Overview of the 2nd SADC Groundwater Conference, Johannesburg, South Africa

4th - 6th September, 2019

Venue: Southern Sun, OR Tambo Airport South Africa

Theme: Groundwater’s Contribution to achievement of Sustainable Development Goals in SADC Region.
2\textsuperscript{rd} SADC Conference Technical Committee

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Foreword

I would like to present this report of the 2nd SADC Groundwater Conference that took place in Johannesburg, South Africa from the 4th to 6th September, 2019. This year’s theme was Groundwater's contribution to achievement of sustainable development goals in the SADC region. The conference is being held at an opportune when our water security is threatened by the adverse effects of climate change, poor agricultural performance, lack of adequate groundwater monitoring instrumentation and an increasing burden of water-borne diseases. Although, groundwater is not explicitly mentioned in the 17 Sustainable development goals, SDGs, it is implicitly linked to SDG 6, 12, 13. In principle, this therefore means groundwater’s contribution in facilitating the attainment of this SDGS is undermined and largely goes unnoticed. It is therefore in this regard, that this conference was themed in this manner to unravel not only the pivotal benefits we can draw from this resource but also to map strategies that would inform how we can sustainably manage our groundwater resources for the future generation.

This conference therefore informs our mandate as SADC GMI, which is to promote sustainable groundwater management and providing solutions to groundwater challenges in the SADC region through creating an enabling policy, legal and regulatory environment, capacity building, advancing research, supporting infrastructure development, and enabling dialogue and accessibility of groundwater information. Over the three days of the conference, more than 120 delegates spread across the SADC region and beyond participated in this event. Presentation, debates and discussions took place over the three sub themes: 1) Contribution of research towards understanding, the status, trends and risks to groundwater resources, (2) Measuring progress towards attaining SDG targets, data collection and management within the SADC member states, (3) Policy, legal and institutional considerations at the national and trans-boundary levels. It was clear that the challenges of groundwater are multifaceted but we have an opportunity to further evaluate our large scale transboundary issues using the state of art data analytics and machine learning and we must manage our water resources in a conjunctive manner with appropriate tools such as integrated hydrological modelling. Institu data collection remains an issue in the region and we are still challenged with a lack of innovation to comprehensive assess and develop our aquifer system. The technology may either be too expensive or still in it’s infancy. The conference continues to strive to encourage young scientists to attend the conference and take up these challenges through research projects at post-graduate level.

The conference has grown from strength to strength since the first one in 2018. It is therefore at this stage colleagues that I would like to appreciate the support that we receive from our cooperating partners and various other networks. We are grateful for the open door policy and indeed making this event a success. I also want to pay special thanks to the staff at SADC GMI, the local organising committee, the scientific committee for all the hard work. The SADC groundwater conference is here to stay and we look forward to hosting you again in 2020. Enjoy the read.

James Sauramba, Executive Director
Synthesis of the Conference

The 2nd SADC groundwater conference was held in Johannesburg, South Africa, from the 4th to 6th September, 2019. The conference theme was ‘Groundwater’s contribution to the achievement of Sustainable development goals in the SADC Region’. It had three sub-themes, (1) contribution of research towards the understanding, the status, trends and risks to groundwater, (2) measuring progress towards attaining SDG targets, collection and management within the SADC member states, (3) Policy, legal and institutional considerations at the national and trans-boundary level. Seven keynotes were given and three panel discussions took place.

In sub-theme one, 36 oral presentation were planned and 29 took place. Sub-theme two and three, 10 and 11 presentation were planned respectively but only 9 and 10 happened, respectively. Only one poster was missing from the planned 10. From the 136 who registered, only 125 attended giving the conference a 90% attendance. The majority were from South Africa, given that it was the host of the conference. Out of 16 SADC states, three were not present at the conference, namely, Tanzania, DRC and Madagascar. The largest representation at the conference outside South Africa but within the SADC region was Botswana. Only 12 young scientists (5 females, 7 males) were at the conference. There is urgent need to keep encouraging the youth to participate at this forum.

The full outline of the conference programme is given in the appendix section. The official opening ceremony had three speaker, Mr. James Sauramba, the Executive Director, M’s Lindiwe Lusenga, Deputy Director General, Ministry of Water and Sanitation, South Africa and Eng. Remmy Makumbe from Global Water Paternship, South Africa. The key messages from the presentations in relation to the theme were the following:

- Given the importance of groundwater (G/W) in coping with water scarcity and challenges brought about by climate change, there is a need to develop regional G/W assessment and Exploration strategies.

- We should not leave anyone behind as we work towards achieving SDGs. We should endeavour to couple citizen science with the research discourse.

- The 4th Industrial Revolution is here. Let us therefore apply innovation, research and development and evidence-based approaches. Use the technology and novel techniques in this age.

- Although none of the SDGs mention groundwater explicitly, 53 of the 169 targets have clear links to groundwater, particularly those pertaining to SDG 6, 12, 13 signifying the importance of groundwater for achieving these goals. This is therefore an opportunity for impact other interrelated sectors.

Several keynote speakers and presenters, as detailed in the programme gave presentation on research outputs. Key messages by theme are as follows:

1. Sub Theme 1: Contribution of research towards understanding, the status, trends and risks to groundwater resources

- Efficient water use, adopting a broader water mix (e.g. desalination, deep borehole drilling) and a responsive governance systems are effective pathways to manage a water crises (based on experience from Cape town, Day Zero Case).

- Management of groundwater resources at catchment level should include urban water management.

- Develop integrated modelling approaches (e.g. IHM) that support conjunctive use of water resources.

- Use of big data analytics show that the increased future dependence on groundwater irrigation will led to an acute risk of Arsenic contaminated food crops in continents including sub-Saharan Africa.

- Groundwater should be incorporated in catchment management plan within clear objectives, components and an implementation plan.

- Protection of groundwater resources should be enhanced through development of ambient water guidelines.

- There is need to reevaluate and interrogate some hydrological science frameworks e.g. dambos that are hosted underlain basement complex rocks, build the case for exploration of deep aquifers.

- There is need to define climate change tipping point for safe yield to ensure sustainable use.
- Recommendation to remodel the teaching of hydrogeology to incorporate technology.

- In data scarce areas and with large aquifer system, Grace data sets can be used to account for storage changes that could account for climate change impacts.

- Characterization of basement aquifer that are hosted in complex shear zone require integrated approaches e.g. hydrological, modelling and geophysical methods – Ramotswa Aquifer.

- In highly stressed aquifers, managed aquifer recharge can be explored through modelling approaches e.g Ramotswa Aquifer.

- Deep aquifers should be considered as strategic resources that are an important component to reach water security in water scare regions (SDG 6.1).

2. Sub-theme 2: Measuring progress towards attaining SDG targets, data collection and management within the SADC member states.

- Multidisciplinary approaches should be used in order to ensure the groundwater ecosystem linkage (groundwater dependent ecosystems). Supports SDG 15.

- Integrated approaches as well as the establishment of the baseline are the main tool to be used to achieve the SDGs in the SADC region.

- For transboundary aquifer management, in each aquifer region (type or category) it is necessary to establish the monitoring network in order to get groundwater level status (%) instead of average groundwater level. This will inform prediction and management.

- Climate change threatens groundwater management in arid regions of SADC demonstrated in episodic recharge threatens attainment of SDGs.

- There is also a need to involve citizens in data analysis and create ownership of data products.

- Data sharing should be seen as an instrument of cooperation and appropriate models are required.

- Big data analytic require downscaling tools that can assist filling gaps on data within the transboundary aquifer and assist with improved decision making on groundwater resources utilization and protection.

- Tracking process on SDGs should be through countries not RBOs (ownership of data is by countries) but there is need for streamlining to avoid duplication.

- SDG reporting has raised the need for more funding and big data analytics may assist although not a panacea.

3. Sub theme 3: Policy, legal and institutional considerations at the national and trans-boundary levels

- Make sure that scientific research findings get to policy-makers and eventually translate into better management.

- Share knowledge with all stakeholders that play a role in groundwater management, from policy-makers to groundwater users.

- Groundwater regulation (e.g. licenses) requires enforcement and assessment (for potential improvement).

- Transboundary cooperation on groundwater resources is at the forefront of SADC. Investments must therefore continue.

Details of the deliberations have been provided in the document. In general, the conference was a successful and provided a platform for networking and exchange.
01

Opening Ceremony
Mr James Sauramba, the Executive Director of SADC - Groundwater Management Institute (GMI) officially opened the 2nd SADC Groundwater in Johannesburg, South Africa from the 4th – 6th September, 2019. He stated SADC-GMI commenced full operations on the 26th September 2016 at the Protea Hotel. The institute’s main goal is to be a center of excellence for groundwater management in the SADC Region. Through close collaboration with partners, SADC-GMI has set itself to identify what is required to respond to it’s mandate while answering the question, “Groundwater for What?”. The Executive Director highlighted the following as key messages from the 1st Groundwater Conference:

(i) Groundwater supplies many cities and rural communities in Africa. 75% of Africa population depends on G/W for drinking

(ii) G/W is more resilient to climate change than surface water.

(iii) Because of the importance of G/W in coping with water scarcity, challenges brought about by climate change, there is a need to develop regional G/W assessment and Exploration strategies.

(iv) Successful Conjunctive use and management of G/W and Surface water resources at national and transboundary level should be supported by science-based evidence from research, capacity building and an enabling policy, legal and institutional framework.

(v) The implementation of Managed Aquifer Recharge (MAR) schemes has been successfully implemented in several African countries and it has proved to be successful.

(vi) 72 TransBoundary Aquifers (TBA) have been identified in Africa.

(vii) Experience of TBA Management in SADC shows that Transboundary Organisations are instrumental in managing TBAs.

(viii) G/W issues arise at local, national and transboundary level.

(ix) G/W schemes fail because of poor operations and maintenance.

(x) Sanitation and waste handling is closely linked to G/W

(xi) Coastal Aquifers present a special challenge due to the risk of seawater intrusion.

(xii) AMCOW, and African states were strongly encouraged to foster learning alliance, capacity development, knowledge sharing and networking on G/W at the continental and international levels.
Ms Lindiwe Lusenga, the Deputy Director General in the Ministry of Water and Sanitation, South Africa, in her address highlighted that we should not leave anyone behind as we work towards achieving SDG 6. Furthermore, she stressed the following:

I. Women and Youth in communities are integral to groundwater (G/W) resources development.

II. There was need to educate our communities to harness and manage the groundwater resources in a sustainable manner.

III. Climate Change is here to stay and we therefore need to adapt and start tapping into G/W resources.

IV. The 4th Industrial Revolution is here. Let us therefore apply innovation, research and development and evidence-based approaches.

V. We need to work on shared aquifers to benefit all.

Engineer Remmy Makumbe from the Global Water Partnership, South Africa, in his keynote address focused on “Perspectives, Challenges and Opportunities in Groundwater Policy, Governance and Management”. He mentioned that GWP’s vision is “a water secure world in the SADC region” with a mission “to advance governance and management of water resources for sustainable and equitable development”. In this endeavor, GWP-SA has a Memorandum of Understanding (MoU) with the Groundwater Management Institute of Southern Africa, in pursuance of its partnership framework and mandate.

The address briefly spoke to the following issues:

(i) Institutional Development of the SADC Groundwater Management Institute;

The Groundwater Management Institute of Southern Africa has grown from strength to strength, into a reputable Centre of Excellence, that can provide credible leadership to strengthen groundwater management in the SADC region, thanks to the collective vision of the SADC member States, the support from the SADC Secretariat, the leadership provided by the Executive Director of GMI, International Cooperating Partners, led by the World Bank and the stewardship of the University of the Free State, under the guidance of the dynamic GMI Board of Directors.

(ii) Key Challenges Facing the Groundwater Sub-Sector;

The following were raised as key challenges facing the groundwater sub-sector:

- Degradation of groundwater in the region arising from a variety of land use activities and over abstraction in some areas;
- Groundwater contamination from diffuse pollution and point source pollution;
- Lack of accurate and up to date data around shared aquifers, limited technical capacity at regional and national levels, as well as lack of adequate legal frameworks to underpin groundwater management;
- Limited research capacity, information sharing and knowledge management;
- Adverse effects of climate variability giving rise to a major squeeze of groundwater resources especially with persistent droughts ravaging the SADC region;

(iii) The Burning Issue of Groundwater Governance;

There is need to match the “demand side with the supply side” of water resources, in a sustainable manner. Indiscriminate resource exploitation has led to serious groundwater table decline and has unfortunately been accompanied by pollution of shallow groundwater, due mainly to uncontrolled urbanization, giving rise to adverse impact on human livelihoods and health. Improving the management and protection of groundwater constitutes a ‘major environmental challenge’ if groundwater abstraction remains uncontrolled, given the impact of a plethora of polluters, necessitating the flexing of muscles through a proper governance framework by the authorities. In an effort to strengthen governance of groundwater systems, the classic groundwater resource manager’s tool-kit which comprises a wide assortment of approaches, namely, planning, controlling, and behaviour changing instruments should be invoked.

(iv) The Intersection of Climate Change/Variability and Groundwater;

Global environmental change, including global climate change have had profound impacts on the hydrological cycle and available water resources. Water resources have therefore been given prominence within the global climate change research agenda. According to recent regular regional assessments, Southern Africa will continue to experience an increase in average temperature, which will lead to an increase in of 1 to 2 degrees, culminating in climate variability, thereby causing extreme droughts and floods vulnerabilities. Global environmental changes impact on water resources, and at the same time alter water demand and consumption dynamics. An increase in average temperatures is expected to change consumption patterns and increase total water consumption. Climate change continues to affect the global water balance, and it remains critical for state parties to continue pushing the highly industrialised...
world to scale down on Green House Gas Emissions, through compliance with the various global protocols, among then the Kyoto Protocol.
02

Sessions and Plenary
Prof. Yongxin Xu, UNESCO Chair of Hydrogeology, University of the Western Cape, presented a keynote on, Water Security: A perspective of Cape Town Water Crisis. In January 2018, it was announced that Cape Town, a city of 4 million people, was 3 months away from running out of municipal water. The proposed day, April 12, 2018, then came to be called ‘Day Zero’. Although the city did not run out of water on the proposed date, it experienced two consecutive years of anaemic rainfall. Several interventions were put in place to mitigate the water crisis in the context of IWRM that include:

- Construction of new dams
- Boreholes ~ groundwater development
- Storm water, reuse of water, treated effluent
- Desalination plants
- Rain water harvesting
- Conservation measures: fixing leaks & old pipes, installing meters and adjusting tariffs
- Water Services Act & Water use bylaws
- Political interventions to ensure sectoral collaboration

What can be learnt from Cape Town Crisis?

- Two key areas of failure that increased Cape Town’s vulnerability to drought: failures in managing existing bulk water supplies and failure to utilize groundwater effectively to diversify local water supplies
- In retrospect, however, the water crisis may serve as a case for other global cities to adapt a good governance to avoid such a crisis without first having to go through a similar experience
- Local approach with a top-down facilitation: “Day Zero”, a massive campaign to push it away!
- Adaptation to local history and to Changes (Climate and Global): by integrating GW with surface water on different time scales.
- GW sources must not be ignored and treated as Cinderella. If not being valued, it wouldn’t be protected and engineered.

Kevin Pietersen, Hans Beekman and Thokozani Kanyerere: Groundwater resources - The road to water resilience in urban water cycles.

- Resilience system analysis is increasingly applied to water governance to understand socio-ecological systems ability to recover from imposed shocks.
- The SADC Region is prone to environmental, political, economic and social shocks and stresses.
Opportunities for solutions:

- Water Security Partnerships - Closer cooperation between Public Sector, Private Sector and Civil Society - secured on a long term with appropriate budgets
- Road maps should have implementable steps
-Occupationally directed capacity building
- Targeted awareness campaigns should be explored.

Erika Braune & Kobus du Plessis: Conjunctive Water Use Model for Local Authorities.
- Conservative monthly groundwater yields are assessed for different stochastic sequences
- Surface Water, Groundwater, Desalination and Water Reclamation are combined to determine the conjunctive yield.
- Increased internal water assessment and management capacity at local authorities are required for effective conjunctive water use.

Stanley Nzama, Thokozani Kanyerere, Audrey Levine: Groundwater resources protection: Reflection on the relevance of the groundwater quality component of the Reserve for provision of clean water and sanitation.
- South Africa (SA) has grown from policy development (NWA, 1998; NWRS-2, 2013; NGS, 2016), to policy implementation (through Research Data Management (RDM) Studies).
- SA have been learning & improving along the way through adaptive management practice
- Public Private Partnership (PPP) was important
- Importance of stakeholder engagements should not be neglected.
- Knowledge sharing and transfer of skills is crucial
- RDM studies in all catchments at the same time can not be done because of costs.
- Linkages and alignment of RDM with other studies and initiatives is important
- In catchments where gazetted, they are legally binding
- Where gazetted, there needs for implementation measures.
- SA’s water situation presents a range of opportunities to achieve SDGs through RDM.

Karen Grothe Vilholth, Mohammad Faiz Alam & Joel Podgorski: Human dietary exposure risk via crop consumption from arsenic-contaminated groundwater-irrigated areas and transmission through international trade
- Approximately 1.5 billion people globally are living in countries with risk of high arsenic intake via food crop intake, while 53 million out of these are estimated to be exposed significantly through the trade pathway only
- Rice is of predominant concern for arsenic dietary intake for both large and small countries, wheat in few large countries, maize negligible
- Future groundwater irrigation expansion into presently rainfed or surface-water irrigated areas could almost triple the areas at risk of arsenic-contaminated crop production, mainly in tropical and semi-tropical regions

Marcus Fahle & Roland Bäumle: How to Develop Groundwater Management Plans
- Groundwater should be incorporated in catchment management plan within clear objectives, components and an implementation plan.
- Protection of groundwater resources should be enhanced through development of ambient water guidelines.

Andy Bullock: Understanding African groundwater by unlocking a critical divergence in the hydrological science of headwater wetlands
- Depletion of water stored within the swamp is dominated by evaporation rather than by contribution to stream flow.
- Contrasts with the common perception that wetlands attenuate flows findings certainly needs support to recent suggestions that headwater wetlands do not necessarily attenuate floodwater and augment base flows.
Afternoon Session:

Key Note 3: Dr. M.W. Lubczynski. Monitoring, remote sensing and integrated hydrological modelling for groundwater management in Southern Africa.

Dr. M.W. Lubczynski, Associate Professor at the Department of Water Resources of ITC Faculty of University of Twente in The Netherlands, gave a third Keynote with a focus on Monitoring, remote sensing and integrated hydrological modelling (IHM) for groundwater management in Southern Africa. The following were given as threats to groundwater:

- Highly unpredictable rainfall
- Climate Change
- Large PET expected to increase
- Thirsty Vegetation — Not only to failure to tap water but it’s tapping from Ground water
- Insufficient monitoring network

How to handle it

G/W resources replenishment dynamics evaluation critical for management purposes. This is achieved by Integrated Hydrological models (IHMs).

- This combines Surface and Ground water modelling
- Spatial data acquisition (remote sensing, hydrogeophysics and ground data)
- Monitoring temporal data
- Predictions of IHMs

Advantages of IHM

- Groundwater fluxes are not arbitrary defined but calculated
- Past surface and ground water modelers were separate
- IHM integrates Surface unsaturated zone and unsaturated zone therefore more reliable than and ground water and Surface water models alone
- Generated Outputs is the complete list of water cycle fluxes

Conclusion

- IHM is more reliable reliable than tradition stand alone
- IHM intro opens Remote Sensing applications as input for HIMS
- Gross and net recharge can be optimally quantified by IHMs


Main objective: To assess the surface-groundwater interactions dynamics in Boteti River Area (BRA) using an Integrated hydrogeological model. The finding suggest that Gross recharge not consistent with rainfall pattern but flow from the river. In addition, throughout the simulation period the aquifer generally lost groundwater towards the river channel with net water gain of 32 mm which is about 16 mmyr-1.

Recommendations

- Development of well distributed hydrological stations with alternative discharge estimation methods; for example, using Manning’s equation.
- The state/nature of the Thamalakane fault, laid N to NW boundary of the modelled domain should be studied


The main objective of the study was to assess the potential groundwater vulnerability of the Masama East wellfield to pollution. DRASTIC Index model is used to assess the groundwater pollution vulnerability.

Conclusion:

No contamination risk is expected from land use/cover types other than existence of residential and agricultural land in the Masama well field.

3. Andrew Joloza & Eddie Banks: Hydrogeochemical characterization of groundwater in the major aquifers in Malawi.

The objective of the study was to Investigate and compare the spatial relationships between, Groundwater chemistry, Hydrogeological characteristics of aquifer systems, Variation within the geological framework of the area.

Results and Conclusions:

- Trend from Ca/Mg-HCO3 type via Na-HCO3 to Na-CI type (Balaka, Machinga and Mzimba Bicarbonate dominate)
- Ca/Mg-HCO3 type dominated in Lilongwe and Nkhotakota samples
- Large increase in Na, CI and SO4 in BALAKA suggesting dissolution of evaporite minerals being dominant
Plenary Discussion

Deep groundwater exploration in SADC.

Panelists: From Botswana (Keodumetse Keetile), Namibia (Bertram Swartz), Prof Lubczynski, Kevin Pietersen.

Key discussion points from the panelists are summarized below.

Namibia (Bertram Swartz)
- Namibia deep lying aquifer, the Ohangwena aquifer, is a large fresh water aquifer hosted at a depth approximately between 250 – 350 m.
- Large amounts of abstractions in the Ohangwena aquifer has been reported and with past experience of drought it calls for increased monitoring.

Cape town (Kevin Pietersen)
- Deep ground water resources will play a major role in water supply
  - We must Focus on reuse and recycling as a norm
  - Conjunctive use needs to be in the perspective

Driller’s perspective
- Cape Town has three main aquifers
- Potential deep confined basins with current knowledge suggesting up to 1 km depth
- Different ground techniques drilling in consideration due to ecological systems
- Deep boreholes are not cheap and may go for more than a million USD. It is expensive but if done properly it’s worth it.

Botswana
- Botswana is very much dependent on ground water for water supply
  - Most aquifers are deep seated 150 km deep Shared with South Africa and Zimbabwe in Karoo sandstone.
- Challenge; Drillers with expertise are not around

Professor M.W. Lubczynski
- We need to know where to drill it, to find water is one thing and to drill is another
- Safe yield; Important - what you can get and replenish
- The recharge is once in a year, but other schools say u abstract and it will be recycled
- Botswana case Kalahari Basin there is a recharge area that comes from Namibia
- Integrated Hydrological Modelling maybe a solution
◦ Policy wise management of ground water
◦ Safe yield – Must be clear of other factors like Climate Change

The key outcome from discussion was that some deep aquifer maybe recharge from another country. For example, the Ohangwene is recharged in Angola which raises the question of transboundary water cooperation. Deep wells are not cheap but are a better options than large dams.

Day 2

Session Chair: Davies Saruchera
Rapporteur : Moiteela Lekula

1. Piet Kenabatho, Thato Setloboko and Bertram Swartz: Assessment of the impacts of climate variability on total water storage in the Orange-Senqu River Basin: implications for groundwater resources management.

The presentation highlighted the use of remote sensing to quantify terrestrial water storage, including groundwater storage, where there is lack of continuous monitoring through a simple water balance model. Two case studies were used, i.e. Stampriet Transboundary aquifer and Orange Senqu basin. However, highlighted limitations were that it’s more applicable to regional studies.

2. Manuel S Magombeyi, Karen G Villholth, Richard Healy, Girma Ebrahim: Recharge assessments across the Limpopo River Basin, approaches and findings

The presentation highlighted how application of multi methods of groundwater recharge assessment complimented each other and raise the confidence level of the results. It outlined how to use a certain groundwater recharge method and the limitations based on available data

3. Cesário Cambaza, Mieke Hulshof, Pieter van der Zaag and Paulo Saveca: IRRIGATION PACKAGE FOR SAND RIVERS – A Feasibility Study in the Limpopo River, Mozambique

The presentation assessed the alternative source of water for irrigation purposes. Different scenarios were assessed and the best choice was based on cost benefit analysis.


This presentation outline different approached on the development of a realistic hydrogeological conceptual model using multi-disciplinary approach.

5. Girma Ebrahim, Karen Villholth, Jonathan Lautze, Keetile Keodumetse, Piet Kenabatho, Sakhile Mndaweni, Naicker Sivashni, Moses Moehadu: Hydrogeological model for the Ramotswa transboundary aquifer - How much do we know?

The presentation defined development of a numerical groundwater model for a transboundary aquifer which will be used for the management of groundwater resources.


The presentation assessed enhanced groundwater replenishment of the transboundary


Groundwater quantity and quality is important for groundwater use and management. High mineralization (high TDS and EC) of groundwater in the SADC region and in Limpopo River Basin are common. The main source of groundwater mineralization in Chokwe District is water – rock interaction however further investigation are still ongoing to establish the local groundwater flow mechanism and groundwater changes during the dry and flooding seasons.


This study uses groundwater processes to model and assess aquifer-river interaction for groundwater dependent communities, semi-arid areas, Hout Catchment. This study is still ongoing and further has not drawn full conclusions in conceptualise of the aquifer conditions.
9. **Modreck Gomo**: On the use of Theis and Cooper-Jacob methods to interpret multi-well aquifer pumping tests in laterally heterogeneous confined aquifer systems.

The main objective of this study is to evaluate the sensitive of the Theis and Cooper-Jacob method in heterogeneous aquifer systems. It concludes that the use of Theis and Cooper-Jacob method is complicated in heterogeneous aquifer and there is need to continue improving the methodology and to carry out sensitivity analysis of the method including the distance of the pumping well from the observation well.


Boreholes as deep as 895m depth are being drilled to provide about 30 litres per second, but they require huge investments and experienced drillers. Compressors are required for drilling these very deep (895m) boreholes. Ecosystems are protected during the drilling and after drilling e.g. The Fanboo. This case study provides a framework for investment in deep well drilling for groundwater.

11. **Eva Masemola**: Barriers Against Groundwater Development

This study shows that:

- Groundwater should be developed to augment the surface water supplies
- Water security should be achieved by both water demand management and developing other sources
- Namibia, Botswana and South Africa have the highest per capita groundwater use in Sub-Sahara
- Institutions and governance capacity in South Africa are not responding appropriately to groundwater challenges
- People should be made aware of the importance of groundwater in water supply, especially under climate change.
Sub theme 2: Measuring progress towards attaining SDG targets, data collection and management within the SADC member states.

Key Note 4: Karen Grothe Villholth: Groundwater and the Sustainable Development Goals - Interlinkages and supportive guideline development

The contamination of groundwater is a growing global concern and its interconnected. It is explicitly linked to ensuring availability and sustainable management of water and sanitation for all. The use of groundwater need special attention for the local ecosystem as well as for sustainable use from recharge areas and discharge areas. Different strategies and multidisciplinary approaches should be used in order to ensure the groundwater ecosystem linkage (groundwater dependent ecosystems). Challenges of groundwater management are due to climate change impact on groundwater. In arid areas, the groundwater recharge will be increasingly episodic and risks are now recognized central to achieving the SDGs by key internationals organizations. Integrated approaches as well as the establishment of the baseline are the main tool to be used to achieve the SDGs in the SADC region. The development of groundwater monitoring stations and action plan to fill the gaps (for each hydrogeological region coverage) and data availability, will contribute to build the scientific understanding in the specific targets water quality parameters. For transboundary aquifer management, in each aquifer region (type or category) it is necessary to establish the monitoring network in order to get groundwater level status (%) instead of average groundwater level. This approach can contribute to predict the variability of groundwater status for the future and ensure the sustainable use of water resources.


This was two phases project that looked at the data need for each member state. A total of 145 Young Water Professional were Interviewed and a gap analysis was presented. The conclusion was that In most SADC member states, common data challenges were observed and a framework can be useful to all member states at whatever stage of groundwater data collection.
This would serve as a guide for planning and organisational aspects of all groundwater data collection as it provides concrete solutions and reference to key documents. In addition, this framework can be used as tool to assess and reorganise the collection and management of groundwater data.

2. Thokozani Kanyerere, Karren Villholth and Jaquiline Goldin: Using citizen science in groundwater data generation research to improve decision-making support on water information.

Citizens need to be aware on the data collected, they should not only be involved when institutions need their assistance but need to be involved on science and data presentation and know the implication on data collection. There are case studies related to citizen involvement in data collection like the Tankwa Karoo - they assist in collecting data from springs, dams and pools. Key aspect was that government departments are mainly involved from the onset and ensure ownership by stakeholders. Data management from various citizens has to be well coordinated in receiving by various institution - the data goes to the university and can be brought back to the government department.


Data should be shared as it was central to sustainable cooperation, a foundation to manage resources, a good place to start negotiation among riparian states, it impacts evaluation and fosters trust among riparian nations. However, with all these benefits, 40% of regional TB agreements are practicality lacking, no assessed quality and quantity of data has been done and no framework of how much data is exchanged, type, frequency, data type, mode of exchange and monitoring networks. This study therefore focused on the status of key data sharing aspects within Transboundary aquifers - member states. This framework applied an inclusion parameter base on surface basin. This study showed there are some ways in which data is being shared: emails, phones, online, social media etc. A key question is what is the best way of sharing? Data that is being shared include river flow, early warning etc. depending on resources available in member states. This study is still ongoing and will evaluate casual linkages models to determine the frequency of data sharing within transboundary member states.


Many formats and data generated from various activities and platforms can be analyzed, however, there was need to consolidate them into one model. Big data Architects have the benefits of storing and transforming analysis and dissemination of large complex data. Down scaling to localized regional aquifer datasets only requires computational power. Down scaling tools can assist to filling gaps on data within the transboundary aquifer and assist with improved decision making on groundwater resources utilization and protection.

5. Andrew Gemmell, Claudia Ruz Vargas and Ebrahiem Abrahams: Consolidation of transboundary datasets to enhance decision-making: lessons learnt from the Ramotswa aquifer southern Africa.

This authors highlight that Big Data Analytics can assist with filling the gaps of the raw data using machine learning. The data is analysed and learnt in four ways: Supervised learning, unsupervised learning, reinforced learning and deep learning.

Panel session: Groundwater and the Sustainable Development Goals: what is needed to move beyond status quo and achieve the targets.

Panelists: Sivashni Naicker (DWS South Africa), Steve Kumwenda (Baseflow Malawi), USAID, Dumisani Mndzebele (SADC Secretariat- Water Division), Trevor Shongwe (Department of Water Affairs Eswatini).

Sivashni Naiker: Each SDG sub goal is at a different level of achievement - TBA indicators are surface water oriented and only recently that groundwater is being considered.

- Nothing has been said on the targets - broken down targets that gets you somewhere, highlighted the gaps that have to get you there - groundwater quality has more gaps and gaps need to be filled.

Trevor Shongwe noted that, as part of SDG reporting, it has been Surface Water oriented but in Eswatini - dominant use is groundwater. SADC GMI should assist with improving knowledge on groundwater as is lagging behind. Transboundary waters - G/W protocols are not fully developed and therefore to manage such conflicts is therefore a challenge.
Maria – Namibia has a platform to report on the progress on SDG – good thing is that they ensure activities are part of the National Development Plan together with the annual plans assist in tracking progress on the SDG aspects. Namibia has four shared Transboundary – g/w and is just gaining momentum at a transboundary progress. No provision on where member states are to coordinate the transboundary issues.

Besides the three countries, a question was made to the audience to give there experiences on SDG tracking:

◦ Zambia – one of the issues from Zambia is lack of ambient water quality standards and how do you report on these aspects

◦ A comment from Eswatini – there is also an AMCOW pan African on the shared aquifers - AMCOW can be assisting with reporting on the SDG as well? - The comment is challenging as member states regarding reporting as there are lots of reporting required at various levels - moving towards a unified systems.

◦ From Namibia - a comment was that it felt like a duplication, AMCOW need reports, Stats Agency in Namibia, with different guide for similar items.

Questions & discussions

James Sauramba: funding on the achievement on the level of SDG – how do you relate the outlook with the level of funding?

SDG’s have raised the bar very high, which need funding - sometime 3 times more than the current basic services and it calls for resource prioritisation to achieve SDG, The Aspect if monitoring – water monitoring need finds, the Big Data Analytical may assist in closing some gaps on groundwater

What do you think should be the best model of reporting – should it be an RBO or at a country level – do RBO’s have enough capacity?

Accountability is on the member states and responsibility is with member states – whose SDG is it anyway? RBO’s have a role to assist Member States on facilitation comes into play. Capacity to gather information and bringing them in to one place. Member states need to come to a point that they use similar language for the same TBA. Reporting should be at country level. Member states need to come together to assist in in responding to SDG reporting need.

SADC’s vision on SDG 6: vision is on sustainable development. Delivering the target becomes very challenging - promotion on infrastructure development. Sanitation and supply - Regional strategic plan - has a reporting dimension and get the member states to respond to SDG Requirement.

The most important aspect is how can the region come together to work on the SDG?

Keys Messages: It was Important to recognise SDG’s – each one can have own SDG - important to give back and communicate - education systems and awareness on the SDG.

If we can get there with a clear TBA management through our RBO’s – get effective involvement of our water utility, realize increased groundwater as a conjunctive use as a regional resource

The SDG’s are about inclusive approach – need people to play from all levels – all people need to be recognized at all levels to ensure suitable water and sanitation

Groundwater has had a lot of studies done but funding to implement is not available at least in the SADC region.

Key issues are resources based on the resources of the member states and SADC GMI has a role to play and all member states need to play a role in SDG’s
Sub theme 3: Policy, legal and institutional considerations at the national and trans-boundary levels

Session Chair: Patience Mukuyu
Session Rapporteur: Kasonde Mulenga

Key Note 5: K. Upton, R. Cornforth, J.W. Foppen, R. Hope, A. MacDonald & R. Taylor: Addressing groundwater policy gaps: evidence from the UPGro Programme

Dr Kirsty Upton gave a keynote on evidence based policy gap analysis through the Unlocking the Potential of Groundwater for the Poor (UPGro) Project. UPGro is a seven-year international research programme (2013-2020) which is jointly funded by UK’s Department for International Development (DFID), Natural Environment Research Council (NERC) and the Economic and Social Research Council (ESRC). The goal is to ensure that the hidden wealth of Africa’s aquifers benefit all citizens and the poorest in particular. UPGro projects are interdisciplinary, linking the social and natural sciences to address this challenge.


This study was focused on the value addition that wetlands provide to support ecosystem services. It re-examines the concept of groundwater dependent wetlands and policy direction that should be adopted.


The presentation showed that although developing countries like Zambia are dependent on groundwater for major cities such as Lusaka, there are different actors that should work together to foster integrated water resources development.

Afternoon Session:


Prof Gildo gave a keynote on SADC Water protocols and the duty to cooperate in the protection and management of groundwater. The following are key highlights of his talk:

- SADC Region has 15 Major river Basins which are transboundary and Shared water courses cut through boundaries
- There are 30 transboundary aquifers;
- Complex water rights are a source of conflict especially when they are transboundary;
On the other hand they are a source of regional cooperation and economic integration;

- SADC Revised protocol on shared water courses are to foster closer cooperation.

- Address prevailing gaps in Legal Policy and regulatory Frameworks;

- Spearhead compliance and advocacy for the implementation of the gap analysis;

- Revised protocol says we should give all the information to other Member states;

- Strengthen groundwater monitoring and data management systems;

- Transboundary cooperation facilities intergration and harmonisations of laws and regulations;

- Need to look at water resources management taking into account Regional cooperation;

- Effective management of shared river systems requires knowledge of the entire River Systems;

Trying to bring the Technicians to implement the norms; must be implemented because they are easier to implement rather than harmonization of the actual laws and try to implement the actual protocols.

The document still needs to be revised and updated. The Member States are not obeying the Laws and we need an authority which makes sure that those who are supposed to implement the laws.

Comment from the floor, in our African culture groundwater is not visible and hence the experts should give us guidance on how to implement the laws. There is a dilemma in the implementation of the law.

There are gaps in the implementation and the people who try to implement Mozambique does not have specialist and technicians who can assist in implementation.

The Water Programme looks at Governance & management, investment in natural water infrastructure, water for development & management;

- Take into account climate change.

3 James Sauramba - Groundwater Policy, Legal and Institutional Frameworks in the SADC Region.

- Lack of data

- Transboundary aquifers experience

- Existing laws.

The desired Future State, Desk study. Linking up of policies of SADC and operate the existing Governance Structures.

- The desired future state was the base line for the GMI-PLI project

- It also looked at the legislative perspective with emphasis on availability of data

- Subsidiary legislation or regulations pertaining to use and protection

- Template laws for the Municipalities.

Gap Analysis at National level he talked about trends, human rights role of groundwater recognition of the social & Economic environment he gave examples of the policies.

Legislation he talked about the trends and gaps at National and Regional level.

On the Regional Perspective - that there are SADC Protocols on Water Policy the issues that were found groundwater is mention but there is no reference some opportunities were identified.

- Opportunities at Regional Level – the RSAPV 4 there is an opportunity to participate in the review of these protocols.;

2. Davison Saruchera – IUCN ESARO Water Programme

Key highlights from IUCN address were as follows;

- When there is a shortage people tend to talk about the water crisis

- We should continue to talk more when there is a crisis;

- Drilling of boreholes in the private yard does not help the crisis;

- IUCN International Union for Conversation of Nature
03

Closing Ceremony
Dr. LaMoreaux from the Sustainable Water Resources Management (SWAM) Journal outlined the procedure required to submit manuscripts to the Journal. He highlighted requirements for a special issue. A team will constitute that will include guest editors to review submissions made but it was important that authors followed the requirements from the Journal as outlined on the website.

Dr. Kawawa Banda gave the presentation on an overview of the conference. He provided a summary of the planned activity as shown in the Table 1, below.

Table 1: Summary of activities sessions planned and actual.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Planned</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contribution of research towards understanding, the status, trends and risks to groundwater resources</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td>Measuring progress towards attaining SDG targets, data collection and management within the SADC member states</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Policy, legal and institutional considerations at the national and trans-boundary levels</td>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>

**Poster Sessions**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Planned</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>
Dr Patrice Kandolo Kabeya, Senior Programme Officer, Water Infrastructure and Services, officially closed the meeting and thanked the local organising committee, partners and everyone for coming to the Conference. He stressed that let the interaction not end at the conference but we must continue to engage and find ways to make groundwater utilisation sustainable and showcase its important role in supporting achievement of the SDGs. He wished everyone a safe journey home.
Appendix
# Conference Programme

**Tuesday 3rd September 2019**

Arrival of Delegates and Registration of participants: Southern Sun, Hotel Foyer

**Wednesday 4th September 2019**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>07:30Hrs-08:30Hrs</td>
<td>Registration of participants: Ilanga Conference Room</td>
</tr>
<tr>
<td>08:30Hrs-10:00Hrs</td>
<td>Official opening: Ilanga Conference Room</td>
</tr>
<tr>
<td>10:00Hrs-10:30Hrs</td>
<td>Tea Break and Photo Session</td>
</tr>
<tr>
<td>10:15Hrs</td>
<td>Key Note 1 – Remigius Makumbe: Groundwater and surface water interactions using stable isotopes: The case of Northern Africa, the case of South Africa.</td>
</tr>
<tr>
<td>10:30Hrs-10:50Hrs</td>
<td>Session Chair: Bertram Swartz, Rapporteur: Arnaud Sterckx</td>
</tr>
<tr>
<td>10:50Hrs-11:05Hrs</td>
<td>Kevin Pietersen, Hans Beekean and Thokozani Kanyerere: Groundwater resources - The road to water resilience in urban water cycles.</td>
</tr>
<tr>
<td>11:20Hrs-11:35Hrs</td>
<td>Stanley Nzema, Thokozani Kanyerere, Audrey Levine: Groundwater resources protection: Reflection on the relevance of the groundwater quality component of the Reserve for provision of clean water and sanitation.</td>
</tr>
<tr>
<td>11:35Hrs-11:50 Hrs</td>
<td>Karen Grothe Villholth, Mohammad FAiz Alam &amp; Joel Podgorski: Human dietary exposure risk via crop consumption from arsenic-contaminated groundwater-irrigated areas and transmission through international trade.</td>
</tr>
<tr>
<td>11:50Hrs-12:05Hrs</td>
<td>Mfundi Biyela, Kevin Pietersen, C Nyirenda and Thokozani Kanyerere: Application of innovation technologies in managing water allocation reform process in Southern Africa, the case of South Africa.</td>
</tr>
<tr>
<td>12:20Hrs-12:35Hrs</td>
<td>Shelta Majowa &amp; Charles Mazhazhate: Bridging the gap between ground water availability and logistics: Engineering for change from a Gender perspective.</td>
</tr>
<tr>
<td>12:35Hrs-12:50Hrs</td>
<td>Robert Dagef Kahsay: Impact of Climate Change on Groundwater Recharge and Base Flow in the Catchment of Tekeze-Atbara Basin, Ethiopia</td>
</tr>
</tbody>
</table>

**LUNCH**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:00Hrs-14:20Hrs</td>
<td>Session Chair: Joanna Fatch, Rapporteur: Steve Kumwenda</td>
</tr>
<tr>
<td>14:20Hrs-14:35Hrs</td>
<td>Key Note 3. Dr. M.W. Lubczynski: Monitoring, remote sensing and integrated hydrological modelling for groundwater management in Southern Africa.</td>
</tr>
<tr>
<td>15:05Hrs-15:15Hrs</td>
<td>Andrew Joloza &amp; Eddie Banks: Hydrogeochemical characterization of groundwater in the major aquifers in Malawi.</td>
</tr>
<tr>
<td>15:30Hrs-15:45Hrs</td>
<td>Teboho Masaka, Moiteela Lekula, Maciek Lubczynski: Integrated hydrological modelling of river-aquifer interactions in the Boteti River, Botswana</td>
</tr>
</tbody>
</table>

**TEA BREAK AND POSTER SESSION**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:45-16:05Hrs</td>
<td>Session Chair: Maria Amakali, Rapporteur: Brighton Munyal</td>
</tr>
<tr>
<td>15:45-16:05Hrs</td>
<td>Key Note 4. T. Himmelsbach: Deep lying Groundwater – Is a strategic groundwater exploration an appropriate key to solve arising water crisis in Southern Africa?</td>
</tr>
<tr>
<td>16:05-16:20Hrs</td>
<td>Andrew Bullock: Understanding African groundwater by unlocking a critical divergence in the hydrological science of headwater wetlands.</td>
</tr>
<tr>
<td>16:35Hrs-17:45Hrs</td>
<td>Panel Discussion: Deep groundwater exploration in SADC.</td>
</tr>
</tbody>
</table>
### Thursday 5th September 2019

#### Sub-theme 1

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Chair: Davies Saruchera</th>
<th>Rapporteur: Moiteela Lekula</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30-08:45Hrs</td>
<td>Irene Kinoti, Marc Leblanc, Albert Olioso, Maciek Lubczynski, Piet Kenabatho, Bertram Swartz, Kwazikwakhe Majola and Tales Carvalho-Resende</td>
<td>Davies Saruchera</td>
<td>Application of remote sensing to assess recharge and discharge mechanism in the Stampriet Transboundary Aquifer System (STAS)</td>
</tr>
<tr>
<td>08:45-09:00Hrs</td>
<td>Piet Kenabatho, Thato Setloboko and Bertram Swartz</td>
<td>Moiteela Lekula</td>
<td>Assessment of the impacts of climate variability on total water storage in the Orange-Senqu River Basin: implications for groundwater resources management</td>
</tr>
<tr>
<td>09:00-09:15Hrs</td>
<td>Manuel S Magombeyi, Karen G Villholth, Richard Healy, Girma Ebrahim</td>
<td>Moiteela Lekula</td>
<td>Recharge assessments across the Limpopo River Basin, approaches and findings</td>
</tr>
<tr>
<td>09:15-09:30Hrs</td>
<td>Cesário Cambaza, Mieke Hulshof, Pieter van der Zaag and Paulo Saveca</td>
<td>Moiteela Lekula</td>
<td>IRRIGATION PACKAGE FOR SAND RIVERS – A Feasibility Study in the Limpopo River, Mozambique</td>
</tr>
<tr>
<td>09:30-09:45Hrs</td>
<td>Philthoa Diloro Keitumetse, Nata Tadesse Tafesse, R. T. Ranganai and Kebabonye Laletsang</td>
<td>Moiteela Lekula</td>
<td>Hydrogeological and Geophysical Characterization of Ramotswa transboundary dolomitic aquifer</td>
</tr>
<tr>
<td>09:45-10:00Hrs</td>
<td>Girma Ebrahim, Karen Villholth, Jonathan Lautze, Keetile Keodumetse, Piet Kenabatho, Sakhile Mndaweni, Naicker Sivashni, Moses Moehad</td>
<td>Moiteela Lekula</td>
<td>Hydrogeological model for the Ramotswa transboundary aquifer - How much do we know?</td>
</tr>
<tr>
<td>10:00-10:15Hrs</td>
<td>Girma Ebrahim, Karen Villholth, Jonathan Lautze, Keetile Keodumetse, Piet Kenabatho, Sakhile Mndaweni, Naicker Sivashni, Moses Moehad</td>
<td>Moiteela Lekula</td>
<td>Assessing managed aquifer recharge potential in the RAMOTSWA transboundary aquifer area – a hydrogeological modelling approach</td>
</tr>
<tr>
<td>10:15-10:30Hrs</td>
<td>Mfundi Mathunjwa, Nokwanda Mhlanga and Khethiwe Ngcobo</td>
<td>Moiteela Lekula</td>
<td>Groundwater monitoring and Management protocols for Komati Basin</td>
</tr>
</tbody>
</table>

**TEA BREAK AND POSTER SESSION**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Chair: Sivashni Naicker</th>
<th>Rapporteur: Emmanuel Magombeyi</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00-11:15Hrs</td>
<td>Lucas Filip Tamele J Junior, Paulino Vicente Muteto, Fatima Mussa, Dinis Juizo</td>
<td>Sivashni Naicker</td>
<td>Assessment of groundwater quality in Great Maputo aquifer system</td>
</tr>
<tr>
<td>11:15-11:30Hrs</td>
<td>Paulo Sérgio L Saveca, Tibor Y Stigter, Dinis Juizo and Elco Lukas</td>
<td>Sivashni Naicker</td>
<td>Investigation of hydrogeochemical processes and groundwater quality in the Chôkwê district, Mozambique</td>
</tr>
<tr>
<td>11:30-11:45Hrs</td>
<td>Lusanda Vindi, Innocent Muchingami, Thokozani Kanyerere and Kevin Pietersen</td>
<td>Sivashni Naicker</td>
<td>Using groundwater process model to assess aquifer-river interaction for groundwater dependent communities, semi-arid areas, Hout Catchment</td>
</tr>
<tr>
<td>11:45-12:00Hrs</td>
<td>Modreck Gomo</td>
<td>Sivashni Naicker</td>
<td>On the use of Theis and Cooper-Jacob methods to interpret multi-well aquifer pumping tests in laterally heterogeneous confined aquifer systems</td>
</tr>
<tr>
<td>12:00-12:15Hrs</td>
<td>Lothar Schäfer, Thomas Himmelsbach, Hans Matthias Schöniger &amp; Jan Gaebler</td>
<td>Sivashni Naicker</td>
<td>Strengthening groundwater management through an integrative approach</td>
</tr>
<tr>
<td>12:30-12:45Hrs</td>
<td>Eva Masemola</td>
<td>Sivashni Naicker</td>
<td>Barriers Against Groundwater Development</td>
</tr>
<tr>
<td>12:45-13:00Hrs</td>
<td>Nijsten, Gomo, Sterckx and Lukas</td>
<td>Sivashni Naicker</td>
<td>SADC-wide Framework for Groundwater Data Collection and Data Management</td>
</tr>
</tbody>
</table>

**LUNCH**
### Sub-theme 2

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Chair: James Manda</th>
<th>Rapporteur: Paulo Sérgio L. Saveca</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:00-14:20Hrs</td>
<td><strong>Key Note 4:</strong> Karen Grothe Villholth: Groundwater and the Sustainable Development Goals – Interlinkages and supportive guideline development</td>
<td></td>
</tr>
<tr>
<td>14:20-14:35Hrs</td>
<td>Fanus Fourie: Making the unseen groundwater levels an indicator of sustainability in South Africa (SDG 6.6.1).</td>
<td></td>
</tr>
<tr>
<td>14:35-14:50Hrs</td>
<td>Steve Kumwenda, Donald Robertson and Robert Kalin: Tracking achievements towards Sustainable Development Goal number 6 through mWater rural water supply forensics (mForensics) in Traditional Authority Mazengera in Lilongwe, Malawi.</td>
<td></td>
</tr>
<tr>
<td>14:50-15:05Hrs</td>
<td>Sivashni Naicker &amp; Fhedzisani Ramusiya: Groundwater in Sustainable Development Goal 6: The South African Case Study</td>
<td></td>
</tr>
</tbody>
</table>

**TEA BREAK AND POSTER SESSION**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Chair: Piet Kenabatho</th>
<th>Rapporteur: Fhedzisani Ramusiya</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:55-16:10Hrs</td>
<td>Thokozani Kanyerere, Karren Villholth and Jaquiline Goldin: Using citizen science in groundwater data generation research to improve decision-making support on water information.</td>
<td></td>
</tr>
<tr>
<td>16:25-16:40Hrs</td>
<td>Kevin Pietersen, Thokozani Kanyerere, Zaheed Gaffoor, Nebojovanovic, Antione Bagula, Tawanda Matsika: A review of downscaling methods to localize regional transboundary aquifer datasets for improved groundwater operational decision making.</td>
<td></td>
</tr>
<tr>
<td>16:40-16:55Hrs</td>
<td>Andrew Gemmell, Claudia Ruz Vargas and Ebrahiem Abrahams: Consolidation of transboundary datasets to enhance decision-making: lessons learnt from the Ramotswa aquifer southern Africa.</td>
<td></td>
</tr>
<tr>
<td>16:55-17:55Hrs</td>
<td>Panel session: Groundwater and the Sustainable Development Goals, Status quo and guidelines for the future towards the achievement of the SDG targets. <strong>Panelists:</strong> Sivashni Naicker (DWS South Africa), Steve Kumwenda (Baseflow Malawi), USAID, Dumisani Mndzebele (SADC Secretariat: Water Division), Trevor Shongwe (Department of Water Affairs Eswatini).</td>
<td></td>
</tr>
</tbody>
</table>
**Sub-Theme 3: Policy legal and institutional considerations at national and trans-boundary levels.**

<table>
<thead>
<tr>
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<th>Key Note/Session Title</th>
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<tr>
<td>08:30Hrs-08:50Hrs</td>
<td>Key Note 5: K. Upton, R. Comforth, J.W. Foppen, R. Hope, A. MacDonald &amp; R. Taylor</td>
<td>Patience Mukuyu</td>
<td>Addressing groundwater policy gaps: evidence from the UPGro Programme</td>
</tr>
<tr>
<td>08:50Hrs-09:05Hrs</td>
<td>Andrew Bullock</td>
<td>Kasonde Mulenga</td>
<td>Unrealised opportunities for African groundwater from reconnecting policy with science under alternative natural capitals.</td>
</tr>
<tr>
<td>09:05Hrs-09:20Hrs</td>
<td>Michael Eichholz, Tobias Godau &amp; Tewodros Tena</td>
<td>Patience Mukuyu</td>
<td>Assessment of groundwater governance capacities in Lusaka.</td>
</tr>
<tr>
<td>09:20Hrs-09:35Hrs</td>
<td>Asare Asante-Annor, Anthony Ewusi, Jamel Seidu</td>
<td>Kasonde Mulenga</td>
<td>The Current State of Water Resources Management in Ghana</td>
</tr>
<tr>
<td>09:35Hrs-09:50Hrs</td>
<td>Mfundi Biyela, Kevin Pietersen, Paul Mensah and Thokozani Kanyerere</td>
<td>Patience Mukuyu</td>
<td>Regulating the regulations for managing groundwater use to improve water security in Southern Africa: Reflection on water use license application process in South Africa.</td>
</tr>
<tr>
<td>09:50Hrs-10:05Hrs</td>
<td>Mfundi Biyela, Kevin Pietersen, C Ngongondo and Thokozani Kanyerere</td>
<td>Kasonde Mulenga</td>
<td>The use real-time model to fast track progress of water entitlements: Rethinking groundwater allocation reform in Southern Africa, Free State Province, South Africa</td>
</tr>
<tr>
<td>10:05Hrs-10:20Hrs</td>
<td>Piet Kenabatho, Thato Setloboko and Bertram Swartz</td>
<td>Kasonde Mulenga</td>
<td>Towards improved governance of transboundary aquifers in Southern Africa: the operationalization of the Stampriet Transboundary Aquifer System (STAS) Multi-Country Cooperation Mechanism (MCCM)</td>
</tr>
<tr>
<td>10:20Hrs-10:35Hrs</td>
<td>Helen Seyler, Kai Witthueser and Kevin Pietersen</td>
<td>Kasonde Mulenga</td>
<td>The framework for a Sustainable Water Supply Strategy to promote groundwater secure transboundary systems.</td>
</tr>
<tr>
<td>10:35Hrs-10:50Hrs</td>
<td>Technical Coordinator - Water: IUCN</td>
<td>Kasonde Mulenga</td>
<td>Water Programme in East and Southern Africa – Key focus areas and opportunities for strategic collaborations.</td>
</tr>
</tbody>
</table>

**TEA BREAK AND POSTER SESSION**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Chair</th>
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<th>Key Note/Session Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:10Hrs-11:30Hrs</td>
<td>Derrick Weston</td>
<td>Micah Majiwa</td>
<td>Prof Gildo: SADC Water Protocols and the Duty to Cooperate in the Protection and Management of Ground Water: between soft and hard law</td>
</tr>
<tr>
<td>11:30Hrs-11:45Hrs</td>
<td>James Sauramba</td>
<td>Derrick Weston</td>
<td>Groundwater Policy Legal and Institutional Frameworks in the SADC region.</td>
</tr>
<tr>
<td>11:45Hrs-12:30Hrs</td>
<td>Member States (Eswatini, Tanzania), Sergio, James Sauramba, Derrick, Prof Gildo, Kevin Pietersen</td>
<td>Derrick Weston</td>
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**CLOSURE PROCEEDINGS**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Chair</th>
<th>Session Rapporteur</th>
<th>Key Note/Session Title</th>
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<tr>
<td>12:30Hrs-12:40Hrs</td>
<td>Dr. LaMoreaux</td>
<td>Derrick Weston</td>
<td>Getting your work published with the Sustainable Water Resources Management (SWAM) Journal.</td>
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<td>12:40Hrs-12:50Hrs</td>
<td>Dr. Banda Kawawa</td>
<td>Derrick Weston</td>
<td>Chief Conference Rapporteur: Overview of the 2nd SADC-GMI Conference.</td>
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<td>12:50Hrs-13:00Hrs</td>
<td>Vote of Thanks</td>
<td>Derrick Weston</td>
<td>SADC - Secretariat</td>
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<td>13:00Hrs-13:05Hrs</td>
<td>Announcements</td>
<td>Derrick Weston</td>
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<td>13:05Hrs-13:10Hrs</td>
<td>Lunch and Departure</td>
<td>Derrick Weston</td>
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Posters


Nelson Cornelio Malikito: Groundwater data collection and management: The role of community. Regional Water Administration of the Centre in Beira-Mozambique.

Hamilton Alberto João Baptista Junior: Groundwater exploration using geoelectrical resistivity/induced polarization techniques for agriculture activities Sustainability in Ulge area.


Jack Hemingway, Alexandra Gormally: Groundwater Governance in South Africa: Domestic and Transboundary Governance, and Preparedness for Hydraulic Fracturing

Coiara, Omar Sirage: Mozambique challenges in groundwater management.

Roland Baeumle and Marcus Fahle: Development of regional groundwater monitoring networks - Theoretical considerations and case study from the Upper Kafue, Zambia.

Lindelani Lalumbe: Groundwater quality status in the Eastern Kalahari Hydrogeological region: SDG 6.3.2 Reporting

Oudi Modisha: How effective is cover system design for mine closure?

KEY NOTE SPEAKERS

Remmy Makumbe: Global Water Partnership – Southern Africa, Special Advisor, Water, Job Creation, Industrialisation and Sustainability. Engineer Remmy Makumbe worked for the Railways in Zimbabwe and rose to the position of Chief Engineer. He joined SADC in 1995, where he later became Director responsible for Infrastructure and Services in January, 2005 for 12 years till end of December, 2016. He joined the Global Water Partnership – Southern Africa in April, 2018, as a Special Advisor, Water, Job Creation, Industrialisation and Sustainability. Remmy is a holder of a B. Sc Engineering Honours Degree from the University of Zimbabwe, a Bachelor of Commerce Degree in Economics from the University of South Africa (UNISA), as well as Master of Policy Studies Degree from the University of Fort Hare, South Africa. He is a Chartered Engineer, a Member of the Institute of Business Advisors of Southern Africa, a Fellow of the Southern Africa Trust, a Non-Executive Director and Shareholder of the African Leadership Institute in Zimbabwe, which focuses on training and development of leaders for tomorrow. He has numerous publications in the area of infrastructure, economic development and financing. He also provides consulting services as Adviser, Infrastructure and Regional Integration to different states and multilateral organisations.

Professor Yongxin Xu – UNESCO Chair of Hydrogeology (University of the Western Cape).

Dr. Yongxin Xu is a Senior Professor of Hydrogeology at the University of the Western Cape and he also holds the position of the UNESCO Chair in Geohydrology. After a brief academic experience in China and the UK, he joined the Department of Water Affairs & Forestry in South Africa in 1989 where he spent much of his career conducting field groundwater investigations until 2001 when he took up the position of the UNESCO Professor of Geohydrology based at UWC. His research has focus on issues of sustainable water resources management in developing countries. He is also involved in multi-disciplinary projects that are conducted in partnership with institutions including HUE & TYLI in China. He currently serves as a Commissioner for Africa Groundwater Commission for AMCOW (Africa Minister’s Council on Water), and the Secretary General of the ChinAfrica Water Association.

Professor M.W. Lubczynski at the Department of Water Resources of ITC Faculty of University of Twente in The Netherlands

Dr. M.W. Lubczynski is Associate Professor at the Department of Water Resources of ITC Faculty of University of Twente in The Netherlands. He obtained two Msc degrees, in Hydrogeology and in Civil Engineering and PhD degree in numerical groundwater modeling. From 1982 till 1992 he worked in Geological Institute in Wroclaw University in Poland and since 1993 till now at ITC. As ITC staff he did lots of applied consulting and research groundwater modeling projects in Southern Africa, mainly in Botswana. In these projects many Msc and 3 PhD students from various SADC countries were trained, most of them, have currently important business or research positions in the water sector. The current research of Dr Lubczynski focuses on modern methods of data acquisition, such as remote sensing, hydrogeophysical and automated monitoring, all for problem solving, mainly applying integrated hydrological modeling.

Prof. Dr. Thomas Himmelsbach is head of the BGR Department “Groundwater & Soil Sciences”

Prof Dr. Thomas Himmelsbach is head of the BGR Department “Groundwater & Soil Sciences”. Aside his work at BGR he was from 2006 -2016 president of the German Chapter of International Association of Hydrogeologists (IAH).
Karen G. Villholth has 25+ years’ experience in groundwater research. She is a Principal Researcher at IWMI-SA (International Water Management Institute -Southern Africa) and coordinates the research portfolio on groundwater. She coordinates the unique global initiative on Groundwater Solutions for Policy and Practice (GRIPP), which, through a partnership of 30 international organizations, supports sustainable development and management of groundwater.

Her key areas of work include research, policy advice, and capacity development related to transboundary aquifers, groundwater irrigation for smallholders, groundwater resources assessment and modelling, climate change and groundwater, groundwater-based natural infrastructure, groundwater and food security, and groundwater management and governance for institutions at various levels, from local to global. She engages with multidisciplinary teams and stakeholders in co-developing tools, capacity, and policies to a more sustainable use of groundwater for livelihoods, food security, and environmental integrity.

Karen holds a PhD and MSc in Chemical Engineering from the Technical University of Denmark and a MSc in Civil Engineering from the University of Washington, USA. She previously worked for DHI-Water and Environment and the Geological Survey of Denmark and Greenland. She is editor/author of three books related to groundwater, and more than 50 peer-reviewed journal papers.

Dr Kirsty Upton Hydrogeologist (British Geological Survey).

Dr Kirsty Upton is a hydrogeologist with the British Geological Survey. Her background is in the development and application of methods for assessing groundwater responses to extreme events. Kirsty is a lead author of the Africa Groundwater Atlas and currently coordinates the UPGro Programme (Unlocking the Potential of Groundwater for the Poor), which is investigating various aspects of groundwater security across Sub-Saharan Africa. In this role, she is working with researchers and stakeholders across Africa to facilitate the translation of research to inform policy and practice to support sustainable groundwater development on the continent.

Professor Gildo: International Water Law Expert (Eduardo Mondlane University), Mozambique.

Prof. Gildo Espada, presents more than 18 years of professional experience as lawyer. He is an expert in Water Law and environmental Law. He works as a consultant, specialized in water law and environmental law. Professor Gildo Espada is a Professor of Eduardo Mondlane University, and has Portuguese as his mother tongue, being fluent in English and French. Education: PHD Public Law – Universidade Nova de Lisboa, 2015, Master in International Law, University of Macau, 2007, Degree in Law – ISCTEM – Instituto Superior de Ciências e tecnologia de Moçambique, 2004.

The SADC-GMI and the Institute of Groundwater Studies (IGS) and the University of the Free State have arranged for a special issue of the Conference to be published in the Sustainable Water Resources Management (SWAM) journal (Publisher: Springer International Publishing). Dr James W. Lamoreaux, the Editor-in-Chief of the Journal will give an overview of the publication process.
Contact us

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