fractions of household and similar waste from the city of Sokodé, a material that can be salted out by leaching and leaching processes in nature. It has thus made it possible to evaluate the reactivity of the waste by promoting access to the composition and the quality of the released organic matter and to facilitate a follow-up of the recovery of the biological activity over a period of 120 hours.

The study of physicochemical quality of the waters of Kpondjo River has shown a link between the deterioration of the quality of the river's water and the manner of waste management.

Given the multiple uses of water, especially for market gardening, actions must be taken to put in place an adequate system of disposal of these wastes to reduce their impact on the waters of the river.

Indeed, the physical characterization of solid waste in the city has revealed that 22% is the biodegradable fraction. Then, a composting valorization of this fraction would reduce the biogas produced by this waste and thus help to reduce global warming trends..

Keywords: Leaching; organic matter.

Natural Products As Adsorbent For Treatment Of Wastewater For Reuse

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Various countries in arid areas have oriented their efforts to use WWs as alternative to face water deficiency. Usage of recycling WWs depends on successful infrastructure, reliable treatment process, financial and economic analysis, public acceptance (overcome health and environmental concern). Basically, wastewater may contain excreted pathogens (bacteria, viruses, protozoa and helminths (worms) that cause gastro intestinal diseases, highly poisonous chemical toxins, and hazardous material from hospital waste, heavy metals and hormones and antibiotics. The magnitude of pollution of WWs was evaluated according to the importance of the population. Various reports attest to the failure of the different treatment processes used to clean WWs; raising concern about the remaining pollutants in WWs released in the rivers or reused in agriculture. Usage of local material could improve the quality of WW. Adsorbents have been prepared from apatite or some vegetable waste of nuts and/or fruits by pyrolysis (500 -700°C) at a reduced level of oxygen or by chemical treatment. In this process, a kind of biochar polymer will form. This material have been grinded to different diameter of granules. Fractions of 0-45 and 45-100 μm and tested. Individual tests of adsorption have been performed with each pollutant and different adsorbents. Isotherms of adsorption have been derived in batch experiments. Different equilibrium concentrations of the pollutants will enable us to draw the isotherm and to compare different common models such as Freundlich or Langmuir. The parameters of adsorption have been deduced from the more fitting model to the data. Effects of different physical-chemical parameters such as pH, CEC, Conductivity..., on the performance of the tested sorbents have been studied using experimental designs.

Keywords: Adsorption; Wastewater; removal rates; water quality

Compost from organic waste as an option for reducing water pollution and improving soil health in Sri Lanka

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Discharging wastewater flows to fresh water bodies and open dumping of municipal organic waste are key threats to healthy water ecosystems in Sri Lanka. Since organic waste contains essential nutrients for improving agricultural soils, composting can be a win-win option to address both water pollution and soil nutrition depletion problems which are acute in the country. An optimal waste management model was applied to assess the feasibility of composting option while considering the externalities of various waste management options (open dumping, landfilling, composting). The results showed reduced water pollution costs and lower expenditures to import chemical fertilizers with the increased application of compost made of organic waste. Inter-regional trade in compost would further expand composting potentials since municipal areas producing large volumes of organic waste can reduce environmental pollution while rural sites with larger areas of croplands can afford replacing higher volumes of chemical fertilizers by compost. Ensuring compost quality standards, easing land use permissions to construct compost plants, increasing availability of funds for composting projects as well as raising awareness on environmental benefits of Resources Recovery and Reuse technologies are also important for successful implementation of composting programs.

KEYWORDS Resources Recovery and Reuse, wastewater, organic waste, soil nutrients, environmental externalities, inter-regional trade in compost, waste management model

Sequential membrane treatment of agro-food wastewaters and recovery of the most valuable compounds by column adsorption runs

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Olives undergo a series of treatments, final separation olive oil from the residual pulp and generate olive mill wastewater (OMWW). This wastewater stream is a strong pollutant because of its high organic load and phytotoxic, due to the presence of antibacterial phenolic substances, resistant to biological degradation. The discharge of OMWW is not allowed through the municipal sewage system and/or natural effluents. Unfortunately, the available technologies for the wastewater treatment are too complicated to be operated in a mill factory environment and very expensive for the olive oil business. The aims of this work were therefore to define and implement a process for the treatment of wastewater derived from agro-food processing, in particular olive mill wastewater (OMWW) by recovery compounds of market interest, such as polyphenols and a possible significant reduction of organic waste in the effluents of olive oil mill factories.

Nanofiltration fraction was obtained following the sequential treatment involving coagulation/flocculation, photocatalysis, ultrafiltration and nanofiltration by cross-flow processing and recovery of the most valuable compounds by column adsorptions runs. Competitive adsorption and selectivity of toxic phenol and hydroxytyrosol were studied on the macro-reticular aromatic polymer (FPX66) and the macroporous polystyrene cross linked with divinylbenzene (MN202). During the intermediate stage of the column operation, adsorbed tyrosol molecules were replaced by the incoming phenol molecules due to the weaker affinity of tyrosol for FPX66 resin and the tyrosol concentration was higher than its feed concentration. Tyrosol and phenol concentrations in the first bed volumes were almost zero before the breakpoint; this effluent could be discharged directly or recycled to be processed as supplement water. From its breakpoint to the tyrosol solution with around 90 % purity in bed volumes, the effluent contains mainly tyrosol and could be sent to a unit of MN202 resin for tyrosol recovery.

KEYWORDS: OMWW, PHENOL/TYROSOL, CROSS-FLOW MEMBRANE, FIXED-BED COLUMN, RECOVERY, VALUABLE COMPOUNDS, FPX66 AND MN202 RESINS

Wastewater savings: matter recovery and valorisation through its reuse in biofarming

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In spite of the wide availability of water in communities, sufficient water supply remains a major challenge to the masses. Most human activities such as agro industrial activities require enormous amount of water. Unfortunately at the tail end of such activities, large volumes of wastewater are released in to the environment which greatly account for environmental degradation.

Waste is rich with different nutrient composition which could be valorized or recycled for improved bio-farm yield reason why this work aims at providing a sustainable use of agro waste water use in the city of Yaounde town. We have developed solutions and tools for wastewater sorting, wastewater treatment for reuse and material recovery. We have dimensioned a treatment process to recover C, N, P nutrients and eliminate hazardous microorganisms in black wastewaters in order to reuse them for irrigation or watering without any discharge in aquatic ecosystems.

KEYWORDS: WASTEWATER, TREATMENT, MATTER RECOVERY, BIO-FARMING, IRRIGATION

Effects of open defecation on some selected dams in the Tamale Metropolis, Ghana

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Clean, safe, adequate freshwater is vital to the survival of all living organisms and the functioning of ecosystems, communities and economies. Lack of sanitation pollutes drinking water which most notably due to open defecation which have health impact on the public. Open defecation plays an important role in polluting surface water due to surface runoff when it rains. Faecal pollution of water leads to introduction of variety of enteric pathogens that causes water borne diseases such as diarrhoea, schistosomiasis and intestinal nematode infections. Ghana has been ranked second in Africa in open defecation. The Northern Regional capital of Tamale has for the second consecutive year, recorded the highest percentage of people who defaecate in the open in the Region. For this reason a study was conducted on 4 dams in the Tamale Meropolis to confirm the presence or absence of faecal bacteria. The results of the study showed that faecal indicator bacteria such as *E. coli*, *Salmonella* and *Shigella* were detected in almost all the water bodies making them unsafe for drinking per the WHO standards for drinking water. The research also revealed that, Diarrhoea, Dysentery, Typhoid and Malaria were the most common water related diseases diagnosed by health facilities around the study area. Toilet and proper sanitation facilities should be provided by city authorities to reduce or eliminate open defecation in the Tamale Metropolis.

KEYWORDS: OPEN DEFECACTION, DEFECACTION FREE, CONTAMINATION, MICROBIAL WATER QUALITY, SURFACE WATER, FAECAL INDICATOR BACTERIA

Renewable energy generation by anaerobic digestion of mixed vegetable waste in a lab-scale BIOCEL reactor

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In this study, biogas yields and methane contents of mixed vegetable wastes (i.e. leaves of cabbages, Chinese cabbage, cauliflower leaves, and a few broccoli stems, water spinach, lettuce) from Thailand's largest agricultural market, were investigated. Granular sludge from an up-flow sludge blanket (UASB) reactor and the digestate from BIOCEL reactor was used as inoculum. The lab-scale BIOCEL reactor was employed for anaerobic digestion in the study. The reactor is similar to a landfill cell that have chambers to collect and control the leachate recirculation. The optimum conditions achieved in the biochemical methane potential tests were applied for the reactors. Both reactors were fed with the F/I ratio of 1.0 and controlled at the mesophilic temperature (37 °C). Bicarbonate sodium was added into reactors to maintain the stability of pH. The NaHCO₃ concentrations were at 500 and 150 mg/g VS feedstock for reactors with UASB sludge and digestate, respectively. Results depicted that the reactor with UASB sludge achieved higher biogas production yields compared to the reactor with digestate. This was due to the lack of alkalinity in the reactor with digestate at the hydrolytic step of the AD. After 165 days, the reactor with UASB sludge achieved methane yield at 756 mL/g VS. While the methane yield of the reactor using digestate was 672 mL/g VS. The study also depicted the important role of volatile fatty acid and total alkalinity ratio to maintain the stability of the AD process. It is necessary to measure the parameters during the experiment and operate the ratio below 0.5. The high anaerobic digestion performance in the study demonstrated the potential of utilizing the organic waste from a vegetable market as a renewable energy source..

Constructed Wetland As A Low Cost Wastewater Treatment Technique - A Case Study From Egypt

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Drainage is and will continue to be a vital and necessary component of the agricultural production systems. In Egypt, Due to scarcity of water resources, drainage water is being reused. Currently about 5.5 BCM of drainage water are being reused after mixing with fresh water. This amount is expected to increase to 9.6 BCM by the year 2017. A major concern when considering drainage water reuse is whether the drainage water quality is within the allowable limits for different uses as outlined by the water quality standards and laws. Wastewater treatment in the Egyptian rural areas lags far behind potable water supply. This practice has contributed to widespread degradation of drainage water quality and, so, the reuse of drainage water plans in Egypt. Among the nature treatment systems, in-stream wetland has a high potential for application in rural areas of Egypt where the treatment process takes place within the drain, so it needs much less land, easily maintained, can adsorb shock loads and relatively needs less capital and operational cost. All these features plus the ability to markedly reduce BOD, nutrients, pathogen concentrations, have made in-stream wetland very attractive option for rural communities. The objective of this paper is to present the site selection criteria, in-stream wetland system limitations, the baseline phase results, intensive water quality monitoring program, and the design criteria. The baseline studies show that the performance of the selected drain without physical engineering intervention varies in a narrow range from 29% to 37% for BOD removal with the expected treatment efficiency in detention time below one day. The overall efficiency of the in-stream wetland including sedimentation zone can reach up to 50 to 80% depending on the allowable detention time. The performance of the in-stream wetland treatment system under Egyptian conditions is expected to be equivalent to the primary to secondary conventional treatment and based on the designed detention time and aquatic species used.

KEYWORDS: CONSTRUCTED WETLAND, ENVIRONMENTAL ENGINEERING, WATER QUALITY TREATMENT, WETLANDS.

Sanitation Safety Planning (SSP) as a tool for ensuring the health and environmental sustainability of fecal sludge management business models

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Functional sanitation systems improve health and welfare and are fundamental to human development. Integrated business models throughout the sanitation value chain can turn waste into valuable resources such as biofuels or fertilizer and save water thus leading to even broader livelihood improvements. Indeed faecal sludge is rich in nutrients such as nitrogen, phosphorus, potassium and organic matter, but also in pathogens (e.g. coliforms, E. coli and helminth eggs). Health and environmental risks are highly likely in waste reuse activities, especially with the recovery of resources from fecal sludge (FS) in the case where the necessary risk mitigation measures are not put in place. This thus results in risks often being neglected or simply remaining unknown. Depending on the scale of FS reuse businesses, whilst risks for accidents (occupational health risks) can be contained, the impact of consumer-related health risks and environmental risks can be significant. Unsafe products and/or health-related incidents can ruin the reputation of the FS reuse business. Because of the nature of RRR businesses, especially FS reuse businesses, it is fundamental that potential health risks to the workforce (workers along the sanitation and reuse value chain) as well as the community (neighbours and consumers) are carefully considered. To this, the WHO Sanitation Safety Planning (SSP) is a risk-based management tool for sanitation systems that entities (public or private) can adopt in their FS reuse businesses. It is a decisive way for FS reuse businesses to achieve business excellence, ensuring that they meet the required product and health and environmental standards.

KEYWORDS: Fecal sludge, sanitation safety planning, resource recovery and reuse, business models, developing countries

Gold mine pit lakes use for aquaculture potential health risk assessment : case study from new mine booming country, Burkina Faso.

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Mining water footprint is huge, competing with local population water demand for their basic need. Open cast mining end up with pits and use of those pits as water reservoir was considered, for use in market gardening and fish farming by local population. This study aimed at determining the levels of minor and trace elements (MTEs) in fish from pit lakes of a gold mining site and their potential health effect on the local human population, in order to evaluate if pit lakes could be safely used for aquaculture. Fish consumption rates in different villages were assessed through a survey. Commonly available fishes were sampled from two experimental pit lakes and Nakambé River. Fish from pit lakes contained higher amounts of MTEs than fish from Nakambé river (WP1 WP2 < NR). From the four species of fish considered, *Oreochromis niloticus* and *Hydrocynus forskahlii* had the highest MTEs content and *Bagrus bajad* and *Clarias anguillaris* had the lowest. Transfer factors pointed out *Oreochromis niloticus* as the champion with a factor of 1722 for Arsenic when considering entire fish results. The results indicated that the entire fish contains higher amount of MTEs than only the fleshy part of the fish, hence consumption of the former results in higher MTEs intake than the latter. Due to low fish intake of 5.34 ± 2.60 g/day/adult deduced from the nutritional survey, exposure to MTEs was below referential doses. Highest arsenic intake was when eating WP1 entire *Oreochromis niloticus* (0.058 mg/day/adult) when the lowest intakes were the Nakambé River fishes with 0.01, 0.00, 0.00 and 0.01 mg/day/adult for *Oreochromis niloticus*, *Hydrocynus forskahlii*, *Bagrus bajad* and *Clarias anguillaris* respectively. According to health risk, gold mine pit lakes could be used for aquaculture, providing nutriments and improving resilience in the after-mine closure for the local population..

KEYWORDS: Mining pit lakes, fish contaminants, health risk assessment, Burkina Faso

Reaeration rate coefficients are underestimated by classic predictive equations in a shallow turbulent river: Gas tracer evidence

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Reaeration is the physical absorption of atmospheric oxygen by water. It is a key process to recover the dissolved oxygen concentration in contaminated streams. Ideally, the rate at which dissolved oxygen is consumed for organic matter oxidation cannot overcome the rate at which reaeration occurs. Therefore, assessing the reaeration rate coefficient (K_2) is critical for water governance, water resources management and modelling. Since K_2 largely varies with stream conditions, it should be assessed locally. Gas tracer tests are the most reliable method for assessing K_2 . Nevertheless, the majority of studies dealing with dissolved oxygen in streams make use of predictive equations rather arbitrarily. In this study, we measured K_2 in two urban reaches contaminated by untreated wastewater in the Vacacaí-Mirim River, southern Brazil. We used propane as the gas tracer and Rhodamine WT as the conservative tracer. Two tracer experiments were conducted under contrasting stream discharges Q . The K_2 coefficients were 30.3 d⁻¹ and 24.8 d⁻¹ ($Q=1.30$ m³ s⁻¹) and 14.9 d⁻¹ and 12.7 d⁻¹ ($Q=0.15$ m³ s⁻¹). We compared the four K_2 coefficients we measured with the predictions of nine equations commonly used in the literature. Equations underestimated the measured K_2 in 33 out of the 36 scenarios, with deviations as high as -87% and average at -39%. We attribute our results to the shallow-depth and high-velocity characteristics of the river reaches we studied, causing turbulent flow conditions that are challenging to predict. At the local level, our results will help us to improve the reliability of our water quality models. On a broader level, the results reinforce the need for more critical and comprehensive approaches on the assessment of K_2 coefficients towards enhanced water security.

KEYWORDS Stream reaeration; K_2 ; Dissolved oxygen; Propane gas, Rhodamine WT

An approach of utilizing the industry waste in the development of maghemite functionalized nanostructures for arsenic removal

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The metalloid arsenic is a concern as a groundwater contaminant among the scientific communities due to its harmful effects on human's health and environment. It is a life-threatening element to which millions of people are exposed in both developed and developing countries. From last few decades, the climatic variabilities lead to decline in the groundwater table which is major cause of arsenic mobilization in aquifer system of India. Among arsenic removal technologies, the adsorption process has gained a considerable attention due to its large scale feasibility and easy operation. Therefore, for facilitating a large scale production of nanomaterials which are also stable, exploring the use of abundantly available industrial and natural waste as a precursor material appears to be a logical choice, which in turn requires the development of a novel approach of synthesis. In present study, raw waste from distillery industry is utilised as a precursor material for the synthesis of nanohybrid. This waste is rich in organic components such as oligosaccharides and polysaccharides (starch, cellulose, hemicellulose and lignin). Under strong alkaline conditions, these have capabilities to form reducing sugars with different compositions. The utilization of industrial waste as precursor material for the synthesis of nanohybrids led to the encapsulation of functional groups on the iron nanoparticles surface having different characteristics.

Keywords: Industrial waste, nanostructures, arsenic removal, Taguchi's methodology

Assessment Of A Wastewater Treatment Plant Performance And Suitability Of Treated Water For Irrigation Purpose: Case Of The Brewery Bb Lome

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One of the options for coping with water scarcity problems is not only, the improvement of wastewater treatment technologies but also, opportunities for reuse of treated wastewater. This study was conducted to evaluate the performance of the wastewater treatment plant (WWTP) of a brewery located at Lomé and to present the opportunities of water reuse using this brewery as an example. The WWTP consists of an anaerobic treatment after pretreatment and equalization process and at the final step a conventional aerobic treatment is used before effluent rejection in Zio River. In the present study we used data of control and monitoring of the WWTP. The results showed that the COD removal efficiencies ranged between 48.65 % - 90.51% for anaerobic treatment at an Organic Loading Rate of 1–3.8 kg COD/m³/day. The COD removal efficiency after aeration was in range of 12% to 74%, making overall removal efficiencies of COD after Anaerobic and Aerobic system to range from 74% to 96%. Microbiological parameters show high values of total coliforms (1,180,000 /100 mL) but compatible with agricultural use because of the absence of *Escherichia coli* in final effluent. Regarding potential in irrigated agriculture we found that the final effluent is suitable for irrigated agriculture with Sodium Absorption Ratio (SAR) and Electrical Conductivity under 40 and 500 μ S/Cm respectively. The final effluent constitutes a supply of nutrients (13.2mgN/L and 7.9mgP/L) and a potential of fertilizing elements in irrigated agriculture for crops growth. This paper includes effluent characterization, treatment scheme and performance of a brewery effluent treatment plant under study. In addition to it, the problems associated with the operation and maintenance of brewery effluent treatment plant was discussed and suitable recommendations were made based on its performance..

KEYWORDS: Brewery; Wastewater Treatment Plant; COD; Anaerobic; Performance; Irrigation

Wastewater situation of abattoirs in Africa and decentral treatment options - a case study from Sunyani (Ghana)

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An appropriate wastewater management and treatment is crucial to sustain a natural environment and intact ecosystems as well as to secure the quality and availability of waterbodies for human use. In most African countries wastewater infrastructure and treatment is at a very low level and a huge amount of untreated or partially treated wastewater is discharged into lanes, ditches, rivers, estuaries and the sea as well as onto open urban spaces with the associated negative effects. From all the different types of wastewater, slaughterhouse wastewater is amongst the ones bearing the highest potential to impact environment and health due to its high levels of organic content, nutrients, solids, fats, fibers and bacterial contamination including pathogens. Despite these risks most slaughter facilities in Africa are currently not treating their wastewater. As a case study a qualitative and interdisciplinary case survey on Sunyani abattoir (Ghana) was carried out on its actual waste water situation, the consequences of the lack of treatment and on options of management and treatment which could improve the situation. At present approximately 2.2 up to 5.4 m³ of a typical slaughterhouse wastewater with a chemical oxygen demand of 3651 mg/l (whereas the German limit value for domestic wastewater is 150 mg/l) are openly running through a densely populated area, ending up in Adjei stream. Possible treatment solutions had been selected to be easy to operate and cost-effective. The case study contributes as an overall objective to a better understanding of the general (slaughterhouse) wastewater situation in Ghana and related countries.

Keywords: Waste Water, abattoir, decentral treatment options, Africa, Ghana

Integrated Faecal sludge-based business models with safe Resource Recovery and reuse: insights from a compendium of empirical cases in developing countries

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Sustainable faecal sludge management (FSM) can be achieved with integrated business models that go beyond standard sanitation services and turn faecal sludge (FS) into valuable resources such as energy and nutrient. The conventional model of providing sanitation and waste disposal as a social service is no longer viable as national authorities lack financial and human resources for operating and maintenance as well as for addressing the sanitation needs locally. One way to address this is through innovative FS-based reuse business models. To achieve success, the FS reuse business models must be technically and financially feasible and the rewards must go beyond business certainty to health risk reduction. Different entities are capturing the commercial value in FS via energy and nutrient recovery to ensure sustainable delivery of sanitation services as well as to save on costs. Energy recovery from FS through the installation of biogas systems provides opportunities for domestic, institutional and industrial sectors to save on energy costs by using biogas produced onsite for cooking, power generation and lighting. Faecal sludge-based reuse businesses are either owned by the public sector with the objective of cost-recovery for sanitation sector and potential for revenue generation or by private sector enterprises with the objective for cost savings or profit maximization. These businesses can also be run as public-private-partnership entities or as community based organizations (CBO) or social enterprise models where the business is driven not by profit maximization but by the aim to maximize social welfare. In this paper, we present successful and emerging business cases for recovering energy and nutrient from FS for developing countries. The business cases are analyzed for their business concepts and opportunities and challenges for scaling-up.

KEYWORDS: FAECAL SLUDGE, BUSINESS MODELS, RESOURCE RECOVERY AND REUSE, DEVELOPING COUNTRIES

Assessment of seasonal and spatial variation of water quality in a coastal Basin: case of Lake Togo Basin

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Abstract Togo is a Sub-Saharan country with tropical climate and a great potential in water resources but the lack of water quality monitoring, data base on water quality and tools for water management caused many damages such as water availability. Lake Togo basin is the third watershed of Togo with costal localization in the south of Togo. This watershed is composed of three main sub-basins supplied by many tributaries and its waters are used for many purposes. This study was undertaken to explore water quality variability, potential factors which control water quality variability and candidate parameters for a future water quality index development. Four sampling campaign were performed in seven sites of permanent running rivers, Notsè dam and in Lake Togo. Water quality analyzes were performed in Laboratory of Water Chemistry using standards methods described by AFNOR. Factor analysis, statistical tests, descriptive statistics and diagrams for evolution trends of parameters were executed by Statistica for window 7.0. Globally water chemical quality agree criterions and standards for surface water quality except EC (Max EC= 32200 μ S/Cm) during the dry period in Lake water. The microbiological quality doesn't meet criterions and standards conditions for surface water in all sites and sub-basins. The target study had highlighted a seasonal variation (between dry season and rainy season) and spatial variation (between sub-basins) in the trends of evolution of parameters in Lake Togo Basin. Statistical tests confirmed at $p < 0.05$ a significant variability of fecal coliforms, E. coli, water Hardness, Temperature, pH and Electrical Conductivity according to seasons and sub-basins. Factor analysis has highlight four main factors (83.46% of total variance) which governed water quality variation in Lake Togo basin.

Water Security in Coastal Bangladesh: Assessment and Prediction of Salinity Concentration in Aquifer Layers

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Groundwater resources are a key factor that influences water security in coastal Bangladesh. The understanding of the hydrogeological system in coastal Bangladesh is particularly critical due to the intricate interaction of the groundwater and surface water. Salinity intrusion into the groundwater aquifers is influenced both by the sea and the complex tidal river system. This study was conducted in the south-west coastal districts of Satkhira and Khulna and aims to understand the distribution of salinity in terms of chloride concentration in the aquifer layers using groundwater models and contaminant transport framework of the Visual ModFlow Flex 2015.1 software. Lithology data obtained from the Bangladesh Water Development Board (BWDB) were utilized to conceptualize the stratigraphic condition of the study area. The simulation of groundwater distribution revealed that the depth to groundwater table stretched as far as 92 meters below ground level in the study area. To ensure consistency with the observed values the calculated values were calibrated with observed groundwater heads from a BWDB groundwater hydrograph report. The study tries to assess and predict the salinity concentration in the aquifer layers under the boundary condition of the interaction of surface water system (tidal rivers and ponds) with the groundwater aquifer system. To obtain a salinity concentration model, a salinity concentration (in terms of chloride) head was assigned to the conceptualized study area, in the model domain under the GMS framework, based on field data measurements and periodic dry period concentration of salinity in the surface water bodies. The salinity concentration in the aquifer layers were computed by the MT3DMS engine of MODFLOW. Simulation results predicted that salinity concentration in the aquifer layers of Khulna will increase from 800 mg/L to 3200 mg/L in 20 years, from present, while that of Satkhira will increase from 2700 mg/L to 4700 mg/L.

KEYWORDS: WATER SECURITY, SW-GW INTERACTION, SALINITY, COASTAL AQUIFER, MODFLOW

Climate change adaptive capacities from legislations on agricultural water management and food security aspects (A case study of Iran)

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Iran, located in an arid part of the world, suffers from severe water shortage. Recently frequent droughts and climate change (CC) phenomena adversely affected water resources of the country.

In response to water scarcity, high attention to water management and food security in the agricultural sector, could be seen in the legislations and the laws and rules sets for these purposes. This fact especially is highlighted in the so called five years National Development Plans (NDP).

The objective of this research is to review and analyze the laws and rules relevant to the agricultural water management and food security from the aspects of their capacity on adaptation to climate change in Iran. The weak points and strengths of some most effective and important laws and policies are provided and elaborated. Review and analysis of the laws and rules indicated that 9 areas (pivots) of the agricultural water management and food security issues relevant to the CC could be identified. These pivots are: 1-Improvement of water consumption pattern, 2-Cropping pattern policies, 3-Consistency and conservation of agricultural production with adaptation to CC, 4- Information and risk management, 5- Food security conservation, 6-Mitigation of CC, 7- Biodiversity conservation and prevention of resources degradation, 8- Support and empowerment of stakeholders and beneficiaries, and 9- Development of research studies on CC.

Some conclusion and analysis were provided for each pivot. From the quantitative aspect, most of the relevant laws and policies were in the field of pivot 1. There are also enough laws and policies relevant to the pivots of 2, 4, 5, 7, and 8. Unfortunately in the pivot of 3, 6, 9, i.e., Consistency in and conservation of agricultural production with adaptation to CC, Mitigation of CC, and Development of research studies on CC, there are limited number of laws and policies respectively.

KEYWORDS: Law, Rule, Development plan, Policy, Climate change, Water management, Agriculture

Rainfall And Temperature Variability And Its Effect On Food Security In Northern Nigeria-Review

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Climate change is the biggest environmental problem of our time which threatens the existence of man and the environment. It is a major threat to agricultural system and food security in many countries in sub-Saharan Africa (Okoli and Amaechi 2014). The Food and Agricultural Organization (FAO) in 2015 revealed that the vast majority of the world's hungry people live in developing countries with sub-Sahara Africa having the highest prevalence of hunger. Agriculture is the main economic activity carried out by a large majority of Northern Nigeria's population as 80% of the food crops consumed in Nigeria are cultivated in the North. Estimates from the 1991 National Population Census in Nigeria indicate that 69% of the population engages in agricultural activities and 40% of the nation's Gross Domestic Product (GDP) is derived from agricultural sector. Climate change impacts the four key dimensions of food security i.e. availability, stability, accessibility and utilization (Khisa, 2017). Changing climate has had a negative effect on food production and water availability in the country; the temperatures are increasing, extreme climatic conditions such as drought have become more frequent and severe in North Nigeria while the amount and frequency of rainfall has reduced leading to food insecurity. However, even if there is sufficient rain, its irregularity has affected yields adversely. When the rains arrive late or fail to arrive during the crucial growing stage of the crops, yields are affected and this in turn impacts on food security. This review recommends measures which need to be put in place so as to reduce the negative effects of climate change on food security in Northern Nigeria. Among them are drilling wells for irrigation, planting trees, planting drought tolerant crops and water harvesting

KEYWORDS: Food Security, Rainfall, Climate Change, Temperature

Evaluating the Suitability of Landsat TM to Detect Water Salinity of Coastal Bangladesh

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Salinity problem is a very common phenomenon in coastal areas and coastal Bangladesh is not any exception. Salinity level is increasing day by day due to various natural and human induced reasons. Both soil and water salinity have increased significantly in coastal Bangladesh. Monitoring the change in water salinity and keeping the track will be proved very vital to promote sustainable water management system. To ensure the availability of fresh water to coastal people, it is very much needed to detect the saline affected water bodies. Mapping the saline affected water bodies and their level of salinity can be done with the help of conventional technique involving collection of field samples and laboratory tests, which is very time and resource consuming. If the open access Landsat images can be proved to have potential to detect saline affected water bodies, it will be great help to map salinity condition very effectively. So this study aims to evaluate the applicability of Landsat TM images to detect the water salinity of coastal Bangladesh. Landsat 5 TM images (dated 27 March 2007) of WRS2 path/row 137/44 and 137/45 have been collected from USGS website and field level salinity data (in terms of EC) have been collected from SRDI. SRDI collected those field samples in the months of March to April in 2007. Band 1, 2, 3 and 4 and seventeen compositions of these bands were compared with the field data and they showed negative correlations. Among them, band 3 showed the highest correlation ($r^2 = 0.6966$) following by values of the product band 2 and 3 ($r^2 = 0.6371$). Other products of different bands showed higher correlations also. A multiple regression analysis has been carried out and an equation has been developed to calculate water salinity from band compositions of Landsat TM images.

KEYWORDS Coastal Bangladesh, Correlation, Landsat, Multiple Regression, SRDI, Water Salinity

Climate Change and Integrated Water Resources Management in Burkina Faso : case of Mouhoun River

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Water and climate change are regularly cited as one of the most serious crises that the humanity will face in the next decades. Water is a central element through which climate changes impact on societies and ecosystems. Integrated Water Resources Management (IWRM) has been widely considered as the most effective approach for an efficient management of water resources and ecosystem goods (EG), and Services (ES) derived from them. In Burkina Faso as many African countries, there is a low degree of the implementation of IWRM practices in order to optimize socio-economic and environmental benefits from EG and ES in response to effects of climate change. To aid in attainment of the sustainable development Goals (SDGs) mainly items 6 and 14 which are focused on water availability, our study investigated the practices of IWRM face to climate change conditions. This study examined the awarded capacities and challenges facing Burkina Faso in terms of the implementation of ecosystems based approaches for effective IWRM practices under changing climatic conditions: case of Mouhoun River ecosystem. Our work aims to contribute at the mitigation and adaptation of the climate change effect on water resources. Both qualitative and quantitative methods and analysis were used to collect and analyze data. Results showed the temperature increased and some modifications of precipitations were occurred causing a decrease of agriculture yields in this region and other negative effects on water resources. Preliminary works indicated the decrease of agriculture yields and the pollution of Mouhoun River due to climate change effects. Water area limits the discharge of Greenhouse Gas (GHG)toward the wastewater treatment. Water is among different strategies of adaptation face to climate change including climatic conditions, exposition, and vulnerability of natural and human systems. Consequently, that places the question of IWRM as one of adaptation conditions to climate change.

KEYWORDS Adaptation, climate change, mitigation, integrated water resources management

Assessment Of Ecosystem Diversity, Economic And Health Implications Of Climate Variability On Rural Dwellers In The Riverrine Areas Of Abia State

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A study of Climate variation is an important phenomena with significant impact on the quality of human lives especially in riverine areas. The study aims to assess the effect of climate variability on the species diversity of riverine ecosystem; the health status, and livelihood of riverine dwellers; the current knowledge, attitude, behaviour, practises in relation to climate variability; and the coping strategies adopted by rural dwellers in riverine areas in Ohafia, Ukwa West, Bende, Ikwuano, and Ukwa East LGAs in Abia State, Nigeria. Climate change is one of the most complex challenges of our young century. No country or state alone can take on the interconnected challenges posed by climate change, including controversial political decisions, daunting technological change, and far reaching global consequences. The benefits of climatic variations can be said to advance or diminish the biodiversity of an ecosystem in any given environment. The benefits of climatic variations can be said to advance or diminish the biodiversity of an ecosystem in any given environment. The study is carried out in five (5) Local Government Areas of Abia State (Ohafia, Ukwa West, Bende, Ikwuano and Ukwa East), Nigeria. Two (2) communities/villages will be selected from each local government area and this will give a total of 10 villages. Qualitative and quantitative data are used in this study. Water and sediment quality are monitored thrice monthly. To determine the physicochemical properties of the water bodies, 3 sampling stations was selected and the coordinates taken. The species richness and diversity of each water body are computed using the Margalef (MI) Index and the Shannon-Weiner Index (H) respectively, while the Sorensces index will used to evaluate the similarity of species between the water bodies. The total outcome of finding from this study will be shared to a wider society after the completion of the study.

KEYWORDS Climate Variability, Biodiversity, Water Quality, Sediment Quality, Abia State, Nigeria

Coping with climate variability and water stress in rice farming of India: a study

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Rainfall variability and rising temperature due to the climate changes adversely affect the productivity of rain-fed rice in India. Rice is the main staple food, therefore, its low yields or crop failure imposes a large negative impact on livelihoods and food security of rural communities. A study is conducted in 6 villages of Bankura district where rice grown under tropical-monsoon climate, to evaluate the farmers' perception about climate vulnerability and their coping strategies, and to suggest the policy interventions for sustaining productivity. Quantitative data is generated from survey of 432 households with structured questionnaire, focus groups discussion and field observations, and statistically analyzed using SPSS. Results reveal that 92% of the respondents are experiencing the changing rainfall pattern and higher temperature compared to the past 20 years. Their perception confirms our meteorological analysis indicating 13% less rainfall and 0.80C higher mean temperature in this area. Farmers realize higher evaporation demands and acute water stress due to in-season drought, so 23% of the farmers have adopted small-scale rainwater harvesting for life-savings irrigation to rice. 31% of the farmers have modified agricultural practices by diversifying the cropping pattern, substituting rice with drought tolerant maize and groundnut crops, and practicing the forage crop-livestock mixed farming to combat climate variability. Our researchers have introduced the system of rice intensification (SRI) method in 2 villages among 26 farmers, which exhibit 28% higher yield using 40% less water. The study suggests the evolution of a robust policy integrating rain-water harvesting, capacity building of stakeholders on efficient rainwater use, adoption of SRI technology and alternate crop-livestock farming, institutional credit supports to farmers, public-private research partnership for developing drought tolerant varieties and technologies, institution-village linkages for strengthening extension services and advanced climate forecasting systems which can significantly increase the subsistence farmers' adaptation to the future climate change.

KEYWORDS: Climate change, water stress, rice yield and adaptation strategies
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Climate change impact on water resources in Amman Zarqa basin: Adaptation scenarios

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Climate change is expected to bring the water shortage problem in Jordan to more severe levels due to reduced resources and increased demands as a result of the projected temperature rise and rainfall reduction. As a consequence, the gap between supply and demand is expected to enlarge which makes a real challenge to the socio economic development in Jordan. This paper investigates several climate change scenarios of temperature rise and rainfall reduction and their impact on water resources management in Amman Zarqa basin in Jordan. The paper further looks into several adaptation scenarios to bridge the enlarging gap between available resources and demands and consequently sustain the socio-economic development. The adaptation scenarios consist of demand management options, increased use of non conventional resources and development of new resources. Demand management options include Non Revenue Water reduction, and improved water use efficiency in the agricultural sector. Non conventional resources includes increased use of treated wastewater due to increasing connectivity to the sewer collection system, and rainwater harvesting, while development of new resources includes the implementation of the Jordan Red Sea Project (JRSP) as well as other smaller scale projects as planned in the Jordan's national water strategy. The results showed that demand management options and increased use of non conventional resources are projected to narrow the gap between supply and demand; however, significant deficiency will still exist. Furthermore, implementing the JRSP project is projected to bring the deficiency to low levels. In addition, a combination of demand management, increased use of non conventional resources and implementing the JRSP project is projected to bring the deficiency into new low levels. The Water Evaluation and Planning (WEAP) system which is developed by the Stockholm Environmental Institute was implemented to model Amman Zarqa basin and to run the climate change and adaptation scenarios.

KEYWORDS: Climate change, water stress, rice yield and adaptation strategies

Environmentally Induced Displacement And Its Interdependencies With Water Security: A Study On Sea Level Rise In Coastal Area Of Bangladesh And Louisiana

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Sea level rise is a slow-onset climate event has both long term and short term impact, and produces both environmental motivated as well as forced displacement. The impacts of climate change on water are leading substantial challenges in security and stability in agriculture, health and other related sectors. Both Bangladesh and Louisiana are not water scarce area but sea level rise and its subsequent impacts are threatening human life, security and sustainability. Based on secondary based research, this study shows the connection between water security which in turn triggers and intensifies migration patterns in Bangladesh and Louisiana coast. Bangladesh government has addressed some climate resilient water supply technologies but such initiatives do not ensure adequate coverage at all time. On the other hand, relative sea level rise and its subsequent challenges in Louisiana make some tribes or communities difficult to stay in their native land. Though Louisiana has taken some coastal protection and restoration programs but still coastal people are migrating from southeastern to northern Parishes or States. People in coastal area of Bangladesh are facing low adaptive capacity, low governmental response led to unplanned urbanization represent a response to the consequence of failed adaptation to water scarcity. The study found out international and national level legal efforts are necessary but local government response can solve this problem an efficient way as they are close to such victim population. Again, developing policy measures or integrating water insecurity issues in national policy level, integrating water rights and resilience issues with existing relevant policies, involving local people in decision making process, developing capacity building for local government authorities and administrators (especially those who are related with water and related tasks) etc. can reduce human displacement due to sea level rise and ensure water security in both delta areas.

KEYWORDS: Sea level rise, Water security, Water governance, Disaster Risk Reduction, Adaptation planning

Geological aspects of CO₂ sequestration in saline carbonate formations

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An increased anthropogenic emissions of greenhouse gases affects climate change by altering the extreme weather conditions and agricultural disruptions. CO₂ being the major contributor of global warming hence, require innovative mitigation techniques like carbon capture and sequestration. Amongst different CO₂ sequestration options, the geological one is the most effective form of capturing CO₂ from large point sources, and storing it in vast geological formations like deep saline aquifer for long period of time. Geological sequestration in carbonate formations is a promising means to reduce CO₂ concentration in atmosphere. The geo-sequestration involves cyclic CO₂-brine flooding hence, investigation of the target formation for capacity, integrity, interaction between rock and CO₂/brine system offers research scope. The intent of this study is to investigate the effect of different environmental factors on the migration pattern of CO₂ in subsurface using a series of laboratory experiments. The impact of injection pressure and salinity is evaluated along with image analysis of the carbonate core samples. A series of laboratory experiments using core flooding apparatus having salinities 3 % and 7.5 % involving 8 and 10 MPa injection pressure is performed. The differential pressure profile of the core samples is observed for feasibility of sequestration study in carbonate formations. The differential pressure across the core increases with salinity and successive injection cycles; and decreases with injection pressure leading to dynamic response of core samples. The changes are attributed due to hysteresis effect, formation changes and acidic chemical reactions between carbonate and brine/CO₂. The image analysis provides mineralogical changes due to dissolution/precipitation of carbonate minerals. The findings of this study will enhance the knowledge of geo-sequestration study in carbonate formations to mitigate the impact of greenhouse gas emissions.

KEYWORDS: Geological sequestration, global warming, cyclic CO₂-brine flooding, mineralogical changes

Using Hybrid Solutions For Coastal Protection As Part Of The Adaptation Of The Nile Delta To Sea Level Rise

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The Nile delta is a typical wave-dominated delta. Most of the 50 km wide land strip along the Nile Delta coast is less than 2 m above sea-level and is protected from flooding by a sand belt that is only hundreds of meters wide at some places. This protective sand belt is facing rapid erosion, which has been a serious problem since the construction of the Aswan dam that totally blocked the river sediment discharge. Rising sea level is expected to destroy weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands. SLR impacts will be very serious including degradation of surface water quality and increasing groundwater salinity, in addition to threatening almost one third of aquaculture production and the most valuable agricultural land in Egypt. UNDP is currently funding an ongoing project in Egypt for the "Adaptation to Climate Change in the Nile Delta through Integrated Coastal Zone Management". The project approach for any measures undertaken for the protection of the delta lagoons against erosion and SLR is avoiding hard structures, be innovative in nature, and provide flexibility for future adaptive activities in the region to augment project activities. The "Living Shorelines" approach meets these criteria and has been shown to be an effective strategy to control erosion and reduce land lost to sea level rise. The new approach is adopted by the Egyptian Government for the protection of Egypt's Low Elevation Coastal Zone (LECZ) in the Nile Delta. A pilot project was implemented to protect the narrow sand barrier of El-Burullus Lagoon. This paper discusses the impacts of SLR on water quality and the ecological conditions in the Lagoon, in addition to the assessment of this adopted approach from both the functional and the ecological perspectives..

KEYWORDS: Nile Delta, El-Burullus Lagoon, Sea Level Rise, Living Shoreline Approach, Water Quality

Bias Correction To Streamflow And Future Streamflow Predictions In The West Seti River Basin, Nepal

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West Seti River of Nepal is one of the major contributor and most vulnerable basin with regards to the potential impact of climate change. It is a known fact that climate change affects the river flow and related component. Also, the importance of predicting flow patterns is paramount for the planning purposes of any region. This study focused on bias correction of flow and flow obtained with the use of bias corrected RCM data. A hydrological model at the basin was developed using SWAT model for the calculations of river flows. The raw river flows were obtained by using downscaled RCM data to feed the model as input. After that, the future flows were bias corrected using Quantile Mapping (QM) for RCMs CCAM (ACCESS), CCAM (GFDL) and CCAM (MPI) and, two future scenarios RCP 4.5 and RCP 8.5. The results determined that the bias correction of flow using QM was most effective, statistically better than LS and hence was used for flow prediction alongside flow simulated with bias corrected RCM data. In addition to it bias correcting the climate data the high flows are expected to increase and low flows are expected to decrease in both Near Future (NF) and Mid Future (MF) for both RCPs. By bias correcting the flows the expected high flows would be less than the base period whereas the low flows are expected to be slightly higher than the base period. Therefore, bias correcting the flows have shown better correlation with observed flows compared to bias correcting the climate parameters. The percentage change in flow of all three stations considered, can be predicted to vary within -10% to +15% of the baseline flow for RCP 4.5 and RCP 8.5 of bias correcting the flows..

KEYWORDS: Climate change, Hydrological modelling, RCM, Flow, Bias correction, SWAT

Building the Adaptive Capacity for Livelihood Improvements of Sahel Savannah Farmers Through NGO-led Adaptation Interventions

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This paper explores the extent to which NGO-led interventions on Climate Change adaptation over the years have developed the adaptive capacity of farmers in Ghana. Drawing on the experiences of farmers from the Savelugu/Nanton Municipal Assembly in Ghana, the paper investigates whether the adaptation practices by NGOs are localized and sufficiently progressive to ensure sustainable adaptation. The study is situated within the interpretive paradigm using a qualitative approach. Data was collected through interviews and focus group discussions with NGOs and farmers in the municipality. The study finds that institutions, particularly international NGOs and the various interventions they led have been very critical for developing potential of farmers to be actively involved in the processes of change to minimize the negative impacts of Climate Change. They provide direct and indirect capacity building activities such as providing farmers with information on climate change and its impact on their yields and livelihoods, building farmers skills and knowledge to deal adequately with climate variability, laying the foundations for individuals to build various capitals, directly assisting in coping and adaptive livelihood activities, financial assistance to build livelihood capitals and engaging in impact offsetting strategies. These determinants of the adaptive capacity provide interesting input in terms of guidance for management options to enhance the adaptive capacity of the communities in the face of climate change. Such results are significant in informing policy and practice at the national and local levels.

KEYWORDS: Climate Change, Adaptation, NGOs, Adaptive Capacity

