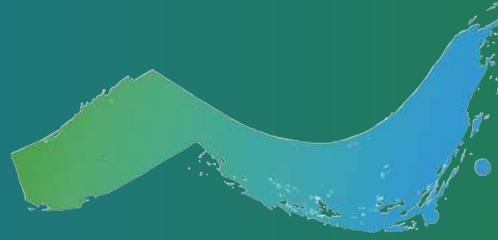




MINISTRY OF WATER



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# BOOK OF ABSTRACTS

## MAJI WEEK 2019

### ANNUAL SCIENTIFIC CONFERENCE

18<sup>th</sup> - 19<sup>th</sup> MARCH, 2019

DODOMA

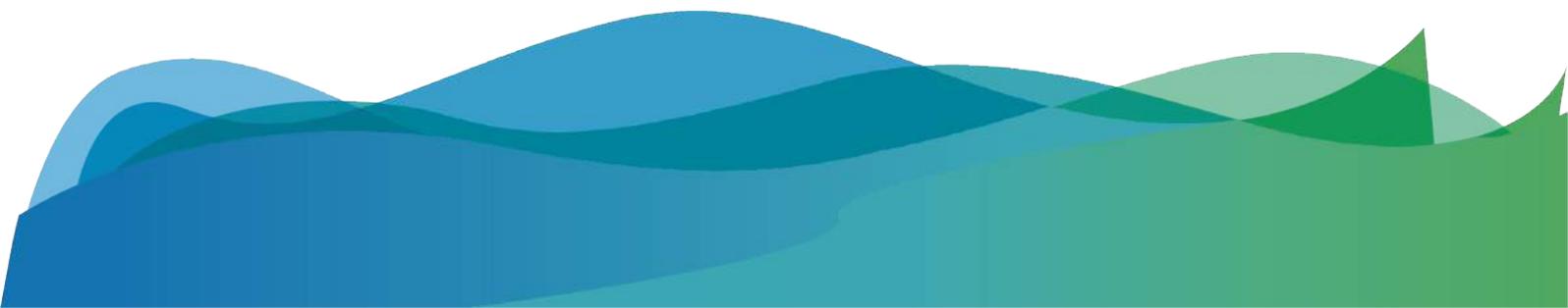
**LEAVING NO ONE BEHIND:** ACCELERATING UNIVERSAL ACCESS TO WATER SUPPLY AND SANITATION SERVICES IN A CHANGING CLIMATE



**LEAVING NO ONE BEHIND: ACCELERATING UNIVERSAL ACCESS TO  
WATER SUPPLY AND SANITATION SERVICES IN A CHANGING CLIMATE**

*Compiled by:*

**Global Water  
Partnership  
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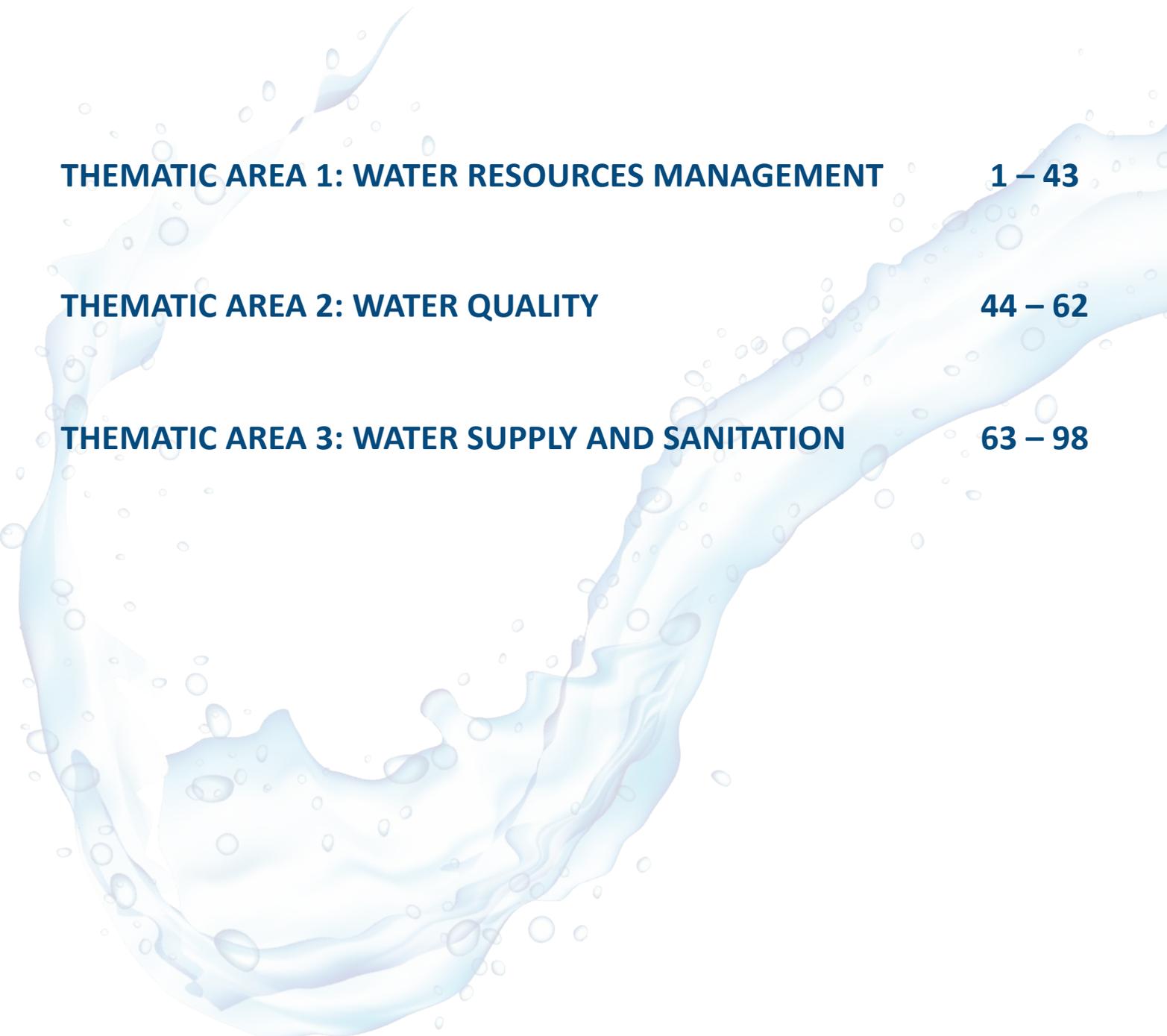


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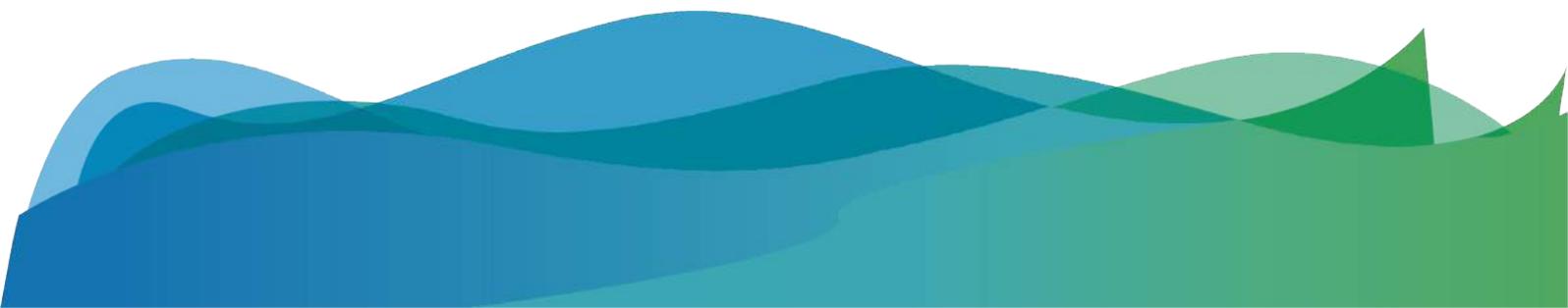


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**THEMATIC AREA 1**  
**MAJI WEEK 2019 Scientific Conference**

A large, dynamic splash of water in shades of light blue and white, with many small bubbles and droplets, forming a shape that resembles a stylized 'W' or a wave. It is centered on the page.

**WATER RESOURCES MANAGEMENT**

# ORAL PRESENTATIONS

## CHARACTERIZATION OF SURFACE-GROUNDWATER HYDROLOGICAL PROCESSES IN USANGU CATCHMENT: ISOTOPIC AND HYDROCHEMISTRY PERSPECTIVE

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### Abstract

The stable isotopes compositions of water ( $^{18}\text{O}$  and  $^2\text{H}$ ), major dissolved ions ( $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{SO}_4^{2-}$ ) and dissolved silica ( $\text{SiO}_2$ ) for rainfall, rivers, springs and wells were used to characterize hydrological processes in the Usangu catchment. Analysis of variance, Hierarchical Cluster Analysis, factor analysis and the Piper diagram were used to determine hydrochemical facies to delineate the origin, flow paths of water and interconnections among water sources. The abundance of dissolved ions in water sources were in the order of  $\text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^+$  and  $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^{2-} > \text{CO}_3^{2-}$ , whereby the highest ions concentration occurred in wells, and differed significantly from that of rivers and springs at 95% confidence level due to prolonged water-rock interactions, suggesting two different subsurface water flow pathways. Low dissolved ions and silica that did not differ significantly at 95% confidence level, as well as their co-existence in the same hydrochemical water clusters suggested a close river-spring hydrological connection. Furthermore, factor analysis showed that 52.8% of variations in water sources was explained by dissolution of carbonate and silicate minerals, indicated by  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{SO}_4^{2-}$ ,  $\text{HCO}_3^-$ ,  $\text{SiO}_2$ ,  $\text{Cl}^-$  and  $\text{CO}_3^{2-}$ , most of which constituted the major hydrochemical facies, and 20.3% by source effects indicated by  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ . The overall mean  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  values in rainwater (-4.2‰ and -27.7‰), rivers (-4.0‰ and -25.0‰), springs (-5.6‰ and -32.5‰) and wells (-4.6‰ and -27‰) did not differ significantly at 95% confidence level, suggesting a recent recharge. However, the water in wells were slightly enriched with  $^{18}\text{O}$  compared to spring and rivers. Further, water in wells had high  $\text{SiO}_2$  concentrations that correlated positively with  $\delta^{18}\text{O}$  values at 95% confidence level ( $r^2=0.96$ ), attributed to prolonged rock-water interactions along the sub-surface flow path. Further studies involving geophysical survey to map specific type and exact depth of aquifers are recommended for better understanding of water resources in the watershed to enable proper water resources use, planning and protection.

**Keywords:** Environmental isotopes, Hydrochemistry, Hydrological processes, Surface-groundwater, Usangu Catchment

# GROUNDWATER RECHARGE AND THE SUSTAINABILITY OF THE MAKUTAPORA WELLFIELD: NEW EVIDENCE FROM MONITORING AND MODELLING

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## Abstract

Intensive groundwater abstraction from the Makutapora Well field in central, semi-arid Tanzania is the primary source of safe water for the rapidly growing population of Dodoma. The long-term sustainability of this source of freshwater remains, however, unclear. Evidence from a near-continuous record of groundwater-level observations since 1954 reveals that recharge sustaining well field pumping occurs infrequently and depends on heavy seasonal rainfall associated with El Niño events. The disproportionate dependence of groundwater recharge on heavy rainfall is further indicated by stable isotope ratios of O and H which show that the isotopic composition of groundwater matches that of daily rainfalls exceeding the 70th percentile. New evidence from high-frequency monitoring of groundwater levels and stream flow stage, implemented in advance of the 2015-16 El Niño event, reveals the dissipation of groundwater 'mounds' laterally away from ephemeral stream discharges. A strong linear correlation ( $R^2 = 0.95$ ) observed between the duration of ephemeral stream flow and the magnitude of groundwater recharge recorded by piezometry strongly indicates that the dominant form of recharge to the Makutapora Well field is 'focused', not diffuse, deriving primarily from leakage of ephemeral streams draining into the well field depression. This newly developed conceptual model of groundwater replenishment, together with new observational records, informs the development of a three-dimensional, discredited numerical model in MIKE-SHE. Preliminary scenarios suggest that the intensification of rainfall under climate change amplifies recharge. Simulations suggest further that recent rates of groundwater abstraction ( $\sim 50\,000\text{ m}^3\text{ day}^{-1}$ ) are viable but that pumpage at the maximum capacity ( $\sim 81\,000\text{ m}^3\text{ day}^{-1}$ ) as determined by the transmission line between the well field and Dodoma, is not. Further field research and modelling are required to resolve the maximum, sustainable pumping rate of the well field. An expansion in the distribution and number of monitoring wells is required to better constrain the response of the well field to intensive pumping. Additionally, the noted predictability of seasons of heavy rainfall associated with El Niño events opens up the possibility of developed adaptive strategies including Managed Aquifer Recharge to amplify replenishment to the well field

**Keywords:** El Niño, Groundwater, Managed Aquifer Recharge, Makutapora Well field, Stable isotope

# GROUNDWATER ASSESSMENT AT JTI TANZANIA CIGARETTE PUBLIC COMPANY LIMITED BOREHOLES LOCATED AT NYERERE ROAD INDUSTRIAL AREA ALONG THE KARIAKOO-UKONGA SECTION, DAR ES SALAAM REGION, TANZANIA

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## Abstract

Decrease in water level and yield as well as water quality deterioration in the JTI Tanzania Cigarette Public Company Limited boreholes compelled the management to undertake groundwater assessment. The Kariakoo-Ukongu section in the Dar es Salaam region where the boreholes are located is densely populated as a result of which the aquifers are easily over-exploited beyond their safe yield due to over pumping. As a result, seawater intrusion leading to aquifer salinization have been caused by declining groundwater-levels. This study attempts to demonstrate methods for groundwater assessment in response to the current water situation using hydrogeological mapping, geophysical investigations, recharge estimations from literature; aquifer and quality testing methods. The study summarizes the most important causes for depletion of groundwater at TCC and nearby areas leading to a decrease in water level and yield. Although groundwater is one of the major freshwater sources in Dar es Salaam region, there has been very little attention on the potential effects of climate change on this resource. Shallow aquifers, which supply much of the local societies, are most sensitive to long term climatic variations and changes. Thus, more attention must be given to the effect of climate change on shallow (unconfined) aquifers. Projected sea-level rise due to climate change and excessive withdrawals along coastal areas may cause salt water intrusion into fresh groundwater reservoirs in the area. "IX1D" program was used for inverse modeling and preparations of apparent resistivity curves. FC-ABC and AquiferTest models were used to determine the aquifer hydraulic parameters and sustainable and safe yield of the borehole from a 72 hours single borehole pumping test. The results show that the presented methods can be satisfactory for groundwater assessment.

**Key words:** Water quality and quantity, safe yield, seawater intrusion, aquifer salinization, hydraulic parameters, hydrogeological mapping

# ENHANCING DECISION-MAKING IN RUFJI AND WAMI-RUVU BASINS THROUGH IMPROVED DATA/INFORMATION MANAGEMENT AND CAPACITY BUILDING

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## Abstract

The Water Resources Integration Development Initiative (WARIDI) is implemented in two of the basins namely; Wami/Ruvu and Rufiji basins. Almost all basins in Tanzania face a critical challenge of data and information management for decision-making. One of the key activities of WARIDI project is to improve data and information management in these two basins through improvement in Hydromet monitoring in order to address the identified data needs and information for decision making. The hydrometric network in Rufiji and Wami/Ruvu basins comprises a total of 57 and 43 hydrometric stations respectively. More than half of these stations have no rating curves, while the rating curves for the remaining stations are most likely inaccurate for low and high discharge values. The existing data and products are generally poor and not satisfactory for decision making. As part of WARIDI project, Twenty-five (25) stations in Rufiji and Fourteen (14) Wami/Ruvu Basins have been selected as highest Priority stations. WARIDI has supported these stations with improved repairs of existing equipment, upgrading stream flow gauging equipment, robust hydro meteorological information management and enhanced capacity in Hydromet monitoring and development of information products. This was done through use of combination of low-cost automatic weather stations, precipitation and stream flow sensors, robust stream flow and water quality sensors, and introduction of a modern hydrologic data management software to provide data and information essential to decision makers involved in water resources management and development. Low cost citizen science techniques are promoted as they have a huge potential to reduce basin office resources requirements given the financing and staffing constraint through engagement of stakeholders. The modern stream flow measurement equipment combined with the hydrologic data management software will provide the basis for improved rating curves and automated hydrometric observations. The project is expected to contribute to the decision making in water resources management specifically for water allocation and permitting through improvement of data collection and processing; data and information storage addressed through improvement of the basin data base server (AQUARIUS), low cost science, operation of dams for hydropower generation, and conflicts resolution.

**Keywords:** Data, Information, Capacity, Decision-Making

# VULNERABILITY IMPACT ASSESSMENT: A TOOL FOR ENHANCING WATER RESOURCE MANAGEMENT IN RUFJI AND WAMI-RUVU BASINS

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## Abstract

Climate change is global threat with profound impacts on river basins as well as all other economic and social sectors in Tanzania. However, the extent with which each sector/basin is affected differ significantly depending on the resilience of each system which is determined/influenced by the three interrelated parameters, exposure, sensitivity and adaptive capacity. This fact suggests that, different parts within the same basin/sectors may require different interventions in order to cope appropriately based on their vulnerabilities. Identifying those areas of concerns 'hotspots' within the basin requires use of credible and robust scientific methodologies combining statistical and dynamical modeling. As part of its efforts to address climate in the Rufiji and Wami-Ruvu basins, WARIDI project applied the IPCC framework to assess vulnerability of water ecosystems and communities to the impacts of climate change. This framework applied an investigative equation whereby vulnerability is a function of exposure, sensitive and adaptive capacity parameters. The inputs to these parameters included both climatic/hydroclimatic data from TMA, hydrometric stations in the two basins and socio-economic data from NBS. Satellite data were also used to fill in the gaps in areas with missing and or inconsistent data series. Through this approach, WARIDI identified a total of 28 hotspots as areas of most concerns in terms of water stress and vulnerability to changing climate, therefore, requiring urgent targeted adaptation measures to reduce their vulnerability and ensure sustainability of water services. These results were presented to the multi-stakeholders' workshop for validation where it was confirmed that the findings reflected to a great extent the observed realities in the identified areas. WARIDI has used this information to prioritize and target those areas for interventions. In addition, WARIDI has disseminated this information to respective basins and LGAs and organized training in order to strengthen their capacity to use the results in planning and decision-making to ensure sustainable management of Water Resources in the two basins.

**Keywords:** Water-stressed areas, Climate change hotspots, Sustainable Management of Water Resources.

# THE INFLUENCE OF 1890, ANGLO – GERMANY TREATY ON TRANSBOUNDARY WATER COOPERATION AND CONFLICT RESOLUTION IN THE SOUTHERN AFRICA REGION (SADC)

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## Abstract

The availability, distribution and control of freshwater resources have been at the centre of the human story since the start of the Neolithic revolution roughly 12,000 years ago. With the advent of the modern nation state and its attendant emphasis on sovereignty, self-sufficiency and rivalry, it comes as no surprise that interactions between states over shared watercourses have at times been tense and conflictual. This fact was elaborated by the Ex- UN Secretary General; Kofi Annan, Message during the World Water Day on 22nd March, 2002. He warned that... “Fierce national competition over water resources has prompted fears that water issues contain the seeds of violent conflict. By the year 2025 two thirds of the world’s population is likely to live in countries with moderate or severe water shortages as demand for water approaches the limit of the available supply”. Water as a fugitive resource, respects neither political boundaries nor commonly accepted notions of fairness or equity, hence posed the most complex management challenges to water managers of today. In the SADC region, shared waters cannot be viewed in a purely national context due to its fluidity and the mobility of its nature. It is factual that, over 70% of the water bodies in the region are transboundary in nature. In terms of state practice, the concept of community of interest is commonly traced back to a French decree of 1792 dealing with the opening of the Scheldt River to Navigation. The position expressed in this decree was quickly adopted in a number of instruments concerned primarily with rights of navigation in international rivers, but also in some early agreements not restricted to navigational uses. Therefore, the lakes, and watercourses which form the frontier between the two states or which are situated at the territory of both or which flow into the said lakes and watercourses shall continue to be considered as “common”. In this regard one may wish to refer to the recent global instruments namely; the UN Convention on the Law of the Non-Navigational uses of International Water (1997) which came into force on 17th August 2014 and the Convention on the Protection and Uses of transboundary Watercourses and International Lakes(1992) which came into force on 6th October,1996 and further in 2016 became an official global legal framework for transboundary water cooperation. These instruments are regarded as a vital step in building a strong foundation for global principles on water management and governance. Legal agreements between states during the colonial era as well as post-independence in the Southern Africa region, have formed the bedrock of cooperative water resources management regionally. The Anglo Germany Treaty of July, 1890 (The Helgoland Treaty), had established an agreement between the colonial powers of Great Britain, France, Portugal, Belgium and Germany and their respective spheres of influence over the African nations aimed to establish borders between the nations. Interesting to note in the presence of scarcity of geo-information over the areas in question; the water bodies (Rivers and Lakes) were used to mark the lines of influence hence boundaries of the sovereign states of today. This paper therefore, will provide an account of the influence of the 1890 Anglo – Germany Treaty (Helgoland Treaty) and international customary law in regard to conflict resolution and transboundary water cooperation in the Southern Africa Region (SADC). It will also examine some of available information as well as the historical background of boundary treaties; legal frameworks for cooperation; importance of Africa Union(AU) resolutions on the same, such as Resolution AHG/Res16(1) of

July 1964 as well as resolution CM/Res.1069(XLIV) of 1986 and finally a conclusion.

**Keywords:**The Helgoland Treaty, AU Charter, Trans-boundary Resources, Anglo-Germany Protectorates, SADC, Spheres of Influence,

## **UPLIFTING WOMEN'S PARTICIPATION IN WATER-RELATED DECISION-MAKING BY TRANSFORMING SOCIAL NORMS: THE UPWARD GENDERED SOCIAL NORMS INTERVENTION**

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### **Abstract**

Women and girls in rural Tanzania disproportionately bear the burden of water scarcity and inadequate sanitation and hygiene, but their needs are underrepresented in community-based water-related decision-making. Women's membership in village and water governance institutions does not equate with meaningful participation. Social norms sanctioning women for speaking in public inhibit participation in decision-making. Through USAID's WARIDI project, UPWARD uses a gendered social norms approach to engage communities in critical reflection in Lulanzi and Kanolo Villages. We conducted a qualitative baseline study to identify norms that most hamper women's participation, developing participatory training materials in response. We trained community-based facilitators to use the materials with community leaders and women's groups over nine months to: identify/challenge harmful gender norms examine community leaders' expectations; and propose/apply more equitable approaches to water-related decision-making. An endline evaluation will gauge norm changes regarding women's participation in decision-making and women's confidence representing their interests in community spaces. Community-based sessions for leaders and women's groups, which were conducted from June to September 2018, generated wide interest across the community about gender roles and gendered social norms. In response, facilitators adapted content, conducting "open" sessions for the full community. In one session, a male village elder spoke to women: "If you are timid to speak in public meetings, keep pushing forward". Preliminary findings suggest social norms are shifting, concurrent with changes in women's participation. In June 2019, we will share findings about the degree to which gendered norms can shift during a one-year intervention. We anticipate evidence of greater participation of women in public decision-making and transformed norms, such as: It is acceptable that women speak with increased confidence in public, There is greater valuation of women's water-related knowledge, It is acceptable for leaders and men to support women's participation in water-related decision-making. Upward is one of the first interventions to adopt a gendered social norms approach to improve WASH-related outcomes. Social norms fundamentally inform behaviors, and changes can be long lasting. Evidence of norm/behavior change suggests this approach may be useful to alter gendered decision-making patterns.

**Keywords:** Gender, Governance, Inclusion, Norms, Women

# THE ALLIANCE FOR WATER STEWARDSHIP AND MAJI SASA! EFFECTIVELY ENGAGING THE PRIVATE SECTOR THROUGH WATER STEWARDSHIP

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## Abstract

The private sector is a major water user, can impose water impacts on other users and the environment, and has resources, influence and power. Effectively working with the private sector to improve water security for all is therefore a priority given Tanzania's many water challenges. This paper describes the work undertaken to date with the private sector in Tanzania through the Alliance for Water Stewardship (AWS) standard. The AWS standard is a global system, which guides and recognizes responsible water use and water user contributions to collective action and basin governance. We draw on participatory evaluations of stewardship programmes in Tanzania to explore the costs and benefits of the AWS approach. We demonstrate the benefits available from water stewardship for communities, government, the environment and business by drawing on case studies from the Ruvuma and Pangani basins. The insights and evidence suggest that a more strategic approach by government, business and civil society to water stewardship, which embeds it as normal business practice will pay long term dividends for social and economic development.

**Keywords:** Stewardship, smallholder, climate, Africa, supply-chains

# FROM PRACTITIONER TO PRACTITIONER: CATCHMENT MANAGEMENT TO SUCCESSFUL IMPLEMENT IWRMD

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## Abstract

Integrated Water Resources Management is the guiding principle of Tanzania's water sector. The fast growing population, the economic development and last but not least the effects of climate change are factors that make it increasingly important to manage the country's water resources to ensure water security for the future. Nine Basin Water Boards realize the management of water resources within hydrological boundaries and by the guidance of IWRMD Plans, which provide an outline for coordination and implementation on catchment level. This implementation requires intense horizontal and cross-sectoral exchange and coordination. However, the translation of IWRM to practice remains often a challenge. Due to the size of the basins, the BWBs' capacities are overstretched limiting institutional solutions closer to water users' problems. Further, the BWBs valuable data about water resources are not yet sufficiently shared and used among stakeholders. But activities for improving water security and the adaptation to climate change are constantly being implemented by different stakeholders. So far, there is no structured water user oriented mean of coordinating stakeholders and their activities. Uninformed decision making and a hampered collaboration between the active stakeholders is the result while information and data is available. The Catchment Management Approach is an opportunity for BWBs to make use of its data, ignite action and fulfil its role as regional coordinator. It provides a tailor-made setting by institutionalizing exchange and coordination of stakeholders while taking existing limitations of resources into consideration and focusing on priority issues of WRM. The approach accompanies repetitive multi-stakeholder events with standardized information products to close the knowledge gap on WRM challenges and issues as well as creating transparency on other stakeholders' activities. The combination of the tools follows a risk-based approach and aims at efficiently steering resources to create highest possible impacts by establishing participatory action plans. Hence it enables governmental and non-governmental institutions to coordinate their activities to implement measures with the focus on improving water security and adaptation to climate change.

**Keywords:** Catchment Management, Implementation of IWRM, Risk Based, User Oriented, Water Security

# IWRMD PLANS AS TOOLS FOR ENHANCING WATER SECURITY AND SUSTAINABLE WATER RESOURCES MANAGEMENT - CASE OF RUKWA AND RUFJI BASINS

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## Abstract

Integrated Water Resources Management (IWRM) principles were declared by the International Conference on Water and Environment in Dublin in 1992. The principles were globally accepted, by world leaders at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro later that year, as the way forward for sustainable water and environmental resources management which underpin sustainable development. The UNCED meeting urged Governments to translate IWRM principles into actionable plans for water, environment and sustainable development. Tanzania reviewed her water policy to reflect the IWRM principles as the cornerstone for sustainable water resources management and development. The new National Water Policy (NAWAPO) of 2002 promulgated the institutional framework appropriate to deliver on IWRM approach whereby Water Basins were designated as units for holistic water resources management and paved the way for enactment of new water resources management legislation. The Water Resources Management Act (WARMA) of 2009 requires each Basin to prepare an Integrated Water Resources Management and Development (IWRMD) plan. The Basin plans are envisaged to improve governance and enhance water security for social economic needs through improved water resources management that addresses multi-sectoral planning, environmental sustainability, stakeholder's involvement and managing water as an economic good, which are the principles of IWRM. Given the increase in population with its concomitant increase in social economic needs for water, storage and development of the same is crucial for enhanced water security. The total water demands for Lake Rukwa Basin in 2015 stood at 600.42 Mm<sup>3</sup> per annum and are projected to increase to 1,298.49 Mm<sup>3</sup> by 2035. To secure future supplies for different uses, Lake Rukwa Basin IWRMD Plan estimates a total storage of 1,575 Mm<sup>3</sup> in its different sub-basins and improvement of irrigation efficiency from 1.56 l/s/ha to 1.01 l/s/ha across the Basin. For Rufiji Basin, the total demand is projected to increase from 5,667,866 Mm<sup>3</sup> in 2015 to 9,077,463 Mm<sup>3</sup> by 2035. The Rufiji Basin IWRMD Plan estimates a total storage of 35,963 Mm<sup>3</sup> and 1,192 Mm<sup>3</sup>/year from groundwater development in order to meet the projected water demands. These proposed storage volumes take into account the impacts of climate change and water for the environment. It is further estimated that water development and storage required to meet future demands would cost 46.95M USD in Rukwa Basin and 7,485M USD in Rufiji Basin. These figures account for 53.15% and 83.5% of the total cost of implementing the IWRMD Plan in each Basin respectively. The costing was made in accordance to 2015 prices and exchange rates. This paper highlights how IWRMD Plans can be used to plan sustainably for enhanced future water security for socio economic activities taking into account the IWRM principles for overall sustainable development.

**Keywords:** IWRM Principles, IWRMD Plans, Climate Change, climate change Environmental Sustainability, holistic water resources management

# “IS TANZANIA’S CURRENT POLICY FRAMEWORKS ADAPTING TO INCLUSIVE WATER RESOURCES MANAGEMENT IN A CHANGING CLIMATE?”

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## Abstract

Water is one of the most treasured resources for driving inclusive local development in Tanzania. Both the Sustainable Development Goals and Tanzania Development Vision 2025 call for commitment to inclusive basic social services including water and sanitation. However, the current generation of policies focus on regulating water resources with the overarching assumption that the country has sufficient water resources to meet its present needs, from both surface and underground sources. Undoubtedly, the new climate normal calls for smarter water resource management with explicit integration of resilience through Climate change adaptation and Disaster Risk Reduction. The geography of inequality in access to water supply and sanitation services in the country raises concerns on potential fault lines in public policies. A retrospective analysis of architecture of policy frameworks that bear complicity to water, sanitation and hygiene was conducted, to characterize the effectiveness of the policy mix towards inclusion and universality. The analysis zoomed in from the general access to water and sanitation services across the country alongside analyzing the priority inter-sectoral issues. The analysis considered the legal and regulatory basis, organizations and policies. Impacts of climate change, ecosystem services and socioeconomic trends were also considered. Results from the analysis indicate weak intersections across the sector policies on land, environment, water, energy and agriculture, a critical nexus for integrated water resources management that can facilitate universal access to water, sanitation and hygiene, fragmented policy and institutional alignments, focus on regulation-only and ultimately decoupling from stakeholder engagement at multiple governance levels and huge gaps in sectoral responses to climate change. It is evident that integration across sectors and reconciling resource uses is challenging, but commitment to evolutionary policy mixes and confluences can make a huge difference in accelerating universal access. The paper suggest a need for pragmatic evolution of core policies towards a comprehensive Water, Sanitation and Hygiene (WASH) policy, rapid and evidence-driven integration of climate proofing and disaster risk reduction, strengthening community engagement particularly in harnessing nature-based solutions, mainstreaming water diplomacy as a tool for cross sector collaboration at sub national and local levels.

**Keywords:** Climate change Inclusion, Policy Water Sanitation

# ACCOUNTABILITY FOR WATER: ENSURING INCLUSION AND IMPACT FOR WOMEN

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## Abstract

Efforts to improve governance through stronger citizen oversight and accountability mechanisms in the water sector have clear potential to accelerate delivery of SDG 6. However, we need to better understand how women and the marginalized can be engaged within these processes, and the degree to which their inclusion influences outcomes. Addressing these knowledge gaps is a priority to avoid 'elite' capture and to ensure that accountability practice delivers equitable benefits. We share insights from new research in Tanzania, which assesses the barriers and opportunities for women's inclusion across multiple case studies of social accountability. Twelve focus group discussions were facilitated within case study communities in Morogoro and Dar es Salaam to investigate gender relations and women's participation in accountability. Specifically we explored: The constraints to women's engagement in accountability mechanisms on water, and how they can be overcome? Whether stronger engagement of women in accountability mechanisms influences outcomes, and if so how and why? Through sensitive open-ended questioning within groups (disaggregated by sex, age and socio-economic status), the insights provide rich qualitative findings to supplement evidence generated via large-n household surveys of water insecurity. Findings and conclusions: Findings confirm the disproportionate impact of water problems on women and highlight difficult barriers to women's involvement in improved governance to resolve these. They demonstrate the need for diligent planning for equitable engagement within initiatives to improve sector governance. These should be cognizant of the local cultural, environmental and political factors, which constrain engagement of women. In depth understanding of local political economies, community and gender dynamics – drawn from participation of communities in design processes – is essential so that power imbalances are challenged rather than entrenched. We make practical recommendations for how women's engagement can be improved. The research is of value to those working towards universal access to water services and water security for all.

**Keywords:** Gender, inclusion participation, social accountability, women

# MISMATCH IN INSTITUTIONAL PRIORITIES IN MANAGING WATER RESOURCES: A CASE OF UGALLA GAME RESERVE - TANZANIA

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## Abstract

A mismatch problem exists between basin-level management objectives and resource management interventions done by state and non-state actors at a fine spatial scale. Using a case of infestation and the spread of water hyacinth (*Eichhorniacrassipes*) in Ugalla Game Reserve, this paper provides some insights on how control of the water hyacinth received less attention compared to other management challenges (e.g. regular anti-poaching activities). Through transect walks and aerial survey, it was recorded that more than 10% of the Ugalla River within the Ugalla Game Reserve was full covered by water hyacinths. Two fishing camps in the Ugalla Game Reserve were closed due to the water hyacinth infestation. The Ugalla Game Reserve is part of the Malagarasi-Muyovozi Ramsar Site (MMRS), which constitute 30% of the Lake Tanganyika catchment. At the basin level, water hyacinth control is among the priority conservation activities because of its far-reaching impacts (if left uncontrolled) in all riparian communities surrounding the Lake Tanganyika in Zambia, Tanzania, Burundi and the Democratic Republic of Congo, and at all levels. Even at the local level, water in Ugalla River is a crucial resource for the survival of wildlife, but also supports livelihood activities legally done by local communities in Ugalla Game Reserve (e.g. fishing and beekeeping). Sector-based resource management approaches are among the causes of the mismatch problem in the Trans-boundary management of natural resources at the basin-level. About 90% of the MMRS is managed in a chain of forest and wildlife protected areas. Timber and wildlife concessions are among the main sources of income in Tanzania. Measures to control illegal lumbering and anti-poaching activities are given priority. For the sustainability of various resource components and ecosystem services in Lake Tanganyika Basin, among other basins, strategies are required that will actively engage state and non-state actors to holistically address various challenges to be recorded in both time and space at different levels.

# INTEGRATING ENVIRONMENTAL ECONOMICS AND ECOHYDROLOGY IN WATERSHED GOVERNANCE: CAN WILLINGNESS TO PAY ENHANCE WATER FLOW?

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## Abstract

The values of watershed services from watersheds has for many years been neglected, underestimated and not factored in land use decisions for sustainable management. Sustainable management of watersheds and environmental friendly economic activities are vital for sustained water flow, steady supply of ecosystem services for societal needs and enhancement of aquatic vegetation and animal species. The problem of the failure to capture actual values of ecosystem services from watersheds and incorporate them in the national income accounting is profound in developing countries which are characterized with constrained budget for financing conservation programs. To resolve this problem attention has moved to market based instruments such as payment for watershed services (PWS). However, the approach to elicit the necessary information for PWS to kick off is still lacking. Furthermore, Ecohydrology, defined as an integrative sustainability science using the interactions between hydrology, biota and natural processes as management tools to reinforce ecosystem services on a broad range of landscapes is a basis for the development and application of market-based approaches in watershed conservation. This study investigated smallholder farmers' willingness to pay (WTP) for watershed services in Pangani River Basin. A contingent valuation method was employed to elicit the willingness to pay for watershed conservation. A probit model was used to determine respondents' response to WTP and factors conditioning the maximum amount they are WTP. Findings indicates that majority of respondents are willing to pay for watershed services. Similarly, result reveals that marital status; household size and distance from the water source positively influence smallholder farmers' WTP and the maximum amount to be paid. Equally important occupation, household size, income from irrigation, and amount paid for irrigation was found to negatively influencing smallholder farmers' WTP. The result also revealed that education level; total land size and yield from irrigated farm plot positively influence smallholder farmers' WTP. These results therefore, indicate that establishment of PWS is feasible.

**Keywords:** Contingent valuation, Ecosystem services, Tanzania, Watershed ecosystem

# POSTER PRESENTATIONS

## ASSESSMENT ON UTILIZATION OF LAKE BABATI RESOURCES BY COMMUNITY IN BABATI DISTRICT, TANZANIA

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### Abstract

The study was conducted to assess community lake resources exploitation and by-laws guiding resources utilization at Lake Babati. The specific objectives were to assess how community is aware on the by-laws governing the lake resources exploitation and how communities utilize the lake resources based on by-laws. Data were collected through questionnaires, key informant interviews, documentary reviews and field observations. Questionnaires were administered to 112 households in three selected villages namely Majengo, Bagara, and Singe. In addition, the satellite imageries of 1995, 2000 and 2015 were downloaded and ArcGIS was used to assess the change in lake size. The major findings revealed that, communities were exploiting lake resources unsustainably due to lack of by-law enforcement. Furthermore, through satellite imageries analysis, the study noted that, there was significantly a change in Lake Babati size as results of human activities conducted along the Lakeshore. The human activities along the lake shore such as bricks making, crop cultivation, house construction, grazing of animals and deforestation were seen to undermine the conservation strategies around Lake Babati. The study revealed significance relationship ( $X^2 = 28.19$ ,  $df = 12$ ,  $P < 0.004$ ) between personal characteristics and level of awareness and implementation of by-laws guiding resource utilization from Lake Babati. The study recommends that, the government in collaboration with private sector should engage in rising awareness campaign on the by-laws and strongly enforcement of the by-laws over resources utilization of Lake Babati. Furthermore, the study recommends alternative income generating activities of the surrounding community because most of them depends the Lake as main sources of income.

**Keywords:** Lake Babati, resources utilization, by-laws

# EFFECTIVENESS OF GROUNDWATER GOVERNANCE STRUCTURES AND INSTITUTIONS IN TANZANIA

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## Abstract

This paper examines effectiveness of groundwater governance structures and institutions in Mbarali District, Mbeya Region. The paper adopts exploratory sequential research design to collect quantitative and qualitative data. A random sample of 90 groundwater users with 50% women was involved in the survey. Descriptive statistics, Kruskal–Wallis H test and Mann–Whitney U test were used to compare the differences in responses between groups, while qualitative data were subjected to content analysis. The results show that the Village Councils and Community Water Supply Organizations (COWSOs) were effective in governing groundwater. The results also show statistical significant difference on the overall extent of effectiveness of the Village Councils in governing groundwater between villages ( $P = 0.0001$ ), yet there was no significant difference ( $P > 0.05$ ) between male and female responses on the effectiveness of Village Councils, village water committees and COWSOs. The Mann–Whitney U test showed statistical significant difference between male and female responses on effectiveness of formal and informal institutions ( $P = 0.0001$ ), such that informal institutions were effective relative to formal institutions. The Kruskal–Wallis H test also showed statistical significant difference ( $P \leq 0.05$ ) on the extent of effectiveness of formal institutions, norms and values between low, medium and high categories. The paper concludes that COWSOs were more effective in governing groundwater than other groundwater governance structures. Similarly, norms and values were more effective than formal institutions. The paper recommends sensitization and awareness creation on formal institutions so that they can influence water users' behaviour to govern groundwater.

**Keywords:** Groundwater, Governance Structures, Formal institutions, Informal institutions, Mbarali District

# COST-BENEFIT ANALYSIS OF GROUNDWATER USE FOR IRRIGATION BY SMALLHOLDER FARMERS IN THE USANGU PLAINS, TANZANIA

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## Abstract

Groundwater (GW) use for irrigation by smallholder farmers has been proposed as a solution to increasing water scarcity in Usangu Plains, in Tanzania. This study evaluated the financial viability of utilizing GW for irrigation by smallholder farmers in Usangu Plains in Mbarali District. Specifically, the study analyzed the cost and benefits of using GW for smallscale irrigation, examined the socio-economic factors influencing the use of GW for irrigation, and assessed the financial affordability of smallholder farmers in investing in GW irrigation. Primary data were collected using a semi-structured questionnaire, which was administered to a random sample of 97 households in three villages, while data from key informants were gathered using a checklist. Secondary data from various sources were used to supplement the primary data. The data were analyzed and net present value (NPV), cost benefit ratio (CBR), and Internal rate of return (IRR) were generated. The SPSS computer programme was used to generate descriptive statistics and Binary logistic regression model was also used. Results show that investment in GWI is economically viable at discount rate of 12% and had the Net Present Value of TZS 38 636 794, Cost Benefit Ratio of 6.55, and Internal Rate of Return was 81% indicating it is worthwhile to invest in GWI by smallholder farmers is financially viable. Socio-economic factors, family size which shows a positive association at  $P < 0.05$ , gender, income level, and membership in socio networks were seen positively in influencing GWI. Household economics does not satisfy with investment in GWI. Conclusively investment in GWI by smallholder farmer is financially viable and socio economic factors are crucial. The study suggests that it is worthwhile for the government and development partners to support GWI for smallholders. Further there is a need for the government to intervene on the market of input and output of agricultural goods and properties.

**Keywords:** Groundwater, Internal rate of return (IRR), Net present value (NPV), Smallholder farmer, Using Plains

# IMPACTS OF CLIMATE-CHANGE ON HYDROLOGICAL CHARACTERISTICS OF MBARALI RIVER CATCHMENT

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## Abstract

This study assesses the impacts of climate change on water resources in Mbarali River sub-catchment using high-resolution climate simulations from the Coordinated Regional Climate Downscaling Experiment Regional Climate Models (CORDEX\_RCMs). Inverse Distance weight average (IDWA) was used to interpolate model gridded climate simulation to the location of Igawa weather station. Daily rainfall, minimum and maximum temperatures for historical climate (1971-2000) and for future climate projection (2011-2100) under two Representative Concentration Pathways RCP 8.5 and RCP 4.5 were used as input into the Soil and Water Assessment Tool (SWAT) hydrologic model to simulate stream flows and water balance components of the Mbarali River sub-catchment. The impacts of climate change on hydrological conditions over Mbarali River catchment was assessed by comparing the mean values of stream flows and water balance components during the present (2011-2040), mid (2041-2070) and end (2071-2100) centuries with their respective mean values in the baseline (1971-2000) climate condition simulated by the individual RCM model and Ensemble. Results indicate that, in the future, under both RCP 4.5 and RCP 8.5 emission scenarios, the four main components that determine change in catchment water balance such as rainfall, evaporation and surface runoff over Mbarali river catchment are projected to increase by 1.96%, 22.08% and 114%. The stream flows, groundwater recharge, and total water yield are projected to decline in the future by 13.67%, 2.13% and 0.72% respectively under RCP 8.5 emission scenarios. The findings show the present and future impacts of climate change on hydrological characteristics of the catchment. Such information may be used for water resources planning and management and for informing the design of appropriate interventions to overcome the impacts.

**Keywords:** General Circulation Models, Hydrological water balance components, RCP, Regional Climate Model, SWAT model

# SPI BASED CHARACTERISATION OF METEOROLOGICAL DROUGHTS IN THE LAKE VICTORIA BASIN, TANZANIA

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## Abstract

Drought is one of the natural catastrophe that disturbs social-economies of different countries in Africa. Lake Victoria Basin consists of approximately 15 million people in the Tanzania side (about 30% of the total population of the country). There are fluctuations in the amount of rainfall received in the basin annually. While in some areas low amounts of rainfall below average are received, in some areas excess amounts are observed. The earlier could lead to meteorological droughts of which are directly linked to reduction in rainfall. The impacts of meteorological droughts are observed in water resources (e.g. rivers, streams groundwater), agriculture activities and social-economies. Prediction and understanding of the meteorological droughts is indispensable for the successful management of this basin. This paper will present characteristics of meteorological droughts in Lake Victoria Basin, Tanzania using the Standardized Precipitation Index (SPI). The SPI values were calculated seasonally and at annual time scale. Monthly rainfall values were grouped into three months, and since rain season is between October and May, OND, JFM and AMJ were considered in the analysis of meteorological droughts. The results (duration, extent of droughts) are expected to add useful information in management of this transboundary Lake and the entire basin at large.

**Keywords:** Lake Victoria Basin, Meteorological droughts, SPI.

# ASSESSMENT OF THE STATUS OF HOUSEHOLDS' WATER AVAILABILITY IN THE SIGI CATCHMENT, TANZANIA

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## Abstract

For many decades, Tanzania has made remarkable progress toward universal access to domestic water. However, the issue of universal access remains unaddressed due to spatial variations in water availability. This study was carried out to understand the extent of households' water availability in the Sigi catchment. Statistical analysis of 344 household questionnaires was done using descriptive and inferential statistics and later complemented by structural content analysis of data collected using in-depth interviews and participatory field observations. Findings showed households' in the Sigi catchment to have various water sources, although the number, spatial distribution and water quantity in the sources were decreasing over time. Declining water quantity and drying of some water sources compelled some households (36.9%) to travel longer distance up to 2.5 km searching for water. In some villages, majority of the households spent more than 60 minutes walking to and from the water sources while others spent more than 60 minutes waiting or queuing for water. Due to difficulties in terms of geophysical terrains and long walking distances, households developed different means of conveying water to their homestead. The means included; the use of bicycle, donkey, motorcycle, and on foot. From the study it has come out clearly that water availability in the Sigi catchment is spatially variable. Owing to the variation dilemma, long-term planning that includes rehabilitation of non-functional water sources and water resources management option is needed.

**Keywords:** Households, water sources, water access, water availability, catchment

# IMPACTS OF CLIMATE CHANGE TO TRADITIONAL IRRIGATION FARMING SYSTEMS AND ADAPTATION STRATEGIES IN WEST USAMBARA HIGHLAND

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## Abstract

This study that aimed at assessing the impact of climate change on traditional irrigation farming systems and adaptation strategies was conducted in Lushoto District. Specifically the study aimed to establish the trend and magnitude of climate change for the past 30 years (1985-2014), to assess the impact of climate change on crop yield in Ndiwa and Chamazi traditional irrigation farming, to analyse the way traditional irrigation farmers' adapt to climate change. A cross-sectional explanatory research design encompassing both purposive and systematic random sampling was adopted. The sample comprised with 380 households, 48 members of Focus Group Discussion (FGD) and 15 key informants. Primary data from were collected through household survey, FGDs, interviews and researcher's observations while secondary data were collected through documents reviews including weather reports of the study area from Tanzania Meteorological Agency (TMA). Descriptive statistics such as mean and percentages were computed to establish the trends and magnitude of climate change using MS-Excel program. Cross tabulation between rainfall and crop yield trends was used to establish the impact of climate change on crop yields. Descriptive statistics such as frequency and Analytic Hierarchy Process (AHP) analysis were performed to identify most feasible adaptation strategies. The results showed that for the past 30 years (1985-2014) climate variables such as annual mean (minimum and maximum) temperature and annual mean rainfall have been increasing and decreasing respectively in fluctuating patterns. For the past 30 years, annual mean (minimum and maximum temperature) have increased by 0.83oC and 2.4oC respectively and annual mean rainfall have decreased by 803mm. Climate change has affected crop yield in Ndiwa and Chamazi irrigation through decrease amount of water for irrigation and outbreak of crop diseases. Farmers engaged in Ndiwa and Chamazi irrigation adopted different adaptation strategies to combat the impacts. These include cultivating near water sources, crop diversification and digging of shallow wells. It has been recommended that stakeholders should extend their efforts to help the farmers engaged in Ndiwa and Chamazi irrigation to improve their adaptive capacity to climate change. They should especially help farmers to access; climate information, financial resources, agricultural extension services and improved irrigation infrastructures.

**Keywords:** Chamazi, Ndiwa, Traditional irrigation farming system

# CLIMATE CHANGES AND FUTURE OF AGRICULTURE PRODUCTION IN THE PANGANI RIVER BASIN

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## Abstract

This paper is based on a study conducted in Pangani river basin in Tanzania. The main objective of the study was to assess the evidences of the climate and map the future of agriculture production in the Pangani river basin. Historical climate data over a period of more than 30 years were collected from 8 stations in Pangani river basin. Qualitative and quantitative data were collected from 9 villages purposely selected based in the location (upper and lower basin and altitude) along the Pangani river horizon. Questionnaire survey and Focus Group Discussions (FGD) were administered to 387 respondents and 40 key informants respectively. The results showed evidences of rising temperatures, changing patterns of rainfall, an increase in extreme weather events such as droughts, floods and hurricanes and the shifting distribution of pests and diseases. Expert opinions also confirmed major changes in climate parameters in recent years. About 89% and 95% of farmers perceive that there is a change in temperature and rainfall respectively and were able to link the changes in crop and livestock types, cropping patterns, and outbreak of human, animal and crop diseases in their respective areas. These changes tends to use more water from the basin. Results from Multinomial Logit Model (MLM) indicate that access to extension services, credit, education level, location and experience positively determines condition farmers' choices of climate change coping strategy. The paper suggests that there must be change of crop types, cropping methods, livestock keeping methods and deliberate migration to new areas as methods to ensure sustainability of the declining water sources of the Pangani river.

**Keywords:** Climate changes; Farming activities and Adaptive strategies, Pangani river basin.

# IMPACTS OF CLIMATE CHANGE AND VARIABILITY ON WATER SCARCITY FOR RAIN-FED AGRICULTURE IN KAGERA RIVER BASIN

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## Abstract

Agricultural activities are the main livelihood for majority of the population in the Lake Victoria Basin (LVB) where subsistence rain-fed agriculture is practiced. However, rain-fed cropping is being threatened by climate variability and change leading to water scarcity. Climate change and variability has affected the rain water supply to agricultural crops. This regional study focuses on assessing the impacts of climate change and variability on water scarcity for rain-fed agriculture in the trans-boundary Kagera River Basin of the LVB. The participating countries in the research are: Tanzania, Rwanda, Burundi, Kenya and Uganda. Climatic data has been collected from historical ground observations and online global data archives. Crop data shall be collected from Agricultural Institutions and field surveys. Study sites will be classified based on climatology, which will inform about the areas' rainwater supply and on water scarcity which is important for agricultural water management. Accordingly, two indices (Crop Water Stress Index and Crop Water Demand Satisfaction Index) will be developed, used, compared or integrated in relation to crop water management. Climatic data shall be analyzed for seasonality and trends using statistical analyses. Climate change scenarios will be developed using irradiative energy scenarios from General Circulation Models (GCMs) whereby downscaling will be performed using stochastic weather generator model (i.e. LARSWG model). The baseline period for climate change quantification will be selected based on data quality and concurrent period of data availability. Estimated crop water requirements from CROPWAT model for both historical and future will be used for impacts assessment of climate change on crop water needs. Results from the study are expected to be used in developing framework for managing risks from climate change and water scarcity. Also, the integration of climate variability and change and its impacts on water scarcity is going to inform the water sector through potential irrigation water requirements and the Ministry of Agriculture on proper agricultural water management and adaptation strategies for agricultural production. Moreover, the study is expected to improve the capacities, governance and management of water resources in Kagera River basin under water scarcity and sharing knowledge and practices to other basins experiencing similar challenges.

**Keywords:** Agricultural water management, Climate change, Kagera River Basin, Rain-fed agriculture, Water scarcity

# ASSESSMENT OF WATER AVAILABILITY AND USES IN KILOMBERO BASIN BY USING SWAT AND WEAP MODELS

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## Abstract

Recently, the SAGCOT and “Kilimo Kwanza” initiatives were introduced in the Kilombero Basin as the best practices to expand agricultural productions. These initiatives resulted in the increase of population and expansion of agricultural activities which directly affects water demands and raise competition among the water users. The main aim of this study is to assess the water availability with respect to water uses in the Kilombero Basin, specifically to assess water users and consumption pattern, to quantify amounts of water available and to assess water allocation scenarios. SWAT model was set up and calibrated in order to fill the gaps and extend the historical flow data so as to quantify water available in the basin. Water Evaluation and Planning model (WEAP) were used to assess water allocation scenarios (expansion of irrigation areas in agriculture and population growth) by 2035. SWAT model was successfully calibrated with the efficiency 0.54 of NS and 0.55  $r^2$  for calibration and validation, respectively. The study identified five groups of water users as domestic, industrial, environmental, livestock and agricultural users. The current water available in the basin was estimated to be 1314.14 MCM (Million cubic meters) in which total demand was 573.7 MCM. Agriculture, domestic, Livestock and industrial water demands comprise 84.53%, 3.06%, 0.61%, and 11.80% respectively of the total water demand. Further, the study shows that the expansion of irrigation schemes and population growth by 2035 will increase the average annual demand by 81.85% and 41.54 % respectively. The conclusion from the finding was that; the current water available is enough to meet current demands (2017), but for the 20 years to come unmet water demand will be experienced.

**Keywords:** Kilombero Basin, water availability, water demand, water allocation, scenarios

# GROUNDWATER RECHARGE ASSESSMENT IN THE MAKUTUPORA BASIN, DODOMA, TANZANIA

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## Abstract

The Makutupora basin is located within precambrianmeta sediments and fractured crystalline granitic rocks in the Dodoma region, central part of Tanzania, and has an area of about 1600km<sup>2</sup>. It is characterized by a semi arid climate with average annual rainfall of about 550mm and evapo-transpiration of 2000mm per annum. The study was carried out cater for the increase in demand of water supply for the Dodoma city. Similarly, it was aimed to enhance the sustainable management of the groundwater resource as the reliable source of water in the region. The recharge flux estimation was done by the Chloride Mass Balance method, WTRBLN Model, Earth model and hydrograph analysis. A conceptual model was developed by combination of satellite imagery information such as Aster image, STRM DEM combined with field observation data including pumping test data, drilled borehole logs and geological map. A distributed single layer model was developed. The aquifer system was modeled using PMWIN as pre and post processor for MODFLOW. It was assumed that the aquifer is under steady state and confined conditions. The Thornthwaite and Mather water balance model was used to study the hydrologic regime of the basin on monthly basis. The recharge flux was estimated to be about 5 to 12mm/yr equal to 1% of annual rainfall. MODFLOW results indicated the annual water budget of the basin reached equilibrium conditions with recharge from precipitation 8.9, abstractions 7.3, and discharge at the outlet of the basin at 1.6 in MCM per year. The Thornthwaite and Mather water balance model indicated no moisture surplus for all dry years with low surplus for the wet years. The water quality assessment indicated that, the Makutupora basin is characterized by CaHCO<sub>3</sub> water type, typical fresh water. The research findings provide appreciable contribution is sustenance and management of groundwater resource in the basin. Despite the data scarcity for monitoring wells in the basin, the developed groundwater model provides more insight in understanding hydrologic behavior of the system in relation to imposed stress on the recharge flux.

**Keywords:** Groundwater recharge, recharge flux estimation, water balance, water quality, modeling

# WATER RESOURCE MANAGEMENT FOR CLIMATE RESILIENCE: LESSONS FROM TANZANIA'S MOST FLOOD AND DROUGHT PRONE COMMUNITIES

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## Abstract

Floods and droughts are the most frequent and damaging disasters facing the people and economy of Tanzania, a trend likely to intensify under climate change. This paper investigates the effectiveness of Tanzania's institutional arrangements for managing floods and droughts, and for protecting communities against their negative impacts. It draws on case study research within flood and drought prone communities in Mpwapwa and Kiteto Districts. The evidence reveals an urgent need for clearer accountability, adequate financing and better coordination among authorities responsible for disaster management. In particular we highlight the central, but as yet unfulfilled role of water resource managers in mitigating water-related disasters. Uhakikawa Maji uses action research within multiple-case studies to test institutional arrangements for water security in Tanzania. From 2014 the programme worked with communities in drought and flood prone areas to document impacts, activate statutory duty bearers, and track the effectiveness of their response. Key informant interviews explored root causes of performance observed, and insights were validated through multi-stakeholder workshops. In these cases at Gulwe and Kiteto we found that floods and droughts occur regularly and impose severe impacts through damage to infrastructure, life and livelihoods. Emergency preparedness and response plans, where in place, do not include prevention or risk reduction, and early warning systems are ineffective. No budgets are allocated for disaster preparedness, and responsible institutions do not have adequate capacity to fulfill their roles. Despite significant investment in climate change adaptation and water resources management in Tanzania, planning and preparedness for water-related disasters is almost non-existent, even in geographies renowned for severe flooding and drought. This calls for a strategic review of disaster management arrangements. Scrutiny is required to ensure that water resource managers are properly resourced and accountable for prevention, mitigation and warning. Stronger leadership in this regard will pay dividends for the resilience of communities and the national economy.

**Keywords:** climate change, disaster management, floods, drought

# IMPACTS OF LAND USE CHANGES ON WATER BALANCE IN MVUHA RIVER SUB-CATCHMENT

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## Abstract

Population growth and development drive up land use changes, which have effects on water balance and quality of a catchment. The study was carried out to assess spatial and temporal land use changes that have occurred over a period of 40 years in Mvuha River sub-catchment and its impacts to the water balance and also to determine runoff hydrologic response and water quality response to land use in the sub-catchment. Land use and land cover change detection was conducted using Remote sensing and GIS techniques, trend analysis of temporal rainfall and river discharge was evaluated using statistical methods and lastly rainfall simulation experiments were used to determine runoff, hydrologic and water quality response to different land uses/covers. Results showed that there were significant land use changes and/or conversions. Forest, bushland and swamps decreased by 8.83%, 3.34% and 66% respectively, while woodland, grassland, settlement and agriculture increased by 9.2%, 22%, and 92% respectively during 1975 to 1995. In 1995 to 2015 forest, bushland and swamps decreased by 26.48%, 7.85% and 2.72% respectively, while woodland, grassland, settlement and agriculture increased by 23%, 9.36%, and 4.69% respectively. Analysis of temporal rainfall data showed that rainfall trend is almost constant and analysis of river discharge data showed a decreasing discharge rate over years. Correlation of long-term rainfall data and discharge rate showed weak positive correlations, which imply weak association. Rainfall simulation experiments revealed significant difference on runoff, hydrologic response and water quality response with land use. Grazing showed the highest runoff rate followed by cultivation and lastly forested land use. In terms of water quality, grazing lands had the highest insoluble suspended solids followed by agricultural land use and lastly forested land use, which had the least insoluble suspended solids. The study recommends that Wami-Ruvu water Basin office (WRBO) to have clear strategies to protect forests from encroachers and reduced livestock grazing activities in the catchment. In addition, suitable land use planning and management strategies are needed in order to avoid catchment degradation

**Keywords:** Cultivated land, Forest, Grazing land, Land use change, Rainfall simulation.

# THE ART OF PROFESSIONALISM IN BOREHOLE COMPLETION - CASE STUDY OF IRAO WELLFIELD – SINGIDA MUNICIPALITY

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## Abstract

Groundwater resources evaluation is an important aspect of water resources' management. It is most important in dry areas where there is no surface water, and hence groundwater becomes the only source of portable water. Urbanization and associated factors leads in water demand, which is accompanied by severe depletion of reservoir storage of the most groundwater. The same case is likely to happen in Singida municipality, where the only source for portable water is groundwater. Management of groundwater resources, identifying determinants of borehole failure is useful in planning borehole and well field remedial measures as well as identifying appropriate water treatment mechanisms if deteriorating water quality and quantity prevails as a result of decline of borehole yield and water level. A continually declining well yield in the Iraowell field, in Singida Municipality, prompted this study. The determinants of groundwater level decline, which reaches about 60% in the well field were identified and their contributions assessed through multivariate analysis. The basic objective of this study was to establish the cause of decline in groundwater production and lowering of water level in Irao well field. Production of water wells dropped significantly from the year 2012 to 2018. Water levels of both productive and non productive wells also declined, which resulted into low borehole yield. The possible causes for the decline in production include over-pumping, improper well design, bio-fouling, chemical corrosion of the screens and borehole interferences. Different methods were deployed to study these possible causes, which include pumping test, picturing of the boreholes using a borehole camera, geophysical surveys, estimation of recharge and establishment of groundwater flow direction in the area. With the use of the borehole camera, bio-fouling, encrustation, rusting of the casings and well design problems were observed in all the boreholes. Flushing of the boreholes increased their yielding capacity, as the screen slots could be re-opened. With the use of pumping test, the wells were found to be over-pumped, which was caused by the contractor's over estimation for the safe yield at the beginning of production. The use of steel casings, double placed in some intervals also reduces the water inflows to the wells. Safe yields for all the five boreholes was re-calculated and found to be 95.03 m<sup>3</sup>/hr in borehole 399-12, 67.06 m<sup>3</sup>/hr in 400-12, 19.47 m<sup>3</sup>/hr in 401-12, 21.22 m<sup>3</sup>/hr in 402-12 and 11.08 m<sup>3</sup>/hr in borehole 403-12

**Keywords:** Groundwater, borehole yield, safe yield, borehole design, borehole interferences, well field

# ASSESSING EFFECTS OF AGRICULTURAL MANAGEMENT PRACTICES ON EVAPOTRANSPIRATION (ET) AND WATER PRODUCTIVITY (WPY/ET) IN MAKANYA CATCHMENT, TANZANIA

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## Abstract

Different agricultural management and water harvesting techniques such as mulching and double digging have been used in semi-arid countries but have not been evaluated systematically on their effect on water infiltration, soil water storage, crop yield (Y), evapo-transpiration (ET) and crop water productivity (WPY/ET). An experiment was conducted in Bangalala village, a semi-arid region in Makanya catchment, Tanzania to evaluate effects of agricultural management practices of flat cultivation with mulching (FCM) and double digging (DD) for the reduction of unproductive water losses through soil evaporation (Es) thereby improving WPY/ET in comparison with the traditional flat cultivation (FC) practice. The soil moisture content (SMC) was measured gravimetrically and ET estimated through soil water balance (SWB) from direct field measurements. AquaCrop model was used to predict the water loss, yield (Y) and WPY/ET. Model predictions of SWC and final biomass and yield for all the treatments were satisfactory with (RMSE <21 mm, RRMSE < 12%) and deviation > 10 % respectively.

The model was also used to partition ET into transpiration Tr and Es although field measured variables varied from those of the model predictions due to underestimation of both Tr and Es. These discrepancies may be attributed to AquaCrop abandoning the FAO Kc and Kcb curve resulting in over dependence of Ta and Es on the CC curve as reported in previous studies. Consequently, model predictions for ET and WPET were fair with deviation ranging from 16% to 24% between observed and simulated values. Results obtained, showed that FCM treatment was the most effective method in improving yields by over 30% and WPET (2.51 kg m<sup>-3</sup>) by 45% also on reduction of unproductive water losses followed by DD.

Overall, AquaCrop model was able to successfully simulate SWC, B, and Y under rainfed and fertility stress conditions. In addition, model predictions for ET were underestimated resulting in fair estimates for WPET

**Keywords:** Agricultural-management-practices, Double-Digging, evapo-transpiration, Makanya-catchment

# “THE EXTRACTIVES-WATER-CLIMATE NEXUS: INCLUSIVE WATER AND SANITATION SERVICES IN A NEW CLIMATE NORMAL TANZANIA ”

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## Abstract

Water is a critical driver in the achievement of both the SDGs and the Tanzania Development Vision 2025. Besides availability of sufficient surface and underground water for its people, Tanzania is endowed with enormous deposits of extractive commodities. Currently, minerals and natural gas are significantly contributing to foreign direct investment inflows, Gross Domestic Product, employment and government revenues. Meanwhile, climate change has become a serious contemporary challenge across development sectors; raising the vulnerability of both environment-physical and socio-economic. The extractives and water resources have strong interdependencies; both have reciprocal relations with climate change, thereby requiring innovative governance frameworks to guide policy and practices. Despite extractive sector investors' corporate social responsibility and water stewardship narratives, there are growing concerns to compliance and weak responses to the new climate normal, signaling threat to sustainability of water and sanitation services. Leveraging linkages between the extractive sector and water is complex. The nexus approach attempts to characterize the relations. A Political Economy Approach to the Extractives-Water-Climate nexus illustrating the need for exploring scenarios for sustainability of water and sanitation services through a risk-based analysis was applied to uncover the interaction between political and economic processes, power and resources distribution. The study tracks longitudinal evidences of reported extractive-water challenges including rupture of tailing dams and records of mineral processing near surface water bodies with varying health implications. Emerging evidence reveal that water and sanitation regulatory frameworks work insularly and remotely linked to other sectors, common fragmentation of enforcement systems are a common reality and undefined residual role of local governance structures unsurprisingly leading to strategic failures. Inescapable policy recommendations from this analysis include: Ensuring policy coherence on the commitment to operationalize the Extractive-Water-Climate nexus consistent with existing frameworks for local sustainable economic development and environmental management, Promoting participatory, context specific research on the Extractive-Water-climate nexus, Strengthening the “whole-government” approach to enforcement of regulations and popularizing the nexus across the sectors and governance structures, Effectively embedding climate actions into sustainable local development strategies, engaging communities as strategic partners beyond local content and corporate social responsibility

**Keywords:** climate, extractives, nexus, Political economy, water and sanitation

# CONTRIBUTION OF CLIMATE VARIABILITY AND HUMAN ACTIVITIES TO CHANGES IN HYDROLOGY AND SUSPENDED SEDIMENTS AT HEADWATER AND BASIN SCALES

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## Abstract

It is widely accepted that anthropogenic activities and climate variability have played a great role in hydrological changes in watersheds and ultimately affect water resources. Hydrological responses to climate variability and human activities were investigated using three experimental watersheds (18-25 km<sup>2</sup> in size). Flow and suspended sediments fluxes were monitored for 2 years in the small watersheds located in the uplands of the Upper Ruvu watershed (Morogoro Rural District). The watersheds are characterized by different land disturbances levels with the Mkungazi being the most disturbed followed by and Mbezi the least disturbed (72% of the area occupied by forest and 38% by cropland). Water yield was high and characterized by flashy response to rainfall in the most disturbed (Mkungazi and Kivumaga) compared to the least disturbed (Mbezi) watershed. High sediment loads were exported from the Mkungazi (284 t km<sup>-2</sup>y<sup>-1</sup>) and 230 t km<sup>-2</sup>y<sup>-1</sup> for Kivumaga,) watersheds, whereas a much lower sediment loads were generated in the Mbezi watershed (117 t km<sup>-2</sup>y<sup>-1</sup>). The less disturbed watershed was characterized by high base flow contribution to total flow and a low flashiness index compared to the two disturbed watersheds (Kivumaga and Mkungazi). Long term rainfall (1956-2012) from 11 stations and stream flow (1971-2012) data were analyzed to identify trends and changes in response to climatic variation and anthropogenic activities. Analysis of annual and seasonal trends for the long-term records at the watershed scale showed that rainfall had significant decreasing trends, with a change point occurring in 1988 while stream flow showed non-significant declining trends. Changes in quantiles of daily rainfall and stream flow extremes displayed variability with positive and negative changes, with decreasing changes being more dominant. At an annual scale, climate variability contributed 46% and human activities contributed 54% of the changes in stream flow, signifying sensitivity of stream flow to human activities. The main human activities in the watershed with significant impacts to stream flow are related to land use change, and results show significant changes from 1991 to 2015.

**Keywords:** Climate variability; headwater; human activities; rainfall; stream flow; sediments

# STREAMFLOW RESPONSES TO LAND COVER CHANGES IN THE KIHANSI RIVER WATERSHED USING THE SOIL WATER ASSESSMENT TOOL (SWAT)

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## Abstract

As in most other developing countries particularly in the Sub-Saharan Africa, rural residents directly derive their livelihoods from nature. Population growth is on the rise and consequently inducing pressure on the natural resources and further shrinking the resource base by deforestation or forest conversion for expanding cultivated land pose negative effects on the environment. This study was aimed at identifying the impacts of land use changes on stream flow in Kihansi using the Soil and Water Assessment Tool (SWAT). To investigate the impacts of changes in land use and land cover on the hydrology of the Kihansi River, three land use maps for 1990, 2004 and 2016 were classified and used in the model. The impacts of changing land use on the hydrology of the watershed were investigated for stream flow at the inflow gauging station (NC3) of the reservoir. Calibration and uncertainty analysis of the model was performed with the Calibration and Uncertainty Programs (SWAT-CUP) using the Sequential Uncertainty Fitting version 2 (SUFI-2). Daily simulation results from 1997 to 2003 were used for model calibration, and evaluation was based on the period from January 2005 to December 2007. Plausible model performance was achieved for simulated daily stream flow through comparison with measured stream flow at NC3 station with the Nash-Sutcliffe Efficiency (NSE) of 0.63 and 0.5 at daily and monthly time steps, respectively. NSE at evaluation was found to be 0.7 and 0.62 at daily and monthly, respectively. The calibrated model was used to investigate stream flow response to changes in LULC between 1990 and 2016. Results indicate on average stream flow decreased from 1990 to 2016 showing about 14% decrease in the average flow. Minimum flows were also less in 2016 (3.19 m<sup>3</sup>/s) from 4.97 m<sup>3</sup>/s in 1990. This indicates that the low flows have been affected by the changes in LULC between the two time periods. Other indices of low flows (Q70 and Q90) show the same pattern showing a decrease of up to 38% for Q70 and Q95. The results reveal the role played by changes land cover in the hydrological processes of the Kihansi River Watershed.

**Keywords:** Kihansi River, SWAT, modeling, streamflow, watershed management

# INSTITUTIONAL CHALLENGES FOR WATER GOVERNANCE IN THE PANGANI BASIN, TANZANIA

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## Abstract

For quite some time, integrated water resources management (IWRM) has been a paramount approach for effective water management and development. However, regardless of the reforms in water policy and water resources development programme and water resources management act to include provisions for IWRM, Tanzania is still facing several institutional challenges in the practical implementation of IWRM. In addition, linking up eco-hydrology practices and IWRM is facing some institutional hurdles. This paper highlights institutional challenges endangering effective implementation of IWRM Pangani Basin in Tanzania. Structured questionnaires, semi-structured interviews, participant observations and review of secondary sources were used in during data collection. The results indicate that effective use of eco-hydrology practices and institutions in water management are hampered by fragmented, loosely connected and poorly integrated institutions at different levels. Although guidance for IWRM implementation are in place, inadequate mechanisms for inter-sectoral coordination triggers fragmentation in institutions and stakeholders that are involved in the management of water and allied resources. At the basin level, the basin water boards, particularly the Pangani Basin Water Board is responsible for water resources management. However, there exist other institutions and authorities including NGOs, private sector, District Councils and Water Supply Authorities playing a great role in water management at basin level. These institutions overlap but do not coincide due to poor coordination. This is due to lack of basin level forum for coordinating multi-stakeholders and institutions with diverse interests and imbalanced power to water resources. As a result, the numerous stakeholders in water resources have interactions with local communities, which take place in parallel and often contradicting one another. This arrangement generates a multitude of local level arrangements and institutions which work without coordination. This state of affairs will continue to hamper national aspirations to effectively implement IWRM in the Pangani basin. Successful IWRM implementation would allow the country to meet its obligations towards sustainable water management.

**Keywords:** IWRM, Institutional challenges, Pangani Basin, Stakeholders participation, Tanzania

# HYDROLOGICAL SERVICES IN WATER STRESSED RIVER BASINS: EMPIRICAL EVIDENCE FROM PANGANI RIVER BASIN, TANZANIA

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## Abstract

Watersheds and rivers are vital ecological features for the provision of hydrological services for the health, welfare and prosperity of human communities. Watersheds are also crucial for provision of hydrological services for the ecological integrity, maintenance environmental flows, and enhancement of nutrient cycling and for offsetting the impacts of climate change and variability. Nevertheless, anthropogenic activities coupled with climate change and climate variability are blamed for degrading watersheds and rivers, thus decreasing their capacity to provide water related ecosystem services. To address the situation, it is important to understand why and how water shortages are occurring. This paper reports findings of a study carried out to determine drivers of water shortages and adaptation strategies to climate change and variability along the Pangani River Basin in Tanzania. To assess the influence of climate change and variability on hydrological flow and water shortages, we compiled time series data on rainfall and temperature from the Tanzania Meteorological Agency. To supplement these ecological data, we used structured questionnaires to collect data on villagers' perceptions about the drivers of water shortages and information about adaptation strategies. Results indicated a decreasing trend of water flow ( $p < 0.05$ ) at Kikuletwa-Karangai gauging station along Pangani River Basin (PRB). Trend analysis indicated a slight decrease of rainfall and increase of temperature. Based on the findings on decline of rainfall and water flow, adaptation measures need to be put in place in order to mitigate against increasing variability, reduced water flow, and projected climate change. Adaptation strategies include water rationing, irrigated agriculture instead of rainfed (e.g. rice varieties -Saro, IR 54 and IR 64) and short term maize varieties (e.g SEED CO- SC 403 and PANNAR - PAN 4M-19, PAN 6 and PAN 63). We propose the implementation of integrated water resource management for enhancing the sustainability of water flow along the PRB. This is one way of abiding by the Dublin Principles that advocate sustainability through environmental integrity, economic wealth, and social justice. This will also promote economic and social wellbeing of the local communities along the PRB who are the guardians of watersheds.

**Keywords:** Climate change, Environmental flow, Hydrological services, Pangani River Basin

# HYDROLOGICAL RESPONSE OF WATER RELATED ECOSYSTEM SERVICES TO CLIMATE VARIABILITY AND CHANGE IN NGORONGORO CONSERVATION AREA

Ongoing PhD Research at the Nelson Mandela African Institution of Science and Technology (NM-AIST)

By Mohamed Fadhili Mwabumba (PhD Student)

Supervisors: Professor Alfred N.N. Muzuka (NM-AIST) & Dr. Madaka Tumbo, Water Institute (WI)

## 1. INTRODUCTION

### Climate



## 2. Problem statement

- \* Since early 2000s, water-related ecosystem services are under stress and has continued to impact human being, wildlife, livestock and livelihoods in Ngorongoro Conservation Area (NCA) (Mkiramweni, 2014).
- \* Limited rainfall and prolonged droughts conditions, combined with a growing water needs in the NCA has created a situation where water demand outweighs supply.
- \* This unbalance between water demand and supply, has several economic, environmental and health-related implications.
- \* To ensure the sustainability of water related ecosystem, appropriate studies on hydrology in climate change

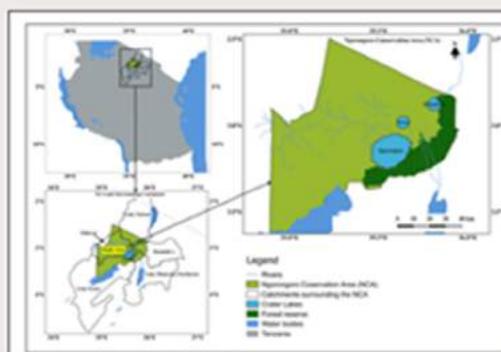
## 3. General Objective

To evaluate the hydrological response of water-related ecosystem services (WES) to climate variability and changes around NCA for hydrological impacts prediction and sustainable water resources management.

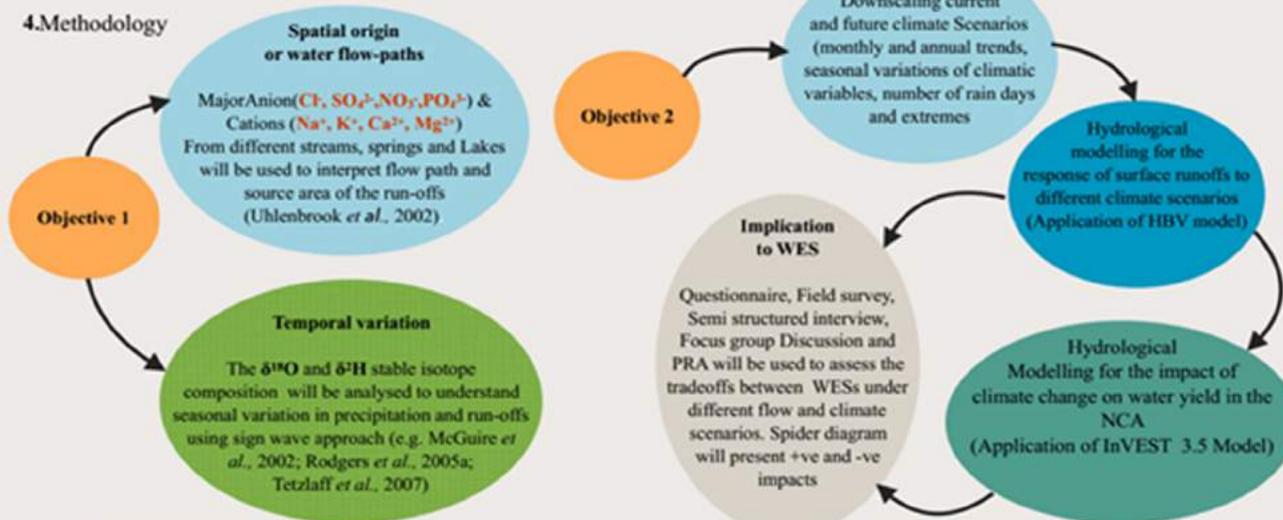
### Specific Objectives

1. To understand the hydrological processes (sources and fluxes on surface runoff) by using different hydro-chemical and isotopic tracers at different spatial scales
2. To assess the interactions between climate and the hydrological processes and implications to water related ecosystem services.

## 4. LOCATION MAP OF THE STUDY AREA



## 4. Methodology



**5. Conclusion:** This study will provide a link between hydrological modelling and the ecosystem services relevant for river basin management and enhance informed water resources management decisions and guide the development of water resource management plan, for sustainable water resources available for the human welfare and ecosystem in the NCA.

# WATER GOVERNANCE IN TANZANIA – A SYNTHESIS OF LEGAL AND INSTITUTIONAL FRAMEWORKS FOR GROUNDWATER MANAGEMENT IN THE UPPER GREAT RUAHA RIVER CATCHMENT, TANZANIA

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## Abstract

An increasing pressure on surface water resources has calls for groundwater, which buffer against climate variability. While groundwater is increasingly extracted and plays a very great role in the supply of water for various domestic and economic uses in the Upper Great Ruaha River Basin, development and management of this important resource has been a challenge at community level. This paper provides an overview of Tanzania's water resource legal and institutional frameworks for groundwater governance in Tanzania. It puts special focus on rules in-use, enforcement and compliance matters in practice, drawing from experience in the Upper Great Ruaha River Catchment and community from Usangu Plains. The findings revealed that decisions on the use of groundwater have been reached without having a comprehensive understanding of river basin characteristics and inter-linkages between quantity, quality and location of a well or a borehole, and are undermined by a lack of knowledge of groundwater resources. The case studies show how law, rules and rights governing water resources are well designed but, most importantly, less actions on its implementation, a snag which arouses shortcomings on how to sustain this important resource. Besides, in the current water governance framework circumstance, groundwater resource development happens largely in the private arena without an effective authority control. The paper further depicts how inadequate human and financial resources at community and local government authority levels, remain stumbling blocks for compliance with the prevailing water management law. It is necessary however that the increase use of groundwater resource should match with proper management for a sustainable use. We also thought that since Tanzania has legal and institutional frameworks governing water resources; once open to perfections, they should strengthen regulatory institutions for groundwater governance.

**Keywords:** Groundwater; Tanzania; Upper Great Ruaha Basin; Usangu Plains; Water/Groundwater governance

# WATER-ENERGY-FOOD NEXUS: A PRACTICAL APPROACH TO SUPPORT WATER MANAGEMENT INITIATIVES IN A CHANGING CLIMATE

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## Abstract

Water is highly climate and environmental sensitive. As the global temperatures approach the 1.5 degrees threshold by 2025, water is becoming a critical resource. Traditional ways of managing water resources were designed to manage a resource that was presumably plentiful. However, as water resources become scarce, innovative ways of managing the limited resource need to be explored. Ways that recognize the complexity and multidimensionality of the resource within ecosystems. The water, energy and food (WEF) nexus approach to water management is understood to be an effective tool for water resource management and ecosystem protection. The WEF nexus highlights the sector's interdependencies and corroborates the need to view water, energy and food not as being separate, but complex and inextricably entwined, such that actions in one sector more often than not have an impact on one or both of the others. The nexus, allows for more integrated and cost-effective policy-making, planning, implementation, monitoring and evaluation related to the different Nexus sectors. Recognizing this fact means that decision-makers in all the three sectors need to urgently focus on how to manage water resources within the context of the WEF nexus. As Tanzania embarks on a water and energy intensive development path, the nexus approach has never been more urgent. The basis of the WEF nexus approach is an attempt to seek to balance different uses of ecosystem resources. It helps to understand the synergies and trade-offs in order to develop response options to ensure water, energy and food security. This paper presents an assessment of the extent to which the WEF nexus is operationalized in Tanzania. Though Tanzania has shifted from a sectoral to a more integrated approach in water management, operationalization of the WEF tool is yet to move from conceptual to operational levels. Urgent policy measures need to be instituted to make WEF a water management imperative.

**Keywords:** WEF nexus; climate change; ecosystems; Tanzania

# APPLICATION OF SYSTEMATIC AND TARGETED APPROACH TO STRENGTHENING CAPACITY OF WATER RESOURCES MANAGEMENT INSTITUTIONS IN TANZANIA

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## Abstract

Wami-Ruvu and Rufiji River basins are two of the nine important water resources management basins in Tanzania. These basins, however, face numerous challenges. Intense water shortages and water stress due to rapid population growth, expansion of socio-economic activities and climate change are among the critical challenges. Most of these problems are attributed to uncoordinated, fragmented, unsustainable use and poor governance of water resources. To address these challenges, the MoW in collaboration with different development partners through the Water Sector Development Program (WSDP) is promoting Participatory Basin Management by ensuring active engagement of all key water governance institutions. In this endeavor priority is given to strengthening capacities of WRM institutions both in terms of organizational capacity and individual human resource capacity at different levels. WUAs are the grassroots institutions responsible for WRM governance at the local levels. However, these institutions currently lack capacity to perform their statutory functions. USAID's WARIDI project is supporting initiatives to strengthen the capacity of Rufiji and Wami/Ruvu basins and lower level governance institutions including WUAs to achieve sustainable and resilient management of water resources. WARIDI designed a WUA baseline capacity assessment tool and used it to conduct participatory baseline capacity assessment to 10 WUAs in the Rufiji and Wami/Ruvu basins to determine capacity gaps and support in estimating and recommending future improvements in WUAs' capacity. The tool assesses the capacity based on pre-determined key capacity areas and attributes. Findings from the assessment show that all assessed 10 WUAs have low existing capacity levels in all capacity areas, which suggest that they are at the emerging stage of capacity development. The results suggest to the need for preparations and implementations of a detailed capacity building plan that includes training manuals, schedules and areas for capacity improvement as well as the methodology.

**Keywords:** Water Resources, Governance, Capacity building

# IMPACT OF LAND-USE AND LAND-COVER CHANGES ON SURFACE RUNOFF AND SEDIMENT YIELD IN LITTLE RUAHA RIVER CATCHMENT

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## Abstract

Little Ruaha River catchment (LRRC) in Tanzania, is one of the country's most significant waterways due to its ecological composition and economic value. Regardless of its ecological and economical value, the regional hydrologic condition has been tremendously affected due to land uses alteration influenced by different social economic factors. Over the years, land use and land cover (LULC) changes have been observed but the present rates, extents and intensities of changes are far greater and faster changes are expected in the future. Therefore, this study was done to understand the extent and rates of LULC changes and their impacts on surface runoff and sediment yield in the LRRC. Remote Sensing and GIS techniques were applied to analyze the spatial and temporal changes of LULC using Landsat imagery and the stochastic CA – Markov chain analysis. Hydrological modeling using Soil and Water Assessment Tool (SWAT) was done to quantify the impact of land use and land cover dynamics on catchment water balance and sediment loads. The calibration and validation of SWAT model were performed using sequential uncertainty fitting (SUFI-2). The results showed that, forest, woodland and wetland has decreased by 60%, 46% and 70% respectively while cultivated land and built up area has increased by 34.36% and 46.31% respectively in the year 2015 relative to 1990. Given the LULC the average annual surface runoff increased from 48.84 mm to 137.77 mm while average annual total sediment loading increased from 2.214 t/ha to 9.984 t/h. The model predicts that in the future there will be higher increase in both surface runoff and sediment load. The study concludes that the modification of the LULC has resulted in the increased surface runoff generation and sediment loading of LRRC, which believed to jeopardize proper functioning of the river. The study recommends that there is a need of multidisciplinary catchment management approaches that will conserve natural resources and provide sustainable rural livelihood.

**Keywords:** Land cover, Land use, Sediment loading, Surface runoff, SWAT Model.

# IDENTIFICATION OF POTENTIAL GROUNDWATER ZONES IN SEMI-ARID AREAS: A CASE STUDY OFBAHI DISTRICT – CENTRAL TANZANIA

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## Abstract

Groundwater assessment Water is a crucial resource that impacts the development of mankind if not available especially in semi-arid areas whereby groundwater is the main source of water supply. Lack of up to date geospatial data on the locations of groundwater limits the government and other stakeholders to drill water boreholes for communities. In this study, groundwater potential zones (GWPZ) at Bahi District in Dodoma region were determined using remote sensing and GIS whereby ten (10) groundwater controlling parameters namely geomorphology, lithology, soil type, drainage density, lineament, rainfall, land use/land cover, magnetic intensity, slope and elevation aspect of a watershed were used. The overall weights and ranking of the ten (10) reclassified groundwater controlling thematic layers was done using AHP Saaty model within a GIS environment to generate the overall GWPZ map. The GWPZ map was validated by overlaying 37 existing boreholes locations with yields and found 6 of the existing drilled water holes were on poor locations while 3 were on very high potential locations and the rest on other zones. The result of the validated map showed different locations of potential groundwater zones; very good (5.1% of the area), good (40.4% of the area), moderate (43.60% of the area), whereas poor and very poor made up of (10.90% of the total area). It was revealed that the high potential zones were mainly located in the areas with higher lineaments density and within downstream areas. This study clearly highlights the efficacy of remote sensing and GIS in conjunction with the Saaty model as useful approaches for GWPZ studies. Further studies should focus on exploring factors that may contribute to the change in GWPZ due to physical and geological disturbances of the aquifer. Also the use of higher spectral and spatial resolution satellite imageries should be included so as to improve the results.

**Keywords:** AHP, GIS, groundwater potential zones, Multi-influencing Factors Analysis (MIFA)

# ASSESSMENT OF SURFACE WATER RESOURCES AVAILABILITY AND ALLOCATION IN NDEMBERA CATCHMENT, RUFJI BASIN

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## Abstract

Ndembera is a tributary of Great Ruaha River in Rufiji basin covering an area of 3,190 km<sup>2</sup>. Surface water allocation is a major challenges facing water resources management in Ndembera catchment. This has resulted to reduced downstream flow, water user conflicts and drying up of Great Ruaha River in the Ruaha National Park. Also, despite the proposed investments in the catchment such as irrigation expansion (3000ha), construction of Lugoda dam (347.45Mm<sup>3</sup>) and Maluluma hydropower (2MW) there is a limited understanding of the future flows in relation to climate change. This study aimed to estimate the current and future water availability as well as their demands, and suggest the best management options. The current and future flows in the catchment were assessed by using Soil Water Assessment Tool while the estimation of demands were guided by Water Supply Design Manual and CROPWAT 8.0 model. Water allocation modelling and Multi Criteria Analysis were done using Mike Hydro model and Nile Basin Decision Support System respectively. Assessment shows that the current flow in the catchment is 969,408 m<sup>3</sup>/day while the demand is 525,112m<sup>3</sup>/day. Also the future flow increased to 1,157,760 m<sup>3</sup>/day while the demand increased to 847,287m<sup>3</sup>/day. The future flow and demand increased due to projected increased rainfall and population respectively. Generally, the water shortage in the catchment is mainly caused by poor planning and management. The study revealed that, the best management option will be attained through irrigation expansion by 1500ha, improved irrigation efficiency by 20%, construction of dam and hydropower as well as diverting the river directly to Ruaha National Park.

**Keywords:** Assessment, demands, flows, management options

# MAPPING OF IMPORTANT WATER SOURCES IN KIHANSI SUB CATCHMENT, TANZANIA

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## Abstract

Kihansi catchment is made up of various streams and rivers that have economic, social and ecological values. However, water sources degradation has been one of the major challenges facing the catchment and yet there is still a limited knowledge on the available water sources as well as their protection status and threats. Therefore this study aimed to understand and map all important water sources in the catchment and their level of threat and hence come up with proper conservation measures. The approach for data collection was participatory, where by different stakeholders including communities were fully engaged. A total 901 water sources were identified and mapped, among them 96.2% were perennial and 3.8% were seasonal. 22.7% of perennial water sources were protected and 77.3% were not protected. Furthermore, 38.2% of seasonal water sources were protected and the remaining 61.8% were not protected. The main threat to water sources was found to be a valley bottom cultivation, which was practiced in 71% of all water sources. Basing on results, the study came up with several recommendations including; development of operational Kihansi Catchment Management Plan, legally protection of the catchment, demarcation of important water sources, providing of alternative livelihood to the community and policy review on the 60m buffer zone.

**Keywords:** Protected, valley bottom cultivation, water sources

**THEMATIC AREA 2**  
**MAJI WEEK 2019 Scientific Conference**

A large, dynamic splash of water in shades of light blue and white, with many small bubbles and droplets, forming a wide, sweeping arc across the center of the page.

**WATER QUALITY**

# ORAL PRESENTATIONS

## SIGNPOSTING PROGRESS FOR POLLUTION CONTROL AND SUSTAINABLE INDUSTRIALISATION IN TANZANIA

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### Abstract

Pollution of water resources is a growing concern for countries pursuing rapid economic development. Although the Water Resource Management Act of 2009 and Environment Management Act of 2004 provide far reaching powers to control pollution, this paper highlights the barriers to effective implementation which in turn cause widespread economic, ecological and social harm. It draws on carefully documentation of case studies since 2013 to explore the functionality of Tanzania's pollution control regime. Despite action by affected communities, NEMC and the Basin Water Boards, severe pollution by untreated industrial effluent and human sewage continues unabated. We link this pollution to impacts on health, the environment and livelihoods, and show how it undermines public trust in government, and threatens effective transition to a middle-income status by 2025. Using a Social Accountability Monitoring (SAM) approach, the Uhakika wa Maji' programme worked with communities to document impacts and activate statutory duty bearers responsible for pollution control at sites of severe pollution in Dar es Salaam, Morogoro and Lake Rukwa. The responses by authorities were tracked and the factors behind the lack of effective action were explored through key informant interviews, and confirmed via participatory meetings with duty bearers. Based on this evidence, priorities for more effective water pollution control in Tanzania include: improved budgeting and financing for responsible authorities; risk-based regulatory strategy which drives action to the most severe problems; clearer lines of accountability for pollution reporting, monitoring and enforcement; creative use of enforcement notices; enactment of polluter pays powers; strategic enforcement, case law, and community lead litigation – potentially against government agencies for dereliction of duty. Ultimately, to avoid sacrificing ecosystems, health and livelihoods to industrial pollution in the name of growth, political will and strong leadership will be needed to change a status quo where the powerful can pollute with impunity.

**Keywords:** Accountability, compliance, pollution, Water Resources

# CHEMICAL AND PHYSICAL POLLUTANTS: CHALLENGES OF DISPOSAL OF ABSOLUTE INFORMATION AND COMMUNICATION TECHNOLOGY MATERIALS.

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## Abstract

Information and Communication Technology facilities have lots of hazardous and toxic materials in them. Poor disposing of these items reach into the ground and water supplies, and then be ingested by human being or animals. Donating Information and Communication Technology facilities is one way of disposing Information and Communication Technology materials without landfills of hazardous materials. Many developing countries receive Information and Communication Technology facilities as donation from developed countries. Developing countries do not depend only on the donated Information and Communication Technology facilities, they also buy new and latest versions. Most of the developing countries are overwhelming with these Information and Communication Technology facilities without understanding the hazardous side of it. Training Institutions and Government offices of Tanzania have different versions of Information and Communication Technology facilities. Some of the Information and Communication Technology facilities are working properly but some are out of order. Some Information and Communication Technology facilities, which are out of order are used for training while some are just dumped. This paper attempts to provide a review of the hazardous materials from Information and Communication Technology facilities, provide current situation of Information and Communication Technology facilities in Mbeya University of Science and Technology and suggests good methods of disposing Information and Communication Technology facilities in Tanzania.

**Keywords:** Developed countries, developing countries, hazardous materials, Information and Communication Technology

# CHEMICALS AND PHYSICAL POLLUTANTS, POSSIBLE CAUSES AND EFFECTS IN ZIGI RIVER

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## Abstract

Zigi River drains a catchment of 1,082 km<sup>2</sup> and impounded to form the Mabayani Dam, the reliable source of water for Tanga City. The main physical pollutants of Zigi River are sediments and organic manure from poor agricultural practices and poor mining, raw effluent from industry, solid waste and sewage from households and the main chemical pollutants are fertilizers and pesticides from improper use of agrochemical. These pollutants contribute significant amount of suspended solids, nutrients, dissolved solids, metals and biodegradable organic matter and cause various water pollution problems. In order to identify magnitude of pollution in the river and recommend mitigation measures for its sustainable management, water quality assessment for river health was conducted which aims to state physical, chemical and biological composition of water. Standard water quality sampling procedures for Examination of Water and Wastewater (APHA 21st Edition, 2005) was followed. Water quality sampling was done in free flowing water from four established representative sampling points. Sampling bottles were rinsed three times with the water to be sampled before filled with sample. The parameters pH, TDS, EC, Temperature, colour and DO were measured in-situ and samples for other parameters were preserved and tested in the laboratory. During sampling campaign, catchment condition and land-use, were also recorded. Water quality were assessed using natural range of water quality from Monitoring Guidelines for Water Resources and Pollution Control and Tanzania standard for receiving water. The results indicate that most of the tested parameters comply with natural range of water quality and fell within the recommended limit of Tanzania standard for receiving water except DO 3-7 mg/l, Total Suspended Solids (TSS) 17-2800 mg/l, Nutrient concentrations (Phosphate 1.1 -5 mg/l, Nitrate 1.06-13.81 mg/l) and BOD 6-12 mg/l. The upper site has the good water quality recording low level of almost all parameters when compared with lower sites. The significance increase of TSS, Turbidity, BOD as well as Nutrient loading have a direct relation with physical and chemical pollutants contributed by anthropogenic activities found within the river catchment. Floating aquatic vegetation observed in Zigi River and Mabayani Dam is an effect of this pollution load.

**Keywords:** Floating aquatic vegetation, Magnitude of Pollution, Physical and Chemical pollutants, Standard water quality sampling procedures, Zigi River

# ANALYSIS OF BACTERIOLOGICAL QUALITY OF DOMESTIC WATER SOURCES IN KABALE MUNICIPALITY, WESTERN UGANDA

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## Abstract

Worldwide, water is an important component of living beings as it performs unique and indispensable activities. However, due to many anthropogenic activities, freshwater resources are getting deteriorated at a faster rate. In Africa, estimates indicate that 327 million people without access to safe drinking water live in Sub-Saharan Africa (WHO & UNICEF, 2010, 2014). Absurdly, people in Tanzania, Kenya and Uganda still drink unsafe water in spite of improved access to safe drinking water. This study, therefore, aims at assessing bacteriological quality of drinking water sources in urban areas, a case study of Kabale Municipality, Southwestern Uganda. A total of 28 spring water samples were collected from 14 water springs during dry and wet seasons. Samples were collected aseptically in sterilized 500 ml sterile plastic bottles and then transported to water quality laboratory for analysis. Membrane filtration method was used in analysis of water samples in accordance with APHA, (2005). The mean concentrations of E.coli, total coliforms, and THB were 24.07 CFU/100 ml, 85.71 CFU/100ml, and 197.07 CFU/100 ml, respectively in the wet season. While in the dry season, the mean concentrations were 2 CFU/100 ml, 10 CFU/100 ml, and 91 CFU/100 ml for E.coli, total coliforms, and THB, respectively. There were significant differences between CFU of total coliforms, HTB, between wet and dry seasons ( $p = 0.026$ ). The concentration of bacteria in water sources did not conform to WHO drinking water quality guideline value of no detection per 100 ml. Conclusion: With the present state of knowledge from this study we can conclude that; (i) majority spring water sources are located in less than 20 meters away from residential areas with significant paved areas, the presence of septic tanks and pit latrines; (ii) wet season significantly affects the quality of domestic water sources than dry season; (iii) majority drinking water sources were in excess of WHO recommended guidelines for drinking water (WHO, 2006) in wet season.

# FLUORIDE CONCENTRATION IN DRINKING WATER SOURCES AND ITS PREVALENCE IN MKALAMA DISTRICT IN SINGIDA REGION

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## Abstract

Fluoride is an ion of the chemical element Fluorine, which belongs to the halogen group. It is the most electronegative of all the elements and is never found in elemental gaseous form except in industrial process. Ingesting Fluoride at an optimum amount (1.0 and 1.5mg/L) has beneficial values for human health. Long-term exposures above 1.5 mg/L results in dental carries and above 4 mg/L skeletal fluorosis while above 10 mg/L it leads to crippling fluorosis. In Tanzania, different studies have shown the presence of high fluoride concentrations in both ground and surface water sources in various parts of the country, where fluoride presence has been associated with geological formations. This paper reports on the findings of a study, which was carried out in Mkalama district in Singida Region, to address problems related to severe fluorosis evidenced by widespread dental fluorosis in this area. The objective was to investigate fluoride spatial distribution, prevalence and associated health risks. Water samples were collected in all 14 wards in Mkalama district. Also Nyalaza salt (a form of mineral trona) was analyzed for F ions using ion selective electrode method. Fluoride spatial distribution was done using GIS software, while prevalence of fluorosis was determined using Dean's method. Fluoride concentration ranging from 0.78-6.8 mg/l, 0.95-7.3 mg/l, 0.64-1.3 mg/l, 0.4-3.4mg/l, and 0.33mg/l in boreholes, shallow wells, rivers, hand dug wells, and spring, respectively were observed. Average fluoride concentration in Nyalaza salt was established to be 2.6 mg/g-f. From the spatial map fluoride concentration of 1.5-4 mg/l covered 69% of the study area, while in 16% of the total area, concentration of  $\geq 4$  mg/l was observed. CFI ranged from 1.83-2.82 indicating a medium public health concern. Exposure doses from water consumption ranged from 0.02 to 0.34 mg/kg/day, 0.01 to 0.25 mg/kg/day and 0.01 to 0.25 mg/kg/day for infants, children and adults, respectively. Noncarcinogenic risk was in order of adult > children > infants, suggesting that infants are more vulnerable to fluorosis risk than other age groups. The study concluded that generally dental fluorosis in Mkalama community is a public health concern and that continuous use of Nyalaza salt will likely lead to severe fluorosis in future.

**Keywords:** CFI, Drinking water, Exposure doses, Fluoride

# DEFEATING FLUOROSIS IN RURAL KENYA USING THE KILIMANJARO CONCEPT: A FEASIBILITY STUDY IN NAIVASHA

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## Abstract

High concentrations of fluoride in drinking and cooking water has been causing both dental and skeletal fluorosis in Naivasha Sub County (Nakuru County, Kenya) for decades. Filtration systems based on bone char have been more or less successfully used as effective mitigation technology for some two decades. The Catholic Diocese of Nakuru is a producer and supplier of household and community bone char filters. Despite local production, biochar based systems have not yet enabled universal safe drinking water provision in Naivasha. Therefore, alternatives are sought. A recent non – treatment alternative termed as Kilimanjaro Concept was recently presented, wherein rainwater is harvested, locally stored in villages and cities and then pumped for storage in stations on hills or mountains. Water from the storage stations is then gravity-fed to water treatment plants where it is mainly blended with fluoride polluted water. The blended water is fluoride free ( $[F^-] < 1.5 \text{ mg/l}$ ) and easy to treat with affordable and efficient methods including bio-sand filters. The poster presentation is on shaping the implementation of the Kilimanjaro Concept (KC) for drinking water supply in Naivasha. This on-going master thesis investigates the potential of domestic and institutional rooftop rainwater harvesting in a local area of Naivasha as case study. The focus is on water quantity (demand), economic (affordability), social, cultural and legal aspects of rainwater harvesting. The goal of the thesis is to contribute to answer the question how to optimize the contribution of Naivasha to the success of the KC at regional scale. This includes the identification of suitable rainwater storage stations in Naivasha. The potential of rainwater harvesting will be evaluated from a multidisciplinary perspective: economic, legal, social-cultural and technical. Existing rainwater harvesting practices (households, institutions) will be evaluated. Semi-structured interviews will be done with several stakeholders at regional and local level, including the users of rainwater harvesting systems. Different aspects of RWH including acceptance, quality and costs will be addressed. Moreover, instrumental rainwater quality assessment will be performed on site: direct rainfall, roof runoff and water inside existing tanks. The quality of available water sources will be analyzed as well to assess the mixing ratios (blending). A conceptual model will be built to assess whether the current amount of harvested rainwater is enough to cover the demand. Because the KC is a regional concept, whether there is enough water for Naivasha or not, the extension of the harvesting network will be discussed. Investment costs will be estimated based on material requirements and local material prices. Operation and maintenance costs will also be considered.

**Keywords:** Fluorosis; Kilimanjaro concept; rainwater harvesting; water blending

# EFFECTS OF DESIGNS, OPERATION AND MAINTENANCES OF CONVENTIONAL DRINKING WATER TREATMENT PROCESSES ON WATER QUALITY

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## Abstract

Water is one of the most important of all natural resources known on the earth. The quality of potable water can be affected by various chemical and microbiological pollutants, which can cause health disorders. Conventional water treatment processes are one of the commonly used water and wastewater treatment technologies. This paper provides a practical experience of the designs, operational and maintenance effects on quality of treated water from Capri Point conventional water treatment plant supplying potable water to Mwanza City in Tanzania. The monitored physical, chemical and biological quality parameters were assessed from raw and treated water samples. The total dissolved solids (TDS), electrical conductivity (EC), chlorine residue, turbidity and E. Coli were determined from raw and treated water samples. The Laboratory analyses were conducted as per Standard Methods for Examination of Water and Wastewater, 23rd edition of June 2017. As a practical experience, the effects of the designs, operation and maintenance of the conventional water treatment plants on water quality are also discussed and presented. The recorded average 2009 water quality monitoring results for treated water turbidity and chlorine residue was 1.24NTU and 0.71mg/L respectively. The average 2018 water quality monitoring results for total dissolved solids, electrical conductivity, turbidity and E. Coli values for the raw water are 48.14mg/l, 99.09 $\mu$ S/cm, 3.91NTU and 200CFU/100 mL respectively. Similarly the average values for potable water from the assessed conventional water treatment plant are 50.79mg/l, 108.81 $\mu$ S/cm, 0.82mg/l, 1.74NTU and 0CFU/100mL for total dissolved solids, electrical conductivity, chlorine residue, turbidity and E. Coli respectively. Comparing the quality of turbidity results of 2009 (1.24NTU) to 2018 (1.74NTU), there is a decline of 29% in quality of treated water probably due to lack of replacement of filter media (sands) and inefficiency backwashing processes. The results for tested parameters from potable water samples are within the permissible limits for Tanzania and WHO Standards for potable water. The conventional water treatment processes are highly efficient in purification of water despite of noted decline in quality of potable water turbidity.

**Keywords:** Chlorination, coagulation-flocculation, conventional water treatment processes, rapid sand filtration

# ASSESSMENT OF GROUNDWATER VULNERABILITY TO POLLUTION DUE TO URBAN SETTLEMENTS: A CASE OF TEMEKE DISTRICT - DAR ES SALAAM

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## Abstract

The global human population is increasing at an unprecedented rate with much of this growth taking place in towns and cities of developing countries. The case study approach was applied to select the Temeke District, which is accommodating approximately 30% (about 1.4 million people) of total population in Dar es Salaam City. Only 10% - 15% of Temeke residents are supplied with municipal surface water supply system, while the remaining population relying on groundwater as their main source of potable water supplied. The poor dumping of solid waste, poor management of sewage and leakage of effluent from domestic and commercial activities dominate in the area. The study aimed to assess the groundwater vulnerability in Temeke District. Specifically, it assessed the land use and landcover using satellite data from Landsat 8, ETM, TM and MSS using GIS techniques. Groundwater quality was tested using the standard methods. Statistical analysis was done using SPSS 17.0 and STATA 11.0. DRASTIC Model was also applied to identify the extent of groundwater vulnerability in the study area. Validation of the groundwater vulnerability was done using spatial WQM, DVI and GRM indices. Results revealed that, over the past 25 years there was significant expansion of built up area by 62% from 1989 to 2014 due to high population growth. The WQ parameters; Turbidity, Total Alkalinity, Nitrate, Iron, Manganese, Faecal and Total coliforms measured in both wet and dry season, found to exceed the permissible limit of Tanzanian and WHO standards for drinking water. The spatial water quality map of measured NO<sub>3</sub>, Fe, EC and Faecal coliforms with LULC map showed the significant positive correlations between anthropogenic activities and groundwater quality. DRASTIC Model identified about 49% of the total study area lie between moderate to extreme high vulnerable to groundwater contamination. The population increase coupled with high usage of on-site sanitary facilities of pit latrines and poor waste management pressed the groundwater resources into high contamination. Regular groundwater quality monitoring should be given high priority. Further study is needed to develop the effective measures in groundwater pollution management to minimize the health risk in Temeke District.

**Keywords:** Contaminants, DRASTIC, groundwater, urbanization, vulnerability

# GROUNDWATER CONTAMINATION AND ASSOCIATED HEALTH RISKS IN EMERGING AFRICAN TOWNS: THE CASE OF BABATI TOWN, TANZANIA

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## Abstract

Assessment of groundwater contamination potential was carried out in Babati town. Diazotization, cadmium reduction, ascorbic acid, ion selective electrode and membrane filtration analytical methods were used, respectively, for nitrite, nitrate, phosphate, fluoride and microbial investigations. Fecal coliforms (FC) and high NO<sub>3</sub> concentrations were present in wells less than 30 m deep. The maximum FC level was 280 CFU/100 ml, and the nitrate (NO<sub>3</sub>) ranged from 1.1 to 357.7 mg-NO<sub>3</sub>/l. In boreholes, nitrate concentrations ranged from 2.3 to 32.6 mg-NO<sub>3</sub>/l, and were all free of fecal coliform. Other parameters were all within recommended limits for all wells tested. Evaluation of the potential contamination pathways revealed that the shallow well depths ranged from 1.2 to 26.67 m – median 9 m (N=366): 70% were unlined and 19% were uncovered. About 74% of the wells were within 30 m of sanitation facilities, of which 60% were traditional pit latrines. The findings revealed that most shallow wells (64%) are polluted and could cause health problems for users. In another study, characterization of water handling chains and their microbial profiles were done. Water samples were collected in triplicate to test for three organisms (faecal coliforms, total coliforms and Salmonella typhi). Descriptive and t-test and anova were used to determine the significance among the chains. Three water-handling chains were determined namely: untreated source (untrS) to treated reservoir (trR) to households (HH), abbreviated as ‘untrS2trR2HH’; untreated source (untrS) to untreated reservoir (untrR) to households (HH), abbreviated as ‘untrS2untrR2HH’; and finally, untreated source (untrS) straight to households (HH), abbreviated as ‘untrS2HH’. The number of users in these three chains was not statistically different ( $p = 0.5226$ ) but the most contaminated chain was the one involving the untreated source to households (untrS2HH). Most households (83%) did not treat the water they used for drinking making those using the untreated source to household chain (untrS2HH) most vulnerable to water-borne diseases. Therefore, it is prudent that the community avoids relying on shallow wells, which are mostly polluted and boiling of domestic water before use is highly recommended.

**Keywords:** emerging towns, groundwater sources, health risks, pollution risk, water pollution.

# BACTERIOLOGICAL QUALITY ASSESSMENT OF DRINKING WATER FROM UNPROTECTED WELLS AND ITS EFFECTS ON RESIDENTS HEALTH IN SUMVE

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## Abstract

Access to drinking water from unprotected wells is common amongst communities in rural areas of developing countries such as Tanzania. This study was carried out to analyze the bacteriological water quality from such wells and its impacts on the health of the inhabitants of Sumve ward, Mwanza in Tanzania. Assessment on well depth and their distance to pollution sources such as pit latrines was carried out. Data of cases of waterborne diseases were obtained from Sumve hospital. A total of 30 water samples from five wells, were examined to determine E.coli and Total Coliform using the most probable number method. Depth of wells found to range from 0.4m to 60 meters, and the distances between the pit latrines and the wells were generally less than recommended 15 m. Reported data from hospital revealed that water-borne diseases like typhoid fever, diarrhea, intestinal worms, schistosomiasis were high, showing infections through consumption of contaminated water. All the examined water samples showed that Escherichia coli and Total coliform were present in higher proportion ( $0.1 \times 10^4$  and  $0.49 \times 10^4$  cfu/100ml respectively) exceeding the standard limit of the most probable number (MPN) per 100 ml set for drinking water as recommended by WHO of less than 10 coliform cells/100ml of water and those of TBS 0/100ml. These results highlight the fact that consumption of such water is a public health concern. Thus, individuals who regularly use such water must be alerted so they may either take preventive measures. It is recommended that wells should be located away from potential sources of contamination, such as pit latrines, and should be properly constructed and covered.

**Keywords:** Bacteriological, drinking water, water borne diseases, wells.

# URANIUM AND HEAVY METALS CONTAMINATION IN GROUNDWATER SOURCES AND POTENTIAL HEALTH IMPACT: A CASE OF SINGIDA

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## Abstract

A study of metals contamination in selected boreholes and shallow wells of Singida region was conducted. The water samples were collected from 58 sites during dry and wet seasons and their concentrations with respect to Uranium, Lead, Aluminium, Manganese, Chromium and Arsenic were determined using Inductively Coupled Plasma Optical Emission Spectrometer. The water samples were analyzed and their levels compared with the international (WHO) and local (TBS) drinking water standards in order to verify their suitability for drinking. Results showed a significantly higher concentration of the toxic metals ( $p < 0.05$ ) in dry season than in wet season, the low concentration during wet season were likely a result of dilution and limited time with rock-water interactions. In addition, higher concentrations of Uranium, Lead and Manganese above the recommended standard in dry season could be due to a long residence time which favors their leaching due to rock-water interactions. Generally, the local rocks and soil appears to be the natural source of most of the metals contaminating the groundwater of the study area, 40- 66 % of all water sources sampled had elevated levels of Mn, Cr, Pb and Al above the recommended standard by WHO, EAC and TBS. These results suggest that most of the water sources are unsuitable for drinking purposes as they may pose significant health hazard to the local community.

**Keywords:** Groundwater, Heavy metals, Maximum Contamination Limit (MCL), health risk

# THE NEED FOR CONCURRENT HOUSEHOLD DRINKING WATER AND SOURCES QUALITY IMPROVEMENT INTERVENTIONS IN TANZANIA

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## Abstract

Tanzania government and partners have put more efforts to meet the global SDG 6, however like many developing countries faces many looming challenges like insufficient financial resources, population increase, and climate change. Consequently, diarrhoea and other waterborne diseases still persist in country. 1/10 of the global disease burden could be prevented by improving water supply, water resources management, sanitation and hygiene. From 2016 – 2018, Ifakara Health Institute partnering with the MoHCDGEC under the UKAid through the World Health Organization (WHO) conducted a longitudinal study in three climate distinct regions of Tanzania (Kilombero, Buguruni and Kondoa/Chemba) to observe the shortterm climate variability impacts on household drinking water quality and water points. The study involved 18 months continued water quality monitoring and surveys for 238 water sources and 640 households in the study sites. Study results found that there was a significant difference in average mean difference of water point microbial quality (E.coli) between the sites ( $p \leq 0.05$ , 95% CI) while there was no significant difference in average microbial quality of household drinking water for all three sites ( $p > 0.05$ , 95% CI). However, the average E.coli count was found to be higher in households samples compared to the water points and this was consistent in all study sites. These findings indicate the need for concurrent drinking water quality improvement interventions both at household and water source level. From the study findings, < 5% of the study participants reported to practice household drinking water treatment. Overreliance on source water treatment can be risky due to factors like climate change, infrastructure damage; anthropogenic activities and households water storage and use habits, which could result into post-treatment contamination. Hence, we recommend for invention of simple and affordable water quality monitoring tools and water purification kits, emphasis on household-based water treatment and safe storage (HWTS), community sensitization interventions, water sources protection and infrastructure improvement, strengthening WASH transdisciplinary collaborations.

**Keywords:** Contamination, E.coli, sanitation, sensitization, water quality.

# SUITABILITY OF STORMWATER RUNOFF FOR WATER SUPPLY IN URBANIZING CATCHMENTS

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## Abstract

Contamination of storm water runoff from urbanizing catchments may pollute receiving water bodies and limit storm water harvesting potential. With the aim of advocating new storm water management practices in fast developing cities we evaluated the quality of storm water runoff in the rapidly urbanizing Mbezi River catchment (56 km<sup>2</sup>) in Dar es salaam, Tanzania, as delineated by use of a digital elevation model and Arc-GIS tools. Runoff from four rain events of the 2016 wet season, with rain depths ranging from 7.1 to 11.8 mm was sampled from nine building roofs distributed over the catchment and six ground runoff sites located in the downstream sub-catchments with impervious surface fractions varying from 0.01 to 68 %. Having insignificant levels of heavy metals (Zn, Cu, Pb), nutrients (N, P), and faecal coliforms, roof runoff seem to present an auspicious drinking water supply source. Conversely, ground runoff exceeded Tanzanian and international guidelines on drinking water quality regarding total suspended solids (TSS) (883 mg/L), Pb (0.18 mg/L), and faecal coliforms ( $4.3 \times 10^5$  CFU/100 mL). The concentrations of other heavy metals in ground runoff were low and almost similar across all the six sub-catchments. A positive correlation was observed between the degree of catchment imperviousness and concentration of nutrients in ground runoff. The proportional increase of nutrients with urbanization and elevating levels of other runoff pollutants threaten the quality of both receiving water environment and the public health at large. Options for treatment of ground runoff to enhance the water supply potential are discussed.

**Keywords:** Green infrastructure, water supply, environmental protection, flood control, runoff routing, rainwater harvesting

# SPATIAL VARIATION OF NUTRIENT CONCENTRATIONS IN RUFIFI DELTA MANGROVES

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## Abstract

The spatial variations in organic matter and nutrient dynamics in water and sediments are crucial for understanding the changes in the Rufiji delta mangroves. This work aimed at (1) elucidation of the spatial dynamics of dissolved inorganic nutrients in the Rufiji estuary, during its transition from the dry to rainy seasons and (2) prediction of future productivity in Rufiji estuarine mangroves using an appropriate ecological model. Water samples were collected from six locations and analyzed spectrophotometrically for dissolved nutrients, total organic and inorganic carbon, chlorophyll-a, chlorophyll-b and total carotenoids. Mean nutrient concentrations were:  $17.54 \pm 0.75$  mg l<sup>-1</sup> SiO<sub>2</sub>-Si;  $1854.20 \pm 139.08$  mg l<sup>-1</sup> NO<sub>3</sub>-N;  $65.88 \pm 1.99$  mg l<sup>-1</sup> NH<sub>4</sub>-N;  $225.89 \pm 9.59$  mg l<sup>-1</sup> PO<sub>4</sub>-P;  $11.24 \pm 0.80$  mg l<sup>-1</sup> TOC and  $13.17 \pm 0.38$  mg l<sup>-1</sup> IC. Likewise, pigments indicated an up-stream increase in total concentrations as indicated by the high enrichment at NR4 station. However, the extent of future net primary productivity in the Rufiji Delta mangroves was investigated by using STELLA software to simulate modeling of nutrients and productivity in the catchment. The results indicated that the Rufiji Delta mangrove forests periodically interchange its role from being a sink to a source for nutrients.

**Keywords:** Estuary, pigments, nutrients, mangroves, primary production

# POSTER PRESENTATIONS

## REMOVAL OF FLUORIDE FROM DRINKING WATER SUPPLIES

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### Abstract

The presence of fluoride in excess of permissible limit in drinking water has been resulting into serious health problems in several countries. Studies have shown that the rift valley regions in Tanzania are the most affected areas, where only 18.4% of 190 water sources showed fluoride values <1.5 mg/l as per acceptable limit by WHO, 56.8% as per Tanzanian standards and 43.2% has extreme fluoride concentrations. In such case, the excess fluoride removal to make the water potable is the only remedy. Various de-fluoridation methods varying in terms of cost of treatment, materials, efficiency and technology are available. This conference paper will discuss de-fluoridation technique using RGAC and CAC as the most suitable technique for rural communities in Tanzania. The optimum fluoride removal conditions, flow rate and removal efficiency of this method will be discussed. This method is not only cheaper in cost but also simple to perform.

**Keywords:** Coconut Activated Charcoal (CAC), De-fluoridation, Fluoride, Regenerated Granular Activated Charcoal (RGAC).

# THE SOCIO-ECONOMIC IMPACT OF RURAL WATER SUBSIDIES IN TANZANIA: BIO-SAND HOUSEHOLD WATER FILTER PROJECT

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## Abstract

The study looked on the socio-economic impact of water subsidies in Tanzania: the household bio-sand water filter project in Kilosa District, Morogoro-Tanzania. This study was undertaken since there was limited empirical evidence of socio-economic impact on the household BSFs' project. The study objectives were: to examine the performance of the Bio-Sand Filter technology in relation to household's health outcomes; to identify challenges facing households when using the Bio-sand filters technology; and to determine the health and economic benefits households derived from Bio-sand filters technology. The study based on selected bio-sand water filters in Kilosa and used purposive and snowballing techniques under non-probability sampling in selecting visited 141 households out of 410 with bio-sand water filters. This study was to understand the impact of Bio-sand filters technology on their health and economic development. The data were obtained through primary source, where primary data were collected by direct interview questionnaires guide, and direct observation. The study adopted direct interview method so as to get detailed information while a direct observation was used during observing the current situation of filters' beneficiaries because the information can be captured in relation to respondents' responses. The SPSS and Excel were used to analyze the collected data from the field (primary source). The study revealed that the household/institution BSFs' project is performing well through playing an important role on improvement to household's health by 97.9%, and economically supportive to all BSFs' beneficiaries. Economic development was through providing clean and safe water for drinking at minimal cost, furthermore encouraged saving and investment to BSFs' project beneficiaries. Based on the findings, further studies on the technology recommended for improving the technology promotion as POU to other regions of Tanzania. The study recommended on water quality test to be conducted basing on Tanzania National standards and according to EMA, 2004, where the national environmental standard water committee prescribe criteria and procedure for measuring standards for water quality. This will provide the best results specifically to help on the documentation for to help on promoting the BSFs' technology within our locality.

# MANAGING DRINKING WATER QUALITY FROM CATCHMENT TO CONSUMER- INNOVATION IN MONITORING

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## Abstract

Endemic and epidemic disease derived from unsafe water supply affects all nations thus water suppliers have a duty of care to persons utilizing the water or service that they supply and therefore, need to be aware of the regulatory and policy framework within which they must operate including guidelines and best management practice. However, the management of water supply businesses or operations also needs to be conducted with an associated knowledge of the risks of not working within the legal and other frameworks. Water suppliers should therefore acquit their operation in a duly diligent manner such that reasonably foreseeable harm is identified; prevented and reasonable measures are taken to protect the consumer. Understanding the nature of sources of contamination and how these may enter the water supply is critical for assuring water safety. An important strategy in providing safe drinking water for the consumer is the multiple barrier approach the application of which is often restricted to the actual water treatment process. This, coupled with the fact that testing of water immediately prior to, or within, distribution (end product testing) can only highlight a potential health problem after the water has been consumed, has led to the recognition of the need to adopt additional approaches to assuring water quality and safety. The most cost effective and protective means of consistently assuring a supply of acceptable drinking water is the application of some form of risk management. It is important that risk management is inclusive and, therefore, needs to cover the whole system from catchment to consumer and is based largely upon Hazard Analysis and Critical Control Point. The principles of HACCP are based on developing an understanding of the system, prioritizing risks and ensuring that appropriate control measures are in place to reduce risks to an acceptable level. These principles have been refined and tailored to the context of drinking water (water safety plans) and to start with this new approach, Tanzania has developed guidelines for the preparation of water safety plans resilient to climate change for both rural and urban water supply services which need to be implemented.

**Keywords:** Consumer, risk, safe, safety, water

# PUBLIC PERCEPTION IN DRINKING WATER QUALITY

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## Abstract

Water Institute undertakes consultancies and/or applied research related to water, wastewater and environment as requested by clients. Water Quality Laboratory Technology is one of the Institute Departments served boreholes owners; who in this case are referred to as clients representing the public views regarding water quality. Water quality refers to the chemical, physical and bacteriological characteristics of water and is assessed based on the characteristics of the water relative to its beneficial uses. This paper intend to associate the public's perception of water quality from groundwater source as reflected in laboratory analyses at Water Institute for five years from 2012 to 2016. It relates client's willingness to determine either the entire package of chemical, physical and bacteriological or only physico-chemical water characteristics. Samples were collected directly from boreholes after pumping to reservoir tanks to get water that is well mixed and analyzed as per the standard operation procedures in the Standard Methods Handbook. Most of our clients believed that groundwater sources have good quality as compared to other sources and therefore only worried with salinity and water hardness. Decision on selecting parameters and willingness to pay for analysis was explained in a simple way of "water is good" or "water is bad" based on organoleptic properties. In 2012 only 15 samples out of 132 demanded for determinations of chemical, physical and bacteriological characteristics parameters; whilst the rest specified for only physico-chemical parameters. In 2013; only 10 clients out of 116 demanded full determinations of water quality parameters; in the years 2014, 2015 and 2016 the trend of opting for full array of water quality parameters went up to 83 samples out of 201; 72 samples out of 197 and 69 samples out of 185 respectively. 98% of samples tested for bacteriological water quality neither TC nor FC colonies detected since clients from beverages and bottled drinking water plants treat water for their production process. From scientific point of view absence of any adverse sensory effects does not guarantee the safety of water for drinking since pathogenic bacteria can be present in water despite of being from ground source.

**Keywords:** Bacteriological, Pathogenic bacteria, physico-chemical, Public perception, Water quality.

**THEMATIC AREA 3**  
**MAJI WEEK 2019 Scientific Conference**

A large, dynamic splash of water in shades of light blue and white, with many small bubbles and droplets, forming a circular shape around the central text.

**WATER SUPPLY AND SANITATION**

# ORAL PRESENTATIONS

## TIME PERFORMANCE ASSESSMENT IN WATER SECTOR DEVELOPMENT PROGRAMME: CASE OF RURAL WATER SUPPLY PROJECTS IN TANZANIA

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### Abstract

Poor time performance in the construction projects has been an issue of concern all over the world, Tanzania is not an exception. This has been experienced in the case of implementation of Rural water supply projects (RWSP) within the first Phase of Water Sector Development Programme (WSDP) which started July 2007 till June 2016. In the category of ten village projects of RWSP a total of 1810 projects were initiated with contract time ranging between six to nine months. This study focused on 1210 ten village projects, which were completed by June 2016. The objectives were to: ascertain the extent of delay; establish the reasons for the delays and their impacts; and propose strategies for improvement in project time performance. Sampled archival data of 193 rural project contracts data from 50 LGAs were collected. Interviews and online questionnaires (Googledocs) were used to gather data from 200 stakeholders including District and Regional water engineers, Service providers, and government officials. Spreadsheet environment was used for analysis. There were 85 respondents out of 200 (43%). The study adopted an opinion survey in exploring the causes of delay, effects and strategies for improvement of timely delivery of projects. Extent of delays was on average 101%. Relative Importance Index was used to prioritize reasons for delays. The study concluded that the most significant factors that contributed to the delays of RWSP were: inadequate project planning and involvement of stakeholders, inexperienced technical experts for all actors of WSDP I, limited project and contract management skills, and poor design of RWSP. Generally, limited capacity in human resources, organizational skills, finances and management was a common cause of delays. The study recommended that comprehensive planning be adopted at the early stage of projects through effective stakeholder's involvement; strengthening the implementing agencies with adequate qualified technical personnel coupled with continuous capacity building; ensuring selection of right and competent service providers; availing adequate funds for project implementation, monitoring and evaluation of projects; and adoption of design and build project delivery method.

**Keywords:** Project Delays, Project Time Management, Rural Water Supply Projects, Ten Village Projects, Water Sector Development Programme

# HOW WATER SECURE ARE TANZANIA'S CITIES? EVIDENCE FROM HOUSEHOLD SURVEYS IN DAR ES SALAAM AND MOROGORO

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## Abstract

With the urban population set to quadruple by 2050, Tanzania will only be able to achieve its development ambitions if it can provide adequate water and sanitation for its growing cities. Our paper draws on large scale surveys of household water security in Dar es Salaam and Morogoro to shed light on the current status of urban water security and to flag urgent strategic priorities. To better support economic and social progress, we argue that water managers, urban planners and decision makers in government can benefit from detailed assessments of the water problems facing urban communities, their root causes, impacts, and the perceptions of the people they affect. Armed with such data, interventions can be targeted to improve governance and service delivery including through stronger accountability, communication and responsiveness between urban populations and those tasked with ensuring their water security. In 2018 ShahidiwaMaji undertook household questionnaire surveys (n=522) to explore water security within six wards in Dar es Salaam and Morogoro. The objectives were: to provide an accurate picture of problems relating to water access, water quality, sanitation, environmental pollution and flooding; and, to explore how well citizens are able to enact their water rights and obligations and hold governance institutions to account. Our data shows how urban households face problems of water reliability, quality, sanitation, flooding and pollution. Whilst respondents see the government as having primary responsibility for these issues, they are unaware of the policies and legal provisions in place for their resolution. Households do not report their water problems to relevant authorities because they lack time, knowledge, confidence that problems will be resolved, and strikingly, because they fear retribution. The research reveals two strategic priorities. Given the scale of the challenge, its importance for stability and inclusive growth, a 'new deal' for urban water security is needed which matches stronger leadership, enforcement and sectoral co-ordination with the investment needed to make our cities safe. Second, strengthening knowledge and systems to improve the responsiveness of duty bearers to the needs of rights holders are likely focus use of limited resources in difficult urban settings, and build the greater legitimacy and trust in government which will be needed to navigate the challenges of rapid urbanization.

**Keywords:** Water security, urbanization, cities, accountability, governance

# COMMUNITY MANAGED RURAL WATER SUPPLY PROJECTS' SUSTAINABILITY DYNAMICS–CASE STUDY IN MOSHI DISTRICT COUNCIL, KILIMANJARO REGION

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## Abstract

Sustainability is defined as development that meets the needs of the present generation without compromising the ability of future generations to meet own needs. Sustainable development is broadly applicable to many disciplines including water supply and sanitation sectors. In some literature water supply sustainability has been defined as supplying or being supplied with water for life or as a continual supply of clean water for human uses and for other living organisms. The challenges for many water supply system especially in rural areas are associated with the effective sustainability indicators for reporting water supply projects' performance that can be understood by rural water supply management entities when reporting to communities and the local authorities. Different scholars perceive sustainability indicators depending on the interests, needs and discipline being focused on. The main focus however is normally directed towards technical operations and system's reliability, financing mechanisms, institutional management capacities and socio-cultural aspects. This paper presents results of study, whose objective was to analyze determinant factors for sustainability of community managed rural water supply projects, focusing on a case study area in Moshi, Kilimanjaro Region. The study adopted a mixed approach of both qualitative and quantitative research methods. The study focused on Board of Trustees and Water User Associations management models. Data collection tools included direct observation, interviews, focus group discussions and questionnaires. Among others, the findings revealed that even with the current high water fees collection efficiency which is (ranging from 75 to 85%), none of the water entities has been able to meet costs for major repair, rehabilitation or project extension which some of them are caused by flood and long rain seasons associated with damage of water infrastructure inside the protected area in KINAPA. The study also found out different levels of willingness to pay for water supply services. Majority of respondents (45%) indicated that most users pay their bills at 75%, while 16% indicated that users pay full bills (100%). Reasons that hinder effective payment of water user fees include low levels of, historical background, community participation, cultural believes, weak institutional capacity as well as high poverty levels. The study findings provided evidence those factors affecting sustainability lies within both informal and formalized aspects. The study has concluded that it is unbearable for the community managed water projects to generate adequate funds to cover project costs and thus recommends that National Water Fund to scale its functions so as to support sustainability like to provide financial support to community managed rural water projects to cover major repair, rehabilitations and management empowerment.

**Keywords:** Community managed water supply projects, Sustainability indicators

# **BUILDING ENTREPRENEURSHIP FOR WATER, LIQUID AND SOLID WASTE MANAGEMENT IN TEMEKE MUNICIPAL COUNCIL OF DAR-ES-SALAAM TANZANIA. A SOCIAL RETURN ON INVESTMENT ANALYSIS**

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## **Abstract**

Social return on investment (SROI) of water, sanitation and hygiene projects has not received the attention that projects in other sectors have received primarily because of perceived difficulties in quantifying benefits yet it is an approach that should be mandatory to all projects as it assesses contributions of an investment beyond economic benefits. SROI denotes a methodology that measures return on a project or investment based on experiences or appreciations of stakeholders and the people affected by a particular investment or project. This paper is an expose of benefits created by liquid and solid waste project in Temeke Municipal council of Tanzania. The project “building entrepreneurship capacity for liquid and solid waste businesses’ is primarily focusing on building entrepreneurship skills for liquid and solid waste businesses using a soft loan facility. Core initiatives include but not exclusively limited to constructing a decentralized waste treatment (DEWAT) facility, supporting small-scale entrepreneurs (SSE) in the development of market strategy and creating awareness on liquid and solid waste management.

# POTENTIAL OF FAECAL SLUDGE TO RESOURCE RECOVERY: MATERIAL FLOW ANALYSIS APPROACH: A CASE OF SELECTED UNPLANNED SETTLEMENTS OF DAR ES SALAAM, TANZANIA

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## Abstract

Based on a situational analysis study on faecal sludge management (FSM) conducted, this study aimed to investigate and propose future strategic and conceptual directions on faecal sludge (FS) resource recovery. Over decades, Dar es Salaam has experienced rapid population increase and urban unplanned settlements growth. Ninety percent of population relies on onsite sanitation with 15 connected to septic tanks while 75% use pit latrines, translating to large amount of faecal sludge being contained onsite. Collection, treatment and proper disposal of FS are major challenges posing management problems and risks to public health. Current situation of Dar es Salaam shows that 57% of generated faecal sludge is well managed while the rest 43% is disposed to the environment. Material Flow Analysis (MFA) approach was used to assess mitigating measures to maximize nutrient recovery and minimize environmental pollution in three unplanned settlements of Dar es Salaam City (Manzese, Keko and Kipawa). Nitrogen (N) and Phosphorus (P) were chosen as indicators assessed throughout the processes. Results reveal that total of 3.5 tonnes of faecal sludge contributed per capita annually is current disposed with zero recovery of resources, 38% out of that does not reach into treatment plants. Nutrient fluxes of approximately 131.8 tonnes N/year and 4.9 tonnes P/year disposed of with greywater. Again 5,149.2 tonnes of N and 3,032.6 tonnes of P are discharged with FS which is emptied but not delivered to treatment plants. The study proposed and analysed 2 mitigating measures through resource recovery scenarios. The analytical results show that the highest reduction in N and P to environment could be obtained by introduction of co-composting as one of resource recovery. Proposed energy recovery through carbonization and briquetting of dried faecal sludge to solid fuel shows promising results if 51.6% of generated FS will be emptied to cover the large amount of wood charcoal currently used by majority.

Key words: resource recovery; unplanned settlements; material flow analysis; Dar es Salaam

# STEP WISE APPROACH OF IMPROVING SANITATION COVERAGE IN TANZANIA

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## Abstract

One of the misconceptions for planning of settlements and infrastructure development in Tanzania was the focus on roads, electricity and water only. Sanitation services were left behind or provided through septic tank/cesspool systems or limited investments in sewerage network. Decision makers and planners gave townships low priorities until they reach a population density to be considered for national sanitation budget. These lead to environmental and public health situation that makes realization of a feasible and sustainable solution a great challenge. Accordingly, this article delineates a stepwise approach for improving sanitation services coverage through effective and sustainable intervention, considering population growth, land-use, access to water, health concerns, financing and environmental resources stewardship. A study carried out in Morogoro, Kahama and Korogwe towns (2017 – 2018) to develop a Guide for joint town-level master planning for improving water supply and sanitation services is the main basis of the proposed approach with the following characteristics: a) The sanitation services chain grow with time to match development b) The current planning consider future developments and immediate land acquisition for the ultimately needed facilities, c) A step-by-step development, as opposed to the “all or nothing syndrome” and expansion of the sanitation services chain to satisfy the needs, and d) Reinforce capacity for stakeholders to jointly undertake their various mandates in the chain and over time. In addition, the technical perspectives in this approach cover safe collection, transportation, treatment and disposal. The investments are shared between households, utilities, municipalities and ministries. The social aspects include culture and behaviour related to sanitation, social acceptance and engagement. Finally, legal dimension is designed to support planning, investment, operations, enforcement and advocacy. In general, sanitation service improvements are prioritized in infrastructure development in urban and rural areas.

**Keywords:** Environmental resource stewardship, sanitation services chain step-by-step development, and social acceptance

# ACCELERATING SCALE UP OF SMARTECHS FOR WATER INTANZANIA, USING A MARKET BASED APPROACH

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## Abstract

In order to reach universal and equitable access to safe and affordable drinking water for all (SDG 6), simple, market based, affordable and repairable technologies, (SMARTechs) such as Rope pumps, may be a good alternative for rural water supply. Together with partners and via local entrepreneurs the SHIPO SMART Centre already installed close to 10,000 Rope pumps in Tanzania, of which half is via Self-supply (private wells). This assessment looked at ways to accelerate scale up of SMARTechs in Tanzania from a marketing point of view. Local entrepreneurs, NGOs and Rope pump users were interviewed to get an idea about the supply chain and motivations of users. The best marketing is a bottom-up approach. Good-working examples with a certain critical mass, and clearly showing the advantages for the user are the most efficient way to create demand and to realize a shift in the customers' decision making in favor of a SMARTech. Consumers do not want to take risks and incline to choose the same technology and supplier as their neighbor. The market for private wells may grow stronger when people better understand the economic benefits (direct and indirect income generation). NGOs play an important role in the first stage of scaling up because both subsidy and social marketing are needed to establish a critical mass, to raise awareness at consumers and to convince the early adaptors of the new technology. To accelerate scaling up of SMARTechs, it is needed to support existing workshops with all aspects of the supply chain and to enhance their technical and business skills. But that is not enough, new workshops need to be found and trained continuously, until a complete national distribution network has been reached. With this approach even 'the last mile' may be reached.

**Keywords:** low cost technologies, rural water supply, self-supply, SMARTechs, Tanzania

# PATCHING SILC INTO COWSOS' PERFORMANCES TO TRIGGER PROJECTS SUSTAINABILITY

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## Abstract

Water supply countrywide in Tanzania at village level is commonly managed by Community Owned water supply organizations (COWSOs), which were initiated as a response to the Water policy of the year 2002. The responsibility of these COWSOs is to own, manage, operate and maintain the water supply systems on behalf of the community and ensure its long-term sustainability. The intention of the approach was to support villagers to manage their water supplies and installed infrastructures on their behalf. On the other hand, the "Saving and Internal Lending Community (SILC)" scheme is commonly established with primary purpose to provide simple savings and loan facilities, in a community that does not have access to formal financial services. Normally, the loan provides a form of self-insurance to members, supplemented by a social fund, which provides small but important grants to members in anguish. The SILC model is thought as a motivating tool to trigger members who ranges between 10-30 maximum to meet regularly, share ideas, contribute money, buy shares, give loans among group members and hence promote petty business among members and encourage them on keeping warm the COWSO. SILC would create opportunity for members to save and borrow flexibly as they need, and make attractive profits on their savings. Nevertheless, SILC would assist members in case of death, disease or natural disaster; local money lenders may not be willing to provide this service to the poorest; and most importantly, SILC help members build self-respect, self-reliance, self-dependence and self-confidence. These in general would build to long-term sustainability of COWSOs if SILC would be patched into it. Would trigger monthly meeting and set time to discuss water issues, their challenges and remediation measures. Thus, to this concept, SILC is hereby thought to be a triggering and motivation tools to make COWSO members meet regularly, discuss issues among others related to water infrastructures, which they are commissioned to operate on behalf of the entire community.

**Keywords:** Water supply, SILC, COWSO

# PLAN AND SUPPLY WATER EFFICIENTLY USING SATELLITE IMAGERY, PRECISE GDEM AND GNSS LEVELING

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## Abstract

Both access and water supply need to be executed timely and cost effectively. Planning for access, current, accurate and detailed topo-maps area needed. The readily available sources are outdated (over 50 years) 1: 50,000 topo-maps with heights in contours of  $\sim \pm 20\text{m}$ , thus, ground features are likely to have changed significantly. Using up-to-date high resolution Satellite imageries (2D visualization) and reliable high resolution DEM, 3D detailed and current digital topo-map is obtained. Free Google Earth maps are unreliable. Unlike developed countries, Tanzania does not have its own DEM. Fortunately there are public GDEMs that are gradually improving. Basic GDEMs are SRTM (USA, 2000) and TanDEM-X (DLR-German, 2010). In 2014 SRTM-1" became public. TanDEM-X 0.4" is commercial but TanDEM-X-3" is public. Most public GDEMs have been compared and validated at Ardhi University, mostly for their vertical performances in different land covers and terrains of Tanzania. Currently, SRTMv3-1" and ALOSv2-1" are the best with about the same vertical performance, their overall RMSE in Tanzania is . In low vegetation and flat areas is and in rough mountainous and forested is . Others like ASTER-1", ACE-3", MERIT-3" and SRTM-3" (CGIAR-CSI v4.1) are less accurate. TanDEM-X-3" is now under assessment. Global assessments show that TanDEM-X 0.4" is superior to any GDEM at the moment. Currently (2018) the absolute vertical mean error is  $< \pm 0.20\text{m}$ , and RMSE is  $< \pm 1.4\text{m}$ . The RMSE in low vegetation is  $\pm 1.1\text{m}$ , in developed areas is  $\pm 1.4\text{m}$  and in forests is  $\pm 1.8\text{m}$ . Spirit and Total Station leveling are the more used methods in water supply. The World is changing to GNSS leveling , whose 2D position is compatible with most of the satellite technologies and the 1D is orthometric height that ensures water flow through gravity. GNSS leveling is conversion of a GNSS position into using precise gravimetric geoid model. Since 2007 Tanzania has determined four gravimetric geoid models; TZG07 , TZG08 , TZG13 and TZG17 . Using TZG17 and accurate GNSS (GPS) position we can obtain a relative height change at about 1-cm level.

**Keywords:** Water Access & Supply, Satellite Imagery, Precise GDEM, Gravimetric Geoid, GNSS Leveling.

# OPTIMIZATION OF UNPLANNED WATER DISTRIBUTION NETWORK: A CASE STUDY OF MWANZA CITY, TANZANIA

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## Abstract

Water Distribution Networks (WDN) in most African cities are challenged by the pace of urban sprawl arising from population growth and rural to urban migration. Urban sprawl increases water demand and leads to organic extensions of the existing distribution networks. This unplanned expansion changes the designed network topology, thereby critically lowering its performance. The water distribution network in Mwanza, Tanzania, is a typical case of this phenomenon. The city's water distribution network is characterized by high operating costs and a large amount of non-revenue water (NRW)/real water losses. The Tanzania Energy and Water Utility Regulation Authority (EWURA) reports that NRW for Mwanza city was about 37% in the year 2017, while the national figure is 38%. This paper investigates the contribution of the existing network topology on NRW and how it can be reduced using optimization techniques. We sampled a District Metering Area (DMA) that comprised of a 13km length of network and about 1,000 customers. To study the impact of topology and hydraulic behavior caused by WDN change, we measured water flow and pressure for 24 hrs at the inflow point of the DMA. The Minimum Night Flow (MNF) analysis was done during early mornings (3:00-4:00hrs). Four pressure loggers were installed at four different points within the DMA to get a representation of pressure variation. The measurements of water flowing into the DMA, minimum flow during early mornings and pressure at 4 points were used to obtain the real losses and water balance. The existing WDN was modeled and simulated. The water balance indicates higher real losses through leakage and pipe bursts compared to the apparent loss. The pressure of the WDN was found to be higher than the threshold, and causes leakage and deterioration of the water infrastructure. The MNF analysis gives an indication of high leakage during maximum pressure. WDN simulation results show the velocity is below threshold at some parts of the system, which indicates the need for further study of water quality to check the biological stability of chlorinated water.

**Keywords:** Non-Revenue Water, Water Utility; Water Distribution Network, Urban Sprawl, Tanzania

# SEASONAL AND ANNUAL RAINFALL VARIABILITY AND THEIR IMPACT ON RURAL WATER SUPPLY SERVICES IN WAMI RIVER BASIN, TANZANIA

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## Abstract

Worldwide, an overall net adverse impact of climate change on water resources and freshwater ecosystems can be noticed. Change in rainfall trends and their spatial distribution modify the natural stream discharges, freshwater availability and groundwater recharge, thus causing an interruption in the water supply. The present study analyses the variability in seasonal and annual rainfall time-series in the Wami River Basin to see if there have been any significant changes in the rainfall from 1983 to 2017 and how it affects rural water supply services. Datasets of monthly precipitation recorded in three rainfall stations were analysed. The Mann–Kendall Trend Test was used to determine whether there occurred a positive or negative trend in rainfall data with statistical significance. The water-point mapping dataset was analyzed regarding its seasonal variation. A detailed statistical analysis applied to the rainfall time-series of all stations indicated that rainfall increase considerably, but without statistical significance. Water points were found to be substantially affected by seasonal changes both in availability and quality of water. The results indicated that the knowledge of the influence of seasonal variability could inform water engineers about critical periods of rural water supply and the future potential of water-services access

**Keywords:** Rainfall, Rural Water Supply, Wami River Basin, Water Points, Water Point Mapping

# SUSTAINABILITY EVALUATION OF REGIONAL WATER UTILITIES IN TANZANIA: NON-REVENUE WATER PERSPECTIVE

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## Abstract

Water utilities in the country are challenged with limited sustainability in water supply service provision, rendering customers dissatisfaction. Non-Revenue Water (NRW) in most utilities is still high. Huge amount of water is lost through leaks in some urban water distribution networks (physical water losses) and the volumes of water distributed without being invoiced (commercial water losses) compound the water supply situation. A study was conducted for the purpose of evaluating sustainability in the view of reducing NRW in 23 regional water utilities of Tanzania. In this study sustainability of a water supply service implies the likelihood of the service continuing to be provided over time. The evaluation was based on six (6) factors namely: adequacy of metering and metering management, meter reading and billing data management, control for unauthorized consumption, leakage control, quality of infrastructure, and governance. Data were collected through interviews whereby structured questionnaires were used. In analysis of the responses the study employed IBM SPSS (version 23), and a fuzzy set concept was adopted to analyze the sustainability index for each utility. All factors were statistically significant ( $P < 0.05$ ), this result indicates the correctness and contribution of the factors towards the sustainability of regional water utilities. DAWASA (Dar es Salaam) in comparison to other utilities scored the highest Sustainability Index (0.80), while G UWASA (Geita) scored the lowest sustainability Index (0.35). This result implies that there is a room for improvement to both DAWASA and G UWASA by 0.20 and 0.65 respectively. From obtained sustainability indices of the water utilities, 26.1% ranged from 0.71 to 0.80 which is termed Good, 30.4% ranged 0.51 to 0.70 which is termed Low, and 43.5% ranged 0.31 to 0.50 which is termed Unsustainable. Despite the above mentioned scores there was no utility in the range of 0.81 to 1.0 which is termed Excellent. Based on the findings, the study recommends that all the factors to be taken into consideration in pursuit of achieving the sustainability of regional water utilities.

**Keywords:** Fuzzy set; Non-Revenue Water, Regional water utilities; Sustainability factors Tanzania

# MISMATCH IN PLANNING OF WATER SUPPLY TO RURAL HEALTH CARE FACILITIES

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## Abstract

Health-care associated infections are a major cause for high morbidity and mortality rates in low income countries, a 'spread of infections in the very place in which patients are seeking care'. To prevent these infections, the 'availability of water, sanitation, hygiene, energy, and waste management' are necessary to create 'safe and adequate environmental conditions'. However, conditions at these places are far from safe and lack adequate environmental conditions. An assessment of 186 rural dispensaries and health centres in the seven districts of Dodoma in Tanzania in 2014 for instance revealed, that only 2% of these facilities had water supply on the premises, through a rainwater harvesting installation. The other 98% of the facilities needed to fetch water, from shallow wells and boreholes as far as 2 km away from the health facility or buy water from water vendors. Where connections to community water supply systems exist, the intake of water at the facility suffers from poorly functioning systems in the community. This illustrates a mismatch in planning of water supply systems in rural areas of Dodoma between demand and supply for continuous and safe water supply at public primary health care facilities in rural communities.

**Keywords:** HCAI, rural water supply, water supply systems, demand & supply, planning

# POSTER PRESENTATIONS

## PERCEPTION AND POTENTIAL OF RAINWATER HARVESTING TECHNOLOGY ADOPTION FOR SUSTAINABLE WATER SUPPLY IN TANZANIA

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### Abstract

Rural and urban water supply coverage in Tanzania is limited at 64.8% and 80% respectively. Increased water demand is anticipated due to industrialization strategy. Other studies highlighted that only 0.7% of rainfall is withdrawn in Africa for its major uses. Hence potential for rainwater harvesting (RWH). This study evaluated the perception and potential of RWH for sustainable water supply. An online questionnaire was disseminated to 185 LGAs. The data were analysed by IBM SPSS (version 23). From the findings, 65.1% of respondents admitted that RWH technology was recently introduced, and that the adoption rate scores were 44.8% and 50.6% for moderate and low respectively, while for high adoption rate and none practice was very low at 2.3% each. Nevertheless, 58% agreed that government has played a greater role in its promotion, followed by the private sector (31%). The villagers themselves and the combined efforts of two or more sectors accounted 11%. Demonstration pilot project was the main approach for promoting awareness cited by 53%, presentations in village meetings (43%), and the remaining 4% were for media, brochures dissemination and no awareness campaigns. Moreover, 76.2% and 8.1% of LGAs admitted that the preparation of RWH bylaws were underway and completed respectively, and the rest not done. On meeting daily water demand sufficiently, 53% had ranked it as moderate, while 39% said it was low. On rainwater quality, 33% rated it as excellent, 30% good, 24% fair, and the remaining 13% for both poor and very poor quality. 45% of the respondents cited no major complaints on rainwater quality. No water treatment components are usually included in RWH as revealed by 42%, using coarse screen (27%) and the remaining 31% included options of first flush, sedimentation, and disinfection systems. RWH system construction and maintenance cost were declared moderate by 58% and 62% respectively. As well some modalities of government subsidization were suggested. Therefore, researchers' perception is, there is a potential for achieving sustainable water supply through RWH technology, considering it's convenient and accessible. Henceforth, a more strategic RWH technology adoption, blue printed to include: raising awareness, incentives provision and supportive policy frameworks.

**Keywords:** Local government authorities; Rainwater harvesting technology; Rainwater harvesting technology adoption; Sustainable water supply, Tanzania

# DEFEATING FLUOROSIS IN THE EAST AFRICAN RIFT VALLEY USING THE KILIMANJARO CONCEPT

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## Abstract

Fluorosis has been prevalent in the great East African Rift Valley (EARV) since before this region was given a name. In the 1930s, the clear relationship between high fluoride level and mottling of teeth was established. Since then, the global research community has engaged in the battle to provide fluoride-free drinking water, and the battle is not yet won for low-income communities. An applicable concept for fluoride-free drinking water in the EARV was recently presented, using the Kilimanjaro as a rainwater harvesting park. The Kilimanjaro concept implies that rainwater is harvested, stored on the Kilimanjaro mountains, gravity-transported to the point of use, eventually blended with natural water and treated for distribution. The oral presentation will give a roadmap for the implementation of the Kilimanjaro concept in the EARV. Specifically, at nation scale, the following should be addressed: (i) updated nationwide information on fluoride contaminated areas, (ii) the quality and quantity of rainwater, and current rainwater harvesting practices, (iii) how affordable water filters can be integrated into rainwater harvesting (RWH) systems to provide clean drinking water, and (iv) the need for strict regulation of RWH practices to optimize water collection and storage, while simplifying the water treatment chain, and recommend strict analytical monitoring of water quality and public education to sustain public health in the EARV. The current view to be discussed is that, by combining rainwater harvesting and low-cost water treatment methods, the Kilimanjaro concept has the potential to provide clean drinking water, and overcome fluorosis on a self-reliance and sustainable basis. By drawing attention to the Kilimanjaro concept, this presentation calls for African engineers and scientists to take the lead in translating this concept into reality for the benefit of public health, while simultaneously increasing their self-confidence to address other developmental challenges pervasive in Africa.

**Keywords:** East African valley; Efficient water filters; fluorosis; Kilimanjaro concept; Rainwater harvesting

# THE UNDERLYING ISSUES FOR INEFFECTIVE WATER ACCESS AND COVERAGE: THE EXPERIENCE FROM BUKOBA AND MUSOMA

M.Y. Maganga

## Abstract

The objective of this paper is to alert and inform water services providers on the underlying issues identified from the Vitecon International experiences in Bukoba and Musoma Technical Assistance Project, which greatly affects their efforts towards the improved urban water services. Access to adequate quantity of safe water is a fundamental human need. Leaving no one behind. However, in Tanzania, water produced does not meet demand despite of massive productions. Operational efficiency of water utilities is very low. High Non Revenues continuing affecting utilities' capacity to sustain services provisions. Like other towns in Tanzania, NRW in Bukoba and Musoma stood at 50% and 62% respectively, with stagnant service coverage of 50% by 38%. The recent doubled water productions from the previous of 8,500m<sup>3</sup> to 19,000m<sup>3</sup> (Bukoba) and from 15,300m<sup>3</sup> to 36,300m<sup>3</sup> (Musoma) to augment limited supply exacerbates the loss as higher pressure added to an old distribution system. BUWASA and MUWASA established NRW team to control water losses and appeals for financial resources to invest in pipes replacement and water meters but NRW persisted high with recorded poor services. Thus, VEI experiences shows that NRW contributed mostly by underlying issues which are rested outside the traditional leakages and commercial losses control yet water utilities continues with their traditional practices with limited success. From the ambitious two years TA project's traverses, includes capacity assessment, water flow measurements, training, installation and replacement of water meters/software, water network mapping, coaching and mentorship process, VEI experienced that installation of integrated software which harness utilities' operational process and if given high priorities is a vital key tools in combating NRW reduction process. The TA's established interaction between various and valuable (software) systems and their integration into workable interface within BUWASA and MUWASA has enabled scientific analysis of core operations, retrieves valuable insights for NRW reduction and created momentum in the holistic reduction of NRW for the utilities to increase water access to unserved areas. In the conclusion, the paper is urging water utilities management to embark on scientific and one stop centred systems in addressing water losses for a quick improved water services.

# IMPACT OF PRIVATE SECTOR PARTICIPATION IN RURAL WATER PROJECTS: ELEWA AFRICA EXPERIENCE IN KITETO DC

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## Abstract

The role of private partnership as stipulated in the Water Policy, 2002 emphasize on ensuring Improved service delivery levels through enhanced private sector participation in rural water supply and sanitation services. Water demand is generally known to be one of the leading problems in rural areas and particularly in the arid lands such as Kiteto in Manyara Region henceforth participation of the private sector is of great importance to support government initiatives. This document declare that appropriate private partnership improve water services provision that ensure timely access of water in quality, quantity and affordable cost. Women and children are mostly affected by lack of access to water as walking long distances searching for water; baseline information indicates that under the circumstance, claimed to fronting physical damage and abuse caused harm of health, survival, development and dignity. In recognised situations and conducive environment created by the Government; ELEWA Africa association from 2015 decided to make intervention by providing help to rural poor communities that will improve life conditions and welfare. The identified challenges and gaps addressed in participatory approach through; social and environmental impact assessment, conducting hydrological and geophysical survey for establishment of reliable source, performing deep borehole drilling, project designing, installation of solar power systems, establishment of related water facilities such storage tanks and reticulation system and also, carrying out of management and operation trainings. Definitely, ELEWA Africa demonstrated in action to support achievement of global agenda and local efforts to which 12,227 population (male and female) with investment cost of more than Tshs. 232,165,755 have been reached directly with the improved water services that form an essential foundation for progress in health, education, nutrition, work and economic development.

**Keywords:** Community, Participation, Rural, Supply, Water

# APPLICATION OF MTANGO RURAL WATER SUPPLY SUSTAINABILITY TOOL FOR ASSESSING RURAL WATER SCHEMES IN HANANG' DISTRICT

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## Abstract

Recent reports from the Ministry of Water in Tanzania has portrayed that water supply coverage calculated from the functional water points has decreased dramatically despite of rapid increase in number of new water points that were constructed. It was revealed that sustainability of rural water points has been an outstanding challenge, the situation, which necessitated assessment of the sustainability of rural water supply schemes in Tanzania. This paper was meant to apply Mtango rural water sustainability tool to assess the existing rural water supply schemes in Hanang District and establish the linkage between rural water sustainability rate and coverage of rural water supply. The structured hand phone interviews were conducted with water committee and community water supply organisations' leaders in fifteen (15) sample villages from December 2018 to February 2019. The purpose of these interviews was to find out the number of improved community water point in the schemes that are sustainable based on every factor narrated by the tool. The overall sustainability of rural water supply schemes in Hanang' rural villages was estimated to be 0.479 which can be expressed as 48% sustainable, scaled as moderate sustainability. It was revealed that Getanuwas, Masakta and Garawja villages had high water supply sustainability, with ratio of 0.77, 0.76 and 0.73 respectively. Low sustainability was found in Dawar (0.11), and Bassotugang (0.21) villages. The main causes of moderate sustainability in Hanang' District were absence of operation and maintenance plan, unprotected water sources, Absence of monitoring visits, Inadequate water meters which were installed, Poor access and inability to reserve spare parts for repair.

**Keywords:** Aspects, Coverage, Factors, Sustainability, Water

# PUBLIC PRIVATE PARTNERSHIP TO ENHANCE WATER SUPPLY AND UTILITIES FINANCIAL SUSTAINABILITY

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## Abstract

A significant proportion of urban and rural residents in Tanzania has no access to public water supply and relies on unofficial sources. The water supply distribution network is yet to fully cover the utility mandated service area, and thus there remain considerable areas without utility water services. Utilities are generally trying their best, but, no matter what efforts they make, to cope with the rapid expansion of the urban settlements and achieve the set service coverage in all corners of the town, is for most utilities simply not a realistic target. Some neighborhoods will remain beyond the reach of the network, hence living other people behind. Reason mostly paused have been financial constraints facing the utilities. This paper indicates how PPP can enhance Water Supply and Utilities' Financial Sustainability. It draws on qualitative and quantitative techniques to document details of citizens' strategies for accessing water service. A descriptive and evaluative framework is developed to capture the complex mix of sources. It is assessed to what extent these strategies solve access problems like quantity, quality, affordability and reliability. The study however, assesses factors contributing to financial unsustainability and draws conclusion to mitigate. The study based on lessons learned from experience of two years from the year 2015 to 2017 while working with DAWASCO, coordinating the Water by tanker project, mostly involving private entities. The paper reviews and assess roles played by the private sector to explore its potential in the future for sustainable Water supply to leave no one behind in accelerating Universal Access to Water Supply. The paper outline steps needed to be taken facilitating further development of private sector participation and the role of the international community in helping to optimize the sector's potential contribution. It is found that Tanzania Private Sector Foundation (TPSF) in collaboration with Association of Tanzania Water Stakeholders (ATAWAS) can optimize the role of private sector development in Tanzania. Recent trends and prospects in private capital flows and private sector participation in Water services development are described. Various options for private sector participation and strategies for mobilizing private sector resources are outlined and described. .

# THE IMPACT OF PRO-POOR INTERVENTIONS ON THE PERFORMANCE INDICATORS OF A WATER UTILITY: CASE STUDIES OF NAKURU AND KISUMU

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## Abstract

Water utilities have been confronted with the conflicting mandates of expanding services to all, while attaining financial sustainability. In the pursuit of striking the balance between these, often conflicting mandates, the expansion of services in low-income areas has been lagging. Despite the increase of pro-poor interventions in the Global South to revert this trend, utilities still struggle to demonstrate the positive impact of these interventions on the (financial) performance of water utilities. It is often believed that the expansion of services in low income areas will have a negative impact on the utility's performance as typically collection rates are low, vandalism of the infrastructure is high and customer requirements are different from those in other areas of the city. Using the case of the pro-poor units and their interventions in Nakuru Water and Sanitation Services Company Limited (NAWASSCO) in Nakuru- Kenya and Kisumu Water and Sewerage Corporation (KIWASCO) in Kisumu –Kenya, this research analyzes the impact of these interventions in the operational performance of the utility. The results of this research seem to indicate that interventions based on these technological choices revert positively on the operational and financial indicators of the utility, as opposed to what has been presented in other literatures. Apart from having increased their service coverage from 24% and 25.6% to 92% and 63% for NAWASSCO and KIWASCO respectively, the utilities under the study have seen reduced Non-Revenue Water (NRW) and improved collection efficiency. We argue in this article that even though service levels in low-income areas still lag behind those in other areas in the city, the creation of pro-poor units has facilitated (or accelerated) the advancement of services in underserved areas in the cities of Nakuru and Kisumu while allowing utilities to preserve a certain degree of financial sustainability.

**Keywords:** Financial sustainability, Low income areas, Pro-poor interventions, Social responsibility, Water utilities

# CHALLENGES FACE BY THE SCHEMES MANAGED BY COWSO AND PRIVATE SECTOR PARTICIPATION

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## Abstract

Despite the effort made by the government of Tanzania on major reform on the Water Sector since 2002, access to water and sanitation in the country remains low and in particular in rural community. It's a major challenge because it's not easy to establish measures that will ensure that drinking water facilities are provided, maintained and managed in an efficient, equitable and sustainable way. This paper based on the analysis of the data by using CIT model in Bagamoyo district. The paper confirms some findings that COWSOs fail to operate due to lack of education to COWSOs members, location of water point far from the majority population, documentations of financial reports, lack of governance and division of responsibilities to each member. Also most of the COWSO members, lack capacity of understanding that in development there is no miracle since they want water for free by forgetting that there are charges of service for the case of failure in a pump, or leakage in pipes. Failure to contribute in water charges leads to lack of money to run the project after the donor winds up. Also, some COWSOs have a positive effect on the mobilization of payment for water services. Basing on the findings show that leadership also matters for the provision of safe drink water. In particular, findings show that female leaders seem to be effective in this respect. COWSOs and private sector can coexist in management formula that holds together independence and community participation, with efficiency in daily management. The government should increase funds for COWSO registration process and should plan proper monitoring program in advance. Districts should encourage communities to produce monthly reports to monitor the progress of the projects since most of the projects fail after the donor handover to the community due to lack of monitoring that relates to poor governance. We need to increase and improve financing at local level. NGOs can help in this area, as local authorities don't have enough funds located to them from district levels. Evaluation, monitoring and protecting water resources is very important.

**Keywords:** COWSO, management, monitoring, NGOs, rural

# THE RELATIONSHIP BETWEEN TOTAL QUALITY MANAGEMENT AND PERFORMANCE OF THE PUBLIC WATER UTILITIES IN TANZANIA

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## Abstract

This paper draws attention on the relationship between Total Quality Management (TQM) and performance of the regional water and sanitation utilities in Tanzania Mainland. Regional and National water utilities in Tanzania have never been well performing to the customer expectation but also below the mandate given. The main purpose of this study was first to examine and analyze performance trend of the regional and national water utilities for the consecutive 5 years operation horizon from 2012/2013 to 2016/2017. The second purpose was to introduce TQM approach to the regional and national water utilities for the intention of improving performance through continuous quality improvement of service. The study used existing published, grey literatures and official statistics, which elaborate the set of key performance indicators for the regional water and sanitation utilities as established by Energy and Water Utilities Regulatory Authority. This study adopted purposive sampling technique to select 12 regional water and sanitation utilities out of 25 existing currently. Selected regional and national water utilities were of category A, B, and C as per EWURA standards. 03 key performance indicators, which are service delivery, efficiency and sewerage services were selected using a purposive sampling technique. Data for this study was analyzed and presented in terms of charts and graphs. This study revealed that there are challenges on water and sanitation services delivery and hence efficiency and effectiveness issues are the matters to be dealt with while intending to improve performance of the utilities. Therefore, this study recommends on establishment of pilot projects, which will roll on the TQM approach in order to help regional and national water utilities to identify, analyze and assess qualitative and quantitative data which are relevant to their business and to enhance the effectiveness, efficiency, standardization and overall quality of procedures, services and working environment.

**Keywords:** Efficiency; Effectiveness; Performance; Regional Water and Sanitation Utilities; Total Quality Management

# CHALLENGES OF WATER SUPPLY PROJECTS IN RURAL COMMUNITIES TANZANIA' A CASE OF MVOMERO DISTRICT MOROGORO-TANZANIA

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## Abstract

Mvomero district has experienced application of different technologies of water supply since 1980,s. However, these projects are not functioning as very few are operating and for those operating have serious challenges and out of 100% of water points 60% are non-functional. This study intended to assess challenges of selected water supply projects, describe community's altitude towards water supply and institutions. Specifically, it intended to determine the nature and level of community participation in the development of rural water supply projects, to assess the institutions which provide rural water projects and support community and to identify challenges related to potable water supply projects in legal framework and management system in water projects. The research based on assessing the 'Challenges of Water Supply Projects in Rural Communities Tanzania' A case of Mvomero District Morogoro, results shows that out of 409 water points, the only 218 WPs are functional while 191 WPs were not functional and 95% of all available water projects in the study countenance challenges on poor management whereby 63.3% lack training and 80% lack Water Points Management Committees and improper understanding of water policy and 98% of hand pumps and open wells are none functioning, the 43.33% have no water accounts, and lastly,63.3% of Community Owned Water Supply Organizations (COWSOs) lack training and the methodologies used were Focus Group Discussion (FGD), questioners, presentations and Observations while data analysis was done by using Statistical Package for Social Science (SPSS). To address these challenges the research suggested the use of Community Index Tool (CIT) to address the rural water projects for the sustainability purposes based in four domains of Governance, Technical, Financial Management and Operation and Maintenances.

**Keywords:** Rural Water Projects, COWSOs, Water Point Committees and Operational and Maintenance

# TANZANIA WATER'S AND SANITATION CRISIS THAT NEED TO BE EMBARKED TO IMPROVE WATER ACCESS AND COVERAGE

Daniel D. Kasongi

## Abstract

Access to water and sanitation remains low in Tanzania. Determining data on access is particularly difficult because different definitions and sources are used, which results in significant discrepancies. In 2015, 50% of the population had access to “at least basic” water, 79% and 37% of urban and rural areas, respectively. Regarding sanitation around 40 million, in 2015, lacked access to “at least basic” sanitation. In Tanzania, in 2015, only 24% of the population had access to “at least basic” sanitation, 37% and 17% in urban and rural areas respectively. According to the Food and Agriculture Organization (FAO), in 2008 Tanzania had 96.27 km<sup>3</sup> of renewable water resources per year. This corresponds to 2,266 m<sup>3</sup> per person and year. Water resources are however distributed unevenly – both in time and space. During the dry season, which usually lasts from June to October, even large rivers can dry up or their flow declines substantially. Projections indicate that by 2025 Tanzania will experience water stress (defined as average per capita water resources below 1,500 m<sup>3</sup>) due to population growth and the resulting increase in consumption. In Tanzania, demand for both water and sanitation are high. The market for water products (storage tanks, pipes, rain harvesting facilities, etc.) and suppliers appears to be dynamic. And by taking advantage of the growing digital finance sector, there is a strong opportunity for our WaterCredit solution in Tanzania. The biggest problem with water access and coverage in Tanzania is due to poor innovative solutions to tackle the issues directly underlying water stress. Based on the first market assessment in Tanzania in 2016 by (Water.org) concluded that: Use of digital finance is growing rapidly. As many as 10 million people currently have a mobile account. There are estimates that mobile phone agents outnumbered all other financial access points by almost 30 to one in 2016. Rural areas in particular remain generally very poor, with around one third of the rural population classified as living below the poverty line.

**Keywords:** Access to water, water resource sanitation, rural and urban areas

# POTENTIAL OF PREPAID SYSTEMS IN SUSTAINABLE DELIVERY OF INCLUSIVE AND SAFE RURAL WATER SERVICES IN TANZANIA

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## Abstract

Tanzania in collaboration with development partners has invested heavily in rural water supply schemes around the country. Community Owned Water Supply Organizations (COWSOs) are being created to support and improve management of these rural water schemes. However, the issue of sustainability has emerged as an overarching challenge for the rural water sub-sector in Tanzania. For instance, the National water point mapping conducted survey in 2015 found that only 54% out of 86,946 rural water points were functional, and that about 39% were non-functional. Most rural water systems become non-functional one year after commissioning. Also, long downtimes and low revenue recovery characterize functioning schemes. The poor functionality raises severe questions on the capacity of COWSOs, and the possibility of the county to achieve the SDG goal of universal access to safely managed drinking water by the year 2030. To overcome the challenge, the pre-paid water system is currently gaining traction and being considered the game changer technology in ensuring the sustainability of rural water services in Tanzania. So far different models of the prepaid water systems have been piloted, for instance in Babati and Arusha by Ewater, Karatu by CRS and Kishapu by ICS among others. Although these technologies may be promising, it is not clear to what extent it can contribute to the sustainable delivery of inclusive and safe water services in rural areas of Tanzania. This paper is based on a study conducted between March and December 2018 in Babati, Arusha, Karatu and Shinyanga to assess the performance of prepaid water systems implemented in the respective villages. Methods used included: key informants interviews, questionnaires, observations and critical literature reviews. Prepaid systems can improve revenue collection processes. Besides, it generates essential data that is presently only used marginally to acquire financial figures. There is a considerable potential to use this data in understanding various trends, such as the use of water, repair needs, and seasonal demands. Also, the prepaid system business model is critical for its success. We conclude that up-scaling prepaid system in Tanzania should be based on a careful analysis of the business model and data ownership.

**Keywords:** Inclusive service, Prepaid System, Rural Water Supply, Sustainability, Tanzania

# ENGAGING THE MEDIA IN THE FIGHT FOR A WATER SECURE TANZANIA: INSIGHTS FROM HABARI ZA MAJI AWARDS

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## Abstract

The media has a vital role to play in delivering sustainable water services and water resource management in Tanzania. As well as getting important information to the public and water users about their rights and duties, they must: investigate sector performance; ensure transparency; stimulate quality debate and heighten the political and public profile of the sector. This paper draws on documentation and analysis of the HabarizaMaji awards, established in 2017 with the aim of triggering wider coverage and higher quality journalism on water issues. It provides insights on opportunities for improved media coverage of water issues and reflects on the value of the awards as a mechanism to improve media coverage towards delivery of water related SDGs and National Development Vision 2025. Over 30 journalists were trained and supplied with reference materials on water management: laws, policies and regulations. A national call for entries to the HabarizaMaji Awards for outstanding journalism on water was issued and over 80 submissions received. Careful documentation of the awards ceremony and the training event, evaluations and discussions explored the barriers and opportunities for quality journalism on water in Tanzania. Analysis of evidence and testimony from journalists, media experts and editors has confirmed that recognizing journalists through awards has raised the profile of water issues in the media. Feedback also suggests that a stronger 'public interest' ethos is required within the nation's media houses so that issues such as water are afforded the budgets and editorial support needed to sustain quality coverage. Journalists not only require additional capacity, but motivation and incentives to keep them focused. An annual awards process is one route towards this. Impact analysis will now explore whether heightened media coverage translates into action to improve water security by the public and decision makers.

**Keywords:** Accountability, Journalism, Media, Water Resources Management,

# IMPROVING URBAN SANITATION BEHAVIOURS – TACKLING UNSAFE EMPTYING PRACTICES AND THROWING TRASH INTO PITS

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## Abstract

The WASH SDG programme is working towards improved health and quality of life of men and women in Arusha and Shinyanga through access to sustainable and environmentally safe sanitation and improved hygiene practices, and is led by SNV in collaboration with LGAs and utilities.

The WASH SDG baseline assessment showed that in the urban districts of Arusha and Shinyanga there are about 54.5% of households with unsafe emptying practices that contaminate the environment, 76% have unsafe solid waste storage at their premises and 69% with unsafe Menstrual Hygiene Management. From this, two key behaviours, specific to urban environments, were selected: 1) unsafe emptying practices and 2) throwing trash into pits including MHM products. Complementing the work of the National Sanitation Campaign, the WASH SDG programme, along with local authorities and utilities, designed a Formative Research to gain further understanding of the factors (barriers and drivers) which influence these two behaviors and the best ways to reach them through behavior change interventions along the sanitation service chain. For this research a SaniFOAM framework was used and a random sample was selected for Focus Group Discussions (FGDs) and In-depth Interviews (IDIs). Representatives from targeted populations were selected according to gender, geographical area and financial situation and a smaller target group with potential influence over the target consumer groups was selected for IDIs. Results showed that, in general terms, behavior practices are mostly influenced by inadequate knowledge on environmental and health consequences, by having difficulty in accessing professional/safe services and by affordability issues. Furthermore, linking the determinants to human motives, the research showed that nurture, affiliation, fear and disgust are the predominant human drivers. From here, the programme aims to create a successful and sustainable BCC strategy along with NSC Coordinators and other stakeholders and implement relevant communication for development activities through a holistic approach that will allow the programme to prepare the environment so behavior change can take place. This includes improving services, enforcing laws and including women in decision making.

**Keywords:** Behavior Change, Behavior Change Communication, Formative Research, National Sanitation Campaign, Urban

# UPGRADING ON-SITE SANITATION (OSS) FACILITIES IN ARUSHA AND SHINYANGA – DEVELOPING A LOCAL MASON DATABASE

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## Abstract

The SNV-led WASH-SDG programme aims to improve health and quality of life in Arusha and Shinyanga through access to sustainable and environmentally safe sanitation and improved hygiene practices, in collaboration with LGAs and utilities. The baseline and Rapid Technical Assessment (SNV, 2018) shows 52% in Arusha and 40% in Shinyanga do not effectively contain human waste from contaminating the environment. Also septic tanks require frequent desludging, unlined pits cannot be emptied and some latrines cannot be connected to the sewer due to their type and poor designs. Therefore, the programme decided to implement an onsite sanitation facilities upgrading programme in Arusha City and Shinyanga Municipality. The intention is to move people towards on-site containment which is environmentally safe (not leaking into ground water), less susceptible to flooding, and easy/easier to empty safely. As part of this process, a database of local masons was developed, to assess their current capacity and later train them in technical skills and business development. The methodology used involved getting ward leaders to identify masons in their respective areas. One Mason was identified to serve 250-500 people. The data collection was done through AkvoFLOW, a Smartphone application. Data collected included age, education, main expertise and type of toilet and containment they can construct. A total of 495 masons were identified, most having more than ten years' experience. Only 4% were female. Their age range is 19 to 70 years. More than 68% completed standard seven, 17% completed form four and only 14% attended VETA or technical college. Their main area of expertise is in house construction, with most having experience of pit latrine construction. However, less than half of the masons can construct septic tanks or pour flush toilets. With the database, the City and Municipal health departments can prioritise training for masons and thereby support the efforts of the National Sanitation Campaign in moving people up the sanitation ladder.

**Keywords:** On-site sanitation, upgrading, local masons, pits, septic tank

# WATER UTILITIES' IMPROVEMENT: THE NEED FOR WATER AND ENERGY MANAGEMENT SKILLS

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## Abstract

Water supply systems consume energy through individual treatment and pumping equipments and the level of consumption is dependent on many factors such as equipment age and maintenance status. The operator's skill is also influential on water systems' energy consumption. Since energy cost to Tanzania Utilities constitute up to 40% of operating cost, there is a clear motivation for reducing the energy consumption. Besides the energy costs, the utilities suffer from water losses, non-revenue water (NRW). Non-revenue water is also on the higher side, approaches 50% to some Utilities. The high energy cost and non revenue water are therefore impediments to Utilities' performance in expanding water network coverage and for improving service delivery. Curbing non-revenue water is an investment issue since the Utilities requires huge infrastructure investment. However, energy management is mostly skill-related, the Utility staff must be aware of energy efficiency and they should be capable to undertake energy auditing to come up with corrective measures. Energy auditing entails undertaking data collection and analysis and performing detailed energy analysis. In order to bridge the skills gap this paper is presenting the Authors' experience in undertaking energy auditing to water Utilities. This takes into consideration that Tanzania Industrial Research and Development Organization (TIRDO) has a tracked record in undertaking the energy auditing. Conclusively, experience from assessments done to Tanzania Utilities observed limited awareness on energy management, absence of energy policies and inadequate energy management skills. Though some Utilities are already implementing energy management measures, the majority lacks basic skills in production and energy data analysis for developing key performance indicators. Furthermore, absence of advanced skills in undertaking energy auditing for preparing bankable proposals for convincing management to invest in energy management measures is rampant. The general recommendation is therefore to increase energy efficiency awareness and impart the energy auditing skills.

**Keywords:** Energy Management; Energy Policy; Energy Efficiency Awareness; Energy Auditing Skills

# POTENTIAL USE OF FAECAL SLUDGE CHAR BRIQUETTES AS A SOURCE OF COOKING ENERGY

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## Abstract

In Sub-Saharan Africa more than 80% of city residents rely on on-site sanitation facilities for their sanitation needs. However, there are growing challenges on management of faecal sludge accumulating in these on-site sanitation facilities. Dar es Salaam, the ninth fastest growing city in the world rely on on-site sanitation system. Whereby, about 90% of 5.8 million people rely on the on-site sanitation containment technologies, producing massive amount of faecal sludge. Nevertheless, only 43% of the generated faecal sludge is safely managed, the remaining amount ends up directly into either open channels or water bodies, leading to contamination of water sources and risking public health. The generated faecal sludge has high potential of being recovered into solid resource e.g. FS char briquettes or fertilizer for soil conditioning. SDG 7 calls upon strategies for ensuring access to affordable, reliable, sustainable and modern energy for all by the year 2030. By 2032 it is estimated that the city of Dar es Salaam will be generating 10,217m<sup>3</sup>/day of faecal sludge. This is huge quantity to be handled by existing treatment units, i.e. Waste stabilization ponds and DEWATS. The aim of this study is to investigate the potential use of faecal sludge char briquettes as a source of cooking energy in cities of developing countries, Dar es Salaam city being the case study. A lab scale faecal sludge bio-char will be prepared using a pyrolysis plant for carbonization and manual screw press for moulding, the products will be tested for combustion quality, emission levels and social acceptance among the cooks at small scale restaurants and university canteens located in Dar es Salaam city. The obtained data will be analysed using Microsoft excel version 2016, SPSS version 25, STAN tool version 2.6.8 and REVAMP tool. The findings and recommendations from this study will provide a baseline and assistance to decision makers, researchers and other stakeholders involved in the management of faecal sludge and environment, towards formulation of a sustainable intervention that integrates technical, environmental, social and economic benefits of using FS char briquettes over wood charcoal. The study is ongoing, preliminary results will be presented.

**Keywords:** Cities, Faecal Sludge (FS), Faecal Sludge Management, Faecal Sludge Char briquettes, Sanitation.

# ENABLING ENVIRONMENT FOR SUSTAINABLE SERVICE COVERAGE IN URBAN WATER SUPPLY

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## Abstract

The Tanzania Development Vision 2025 target universal (100%) access to water supply in urban areas and 90% water supply coverage in rural areas by 2025. Water supply coverage target set by the Ministry of Water (MoW) is to have 95% coverage in urban areas as 85% coverage in rural areas by the year 2020. There is still an enormous gap between the targets and the actual level of water supply services, the current situation coverage is 78% for urban areas and 58.7% for rural areas (MoW, 2018). Urban water utilities are licensed to provide water and sanitation services in urban areas. Experience has shown that in addition to changing climate there are other factors, which cause slow pace to reaching the service coverage targets. Data and information collected by ATAWAS from its members revealed that utilities in Tanzania are characterized with scenarios of unreliable water sources, deterioration of the quantity and quality of water resources, limited and aging infrastructure in water production, water distribution and even sewerage service provision. Other challenges are understaffing, high water losses and low budget allocation for the water sector. The allocation of the budget for development projects in the water sector are not sufficiently and timely disbursed to the respective projects. This leaves many projects being not fully implemented or not implemented at all. High water losses reduce the amount of water made available to customers and endanger financial position of a utility. Water scarcity, high unpaid water bills from government institutions and shortage of funds for water infrastructure investments is disappointing for utility staff. It also questions the role of the government and development partners in transforming poorly performing utilities into financially healthy enterprises that deliver reliable and affordable water services to customers. Solving some of water supply challenges are way beyond the capacity of the urban water utilities especially those in district and small towns which are in category C. More collaboration and support from the government and other development partners is needed to create for the urban service provider to reach the SDG 6 and leave no one behind.

**Keywords:** Service coverage, urban water supply

# INFORMAL ORGANISATIONAL ARRANGEMENTS FOR MEDIATING THE USE AND MANAGEMENT OF LOW QUALITY WATER AMONG MULTIPLE USES IN PERI-URBAN MOROGORO, TANZANIA

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## Abstract

This study was conducted in Changarawe village; a peri-urban area in Morogoro, Tanzania. It analyzed informal organizational arrangements for the use of low quality water generated from the Mzumbe University waste stabilization ponds. The study was guided by the following questions: Is low quality water used? What are the uses of low quality water? How is low quality water managed? What are the informal organizational arrangements and how do they govern the use of low quality water? A survey was conducted with 30 vegetable farmers, in-depth interviews with 5 key informants and 2 focus groups discussions with low quality water users were also conducted. An interview schedule was used during the survey whereas checklists of questions were used to guide in-depth interviews and focus group discussions. Quantitative and qualitative data were analyzed using Statistical Package for Social Sciences Software and content analysis respectively. The results showed that low quality water from the Mzumbe University waste stabilization ponds was used to support vegetables irrigation, brick-making, fishing activities and as a source of drinking water for livestock. Vegetable farming and brick-making were the major activities; hence informal organizational arrangements for mediating the use of the resource were inevitable in the absence of formal institutions. However, the findings indicated limited informal efforts were devoted to the management of low quality water. With that regard, there is a need for improved collaboration between the Mzumbe University as the owners of the ponds and the multiple users of low quality water from the ponds to strengthen the informal organizational arrangements for management of the low quality water in order to optimize its uses.

**Keywords:** Informal irrigation; irrigation water scheduling; organizational arrangements; waste stabilization ponds.

# DESLUDGING IN UNPLANNED URBAN SETTLEMENTS IN DAR ES SALAAM: SITUATION ON THE GROUND AND POLICY IMPLICATIONS

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## Abstract

Onsite sanitation systems are still the major means for providing sanitation services in unplanned urban settlements of sub Saharan Africa. However, due to limited space in these areas, construction of replacement pits is practically impossible. The viability of onsite sanitation thus solely depends on desludging services, which in most cases are limited. This paper present results based on analysis of data on toilets desludging collected through field observations, key informant interviews and a survey of 395 households in unplanned settlements in Manzese, Keko and Kipawa wards in Dar es Salaam. A total of 191 (48.4%) of the dwelling houses desludged toilets when they were full of sludge. A majority 144 (75.4%) of dwelling houses reported to have used vacuum tankers while the balance 39 (20.4%), 6 (3.1%) and 2 (1%) used manual pit emptying, flooding out and small scale equipment (Gulper) respectively. Manual pit emptying and flooding out presents unhygienic desludging, a human and environmental hazard although is practiced by few. Results of logistic regression analysis shows increased odds of practicing unhygienic desludging among residents in low lying areas with high water table, dwelling houses with toilets that lack lining, dry type toilets e.g. traditional or VIP latrines and those lackingspace for vehicle parkingalong with low income. Furthermore, users seem to be unsatisfied with Gulper performance. As a result, groups that provide desludging services using Gulper have seized operations because of lack of customers. Desludging in the study areas is likely to improve with the lining of toilets to improve their desludge-ability along with financing mechanism for the poor. Application of sanitation technologies that do not require excavation of deep pits such as simplified sewer or Black Fly Larvae toilets may be suitable in areas with high water table. Further studies are needed to investigate the effectiveness of small-scale equipment interms of technological, institutional, socio-economic and environmental viability.

**Keywords:** Desludging, Dar es Salaam, onsite sanitation, unplanned urban settlements, small scale equipment

# MENSTRUAL HEALTH MANAGEMENT DILEMMA: COULD GOVERNMENT ADDRESS A SITUATION BASED ON ITS DEDICATED ROLE?

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## Abstract

Menstrual Health Management is a normal biological process and a key sign of reproductive health, yet in many countries including Tanzania with persisting taboos, negative socio-cultural norms, and limited access to information hamper women and girl's capacity to manage menstruation. These problems are exacerbated by insufficient access to sanitary materials, safe and private toilets and lack of clean water and soap for personal hygiene. In the past decade, many partners in Tanzania have strived to address the Menstrual Health Management (MHM) situation mostly on institutions and health facilities with inadequate coverage to rural and marginalized areas in Tanzania. More efforts are required with Government taking a leading role to MHM partners to ensure that lack of water, sanitation and hygiene services in schools and health-care facilities do not pose infection risk within those institutions to which User's approach and expectation for safe hygienic sanitation facilities, flowing water for cleaning their bodies during menstruation and safe disposal facilities for used sanitary materials. This paper explores and describes the MHM initiatives implemented in schools and institutions in Tanzania and reviews its impacts to women and girls. It concludes that if Government continues to play its critical role on policy formulation, creating conducive environment for key stakeholders on MHM to work efficiently and setting aside the adequate funds for establishment of reliable and safe flowing water supply, clean sanitation facilities and hand washing facilities with soap, changing room and support the menstrual material supply chain, Tanzania could witness the tremendous change to menstruating women and girls with inclusion of the marginalized groups on improvement on infection prevention and control for good health outcomes, dignity and social justice.

**Keywords:** MHM -Menstrual Health Management, Sanitary Materials- All materials used to protect menstrual flow for women and girls, WASH-Water Sanitation and Hygiene

# THE USE OF ENGINEERING ECONOMIC EQUIVALENCE CONCEPTS TO PRIORITIZE OPTIMAL WATER SOURCE FOR HOUSEHOLDS IN TANZANIA

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## Abstract

The efforts to make all Tanzanian citizens obtain safe, clean and affordable water contribute greatly in accomplishing one pillar of the Tanzania Vision 2025, 'achieving a high quality livelihood for its people'. While supply of water to the Tanzanian citizens is mainly through pipes/taps, water accessibility by individual households remains a great challenge. In average, 26% of population living in urban and 38% of population living in rural areas lack good access to the water. When this problem prevails, engineering economic equivalent study concepts are not yet well recognized and used to prioritize water supply source to serve individual households in Tanzania. This study therefore conducts critical review and evaluation of the relevant literatures to help develop a framework that guides in prioritizing and accessing water by the Tanzanian households. The framework has three dimensions: (i) understand water accessibility indicators (ii) define water sources investments and parameters for installing cost consequential (iii) engineering economic equivalence formula and cash flow diagrams for prioritizing optimal water source. Householders in Tanzania and in other developing countries are urged to use the developed framework to evaluate their water needs, prioritize and access the water source. With regard to future study, it is suggested that water project investment components costs must be investigated and used also investigate treatment implication from the respective sources.

**Keywords:** Water accessibility, household, harvesting water, piped water, wells and water by gravity

# SUPPORTING PARTNERS



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 Wizara ya Maji Tanzania