

Canadian Contributions to African University Hydrogeology Programs



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ABSTRACT

There is a need for 60,000 water professionals in sub-Saharan Africa if the Sustainable Development Goals are to be met for the water sector. Currently, there are multiple problems that prevent existing university programs from being effective, which has resulted in sub-standard well installations, an inability of graduates to get jobs, and professionals that leave to work in other countries. While many documents continue to be written on the subject, the water, sanitation and hygiene sector is in a crisis and if something tangible doesn't change quickly, the future economic and social stability of the African continent is at risk. A small Canadian NGO has taken the initiative to address these changes by working with African universities to get practical MSc programs in Hydrogeology and Water Resources Management established in country. These programs are different in the manner the programs are delivered, the curriculum offered, the training assistance offered, and the connections with local industry and communities.

RÉSUMÉ

Il y a un besoin de 60,000 professionnels de l'eau en Afrique subsaharienne si les objectifs de développement durable doivent être atteints pour le secteur de l'eau. Actuellement, de nombreux problèmes empêchent l'efficacité des programmes universitaires existants, ce qui a entraîné des installations de puits de qualité inférieure, l'incapacité des diplômés à obtenir un emploi et des professionnels qui partent travailler dans d'autres pays. Alors que de nombreux documents continuent d'être rédigés sur le sujet, le secteur de l'eau, de l'assainissement et de l'hygiène est en crise et si quelque chose de tangible ne change pas rapidement, la future stabilité économique et sociale du continent africain est menacée. Une petite organisation non gouvernementale (ONG) canadienne a pris l'initiative d'aborder ces changements en travaillant avec des universités africaines pour obtenir des programmes pratiques de maîtrise en hydrogéologie et gestion des ressources en eau établis dans le pays. Ces programmes sont différents selon la manière dont les programmes sont dispensés, le programme d'études offert, l'aide à la formation offerte et les liens avec l'industrie et les collectivités locales.

1 INTRODUCTION

While large non-governmental organizations (NGOs), governments and multi-lateral funding institutes have spent billions of dollars to eradicate large problems, such as malaria, access to safe water, and extreme poverty, these problems continue to exist. In fact, it could be argued that large NGOs would put themselves out of business if they were successful in solving the problems that they aim to address, which is part of the problem. Additionally, continuing to provide aid to the Global South extends the reliance on aid and discourages these people from seeking a future that is built on self-reliance and self-esteem. In the view of Wangari Maathai (2009), Africans are very capable of solving their own problems, they just seem to be stuck in a cycle of poverty and reliance on the west to tell them who they are and what they need to do. Promoting a self-sufficient Africa forms the strategic pillars of the African Capacity Building Foundation (ACBF) and prompts the actions of the African Union (AUC, 2014).

The earth is at a critical point right now. As climate change impacts weather events around the world, population continues to expand at a rapid rate, and political discourse is leading to unrest. The Sustainable

Development Goal (SDGs) were developed to address these social-political and environmental issues with the intent to change our current *modus operandi* and to level the balance between those who 'have' and those who 'have not'. Failure to act, to try to meet the SDGs, will result in chaos in Africa. By the year 2050, it is estimated that one quarter of all people on Earth will reside in Africa, most under the age of 30. If these disenfranchised youth are unemployed, living in poverty and do not have adequate water to feed their families, societal unrest is guaranteed (ACBF, 2016; Cooke and Downie, 2014).

Consequently, if the SDGs are to be met by the year 2030, the current funding and operational model needs to change. There is a need for a paradigm shift in the way the Global North and Global South interact. When it comes to increasing access to safe drinking water the need for water professionals in sub-Saharan Africa (SSA) is dire. The current method for educating and training these professionals will not produce the number of experts needed. Continuing to rely on foreign experts is not the answer because it maintains the current model of reliance on the Global North.

A small Canadian NGO is currently working to create a new way of educating people in Africa based on successful

methods used in the Global North over the past several decades. This paper discusses the problems with the current aid model, introduces a new model for fostering self-reliance and presents a path forward to achieve success in today's changing world.

1.1 The Current Need for Professionals in the Water Sector in Africa

The current shortage of trained water professionals in Africa with the skills required to solve the water challenges of today, has resulted in many of the problems seen in rural and urban environments. Sub-standard water supply infrastructure is a consequence of NGOs having to decide between drilling many wells with no technical assistance or using expensive foreign hydrogeologists but drilling far fewer wells. While drillers in Africa may be qualified to operate a drill and are knowledgeable about where water can be found, few have the education that enables them to understand aquifer flow systems, the impact of poor drilling methods and technical considerations of proper well construction. Eliminating technical oversight in well installation programs has resulted in the following problems: contamination of aquifers; diminished well yields from insufficient well development; well failure from interference effects caused by too many wells completed in the same aquifer; poor water quality from inadequate well design; and, diminished well life from incompatible metals within the well (rising main and pump components). As many as 2/3 of all wells in some SSA countries are not functioning because of the short-term vision of installing as many wells as possible (RWSN, 2010). Properly installed wells typically have a lifetime of 20 to 25 years, however, because of lack of technical oversight, many wells funded by NGOs only operate for a few years. When wells fail, local technicians lack the skills to evaluate and rehabilitate the wells. Furthermore, there is the social ideology related to whoever installs the well, owns the well, and therefore needs to fix the well (Maathai, 2009).

Based on data provided by the International Water Association (IWA, 2014), where the shortage of water professionals in 15 developing countries (9 of them in SSA) was estimated, UniWater Education predicts that there is a need for 60,000 water professionals in SSA *now* if the SDG target 6.1 (universal access to drinking water) is to be met by the year 2030. Professionals from many water-related disciplines are required to be employed by industry, municipal and government services, to work as researchers in academia, or as professional consultants.

1.2 Existing Problems in the WASH Sector in SSA

1.2.1 Groundwater versus Surface Water

Surface water (hydrology) can be visualized so the cause and effect relationship to flow systems is more easily understood by most people. But because groundwater (hydrogeology) flows within pores of rock below ground, it is not visible and is more difficult to understand. The science of groundwater flow is complicated as flow is interpreted indirectly via pressure responses or changes in water levels in a monitoring well. Most 'water' programs at

universities only address surface water, however, the largest freshwater resource on the planet excluding glaciers is found as groundwater. Interestingly, many university programs related to water security of the future only address long term impacts to surface water. Compared to surface water, groundwater is buffered to changes in climate, has some level of protection from pollution events occurring at ground surface, and occurs beneath our homes and businesses. It is therefore worth the effort to develop groundwater as a water source in parallel with surface water, but it is recognized that more effort is required to convince funders of the significance and importance of this resource.

1.2.2 Current University Programs

According to the Africa Capacity Building Foundation, for every million people in North America, there are 4,000 engineers and scientists, but in Africa, that number drops to 35 per million people (ACBF, undated). This lack of technical professionals is limiting the economic development of these countries (UNICEF/Skat Foundation, 2016).

Hydrogeology programs are offered at a Master's level in African universities, however, there are insufficient programs available, and those that do exist are very academic and do not teach the applied skills needed by graduates entering industry (IWA, 2014; WEF, 2014). These types of programs are useful to develop research or teaching skills but are not effective in equipping graduates with the necessary field skills for working in industry or as consultants. Thus, current graduates are unable to get jobs (Prof Daniel Ichang'i, University of Nairobi, Pers. Comm., 2011). Often the reason students are not taught field skills is because their professors do not have such skills or industry experience themselves. Therefore, MSc-level hydrogeologists continue to complete PhD programs because it is the only career option available to them (Cap-Net et al, 2007).

According to a survey conducted in 44 African countries by the ACBF (WEF, 2014), the need for training was ranked as 'high' or 'very high' to address the apparent disconnect between what students are learning in their university programs and what is required by industry.

According to the Africa Capacity Report 2017 (ACBF, 2017), there need to be major changes in the science, technology and innovation (STI) sector on a continental scale. There is a need for improving the quality of higher education by enhancing professional training, providing adequate school facilities, attracting good lecturers and updating the pedagogical materials.

The ACBF (2016) blames the shortage of critical skills, inadequate leadership, inhibiting mindsets and weak institutions as the underlying causes of the economic underdevelopment of the continent. They claim there will be a deficit of 4.3 million engineers and 1.6 million agricultural scientists by the year 2063 if the current training model continues. Also, in most African countries, the current gap between the actual number of trained professionals available and the forecast needed is 70%. They note one reason could be the decline in the number of Technical Vocational Education and Training programs.

According to the World Bank (WBG, 2017), the amount of funding that needs to be provided to the sector (worldwide) is \$1.7 trillion, which is three times historical levels of funding, if SDG target 6 is to be achieved. In fact, in SSA progress has been exceptionally slow and expenditures in the range of 0.29 to 1.0 % of gross regional product would be needed to achieve the SDG targets (Hutton and Varughese, 2016). Also, Africa accounts for about 5% of the global gross domestic product, but only 1.3% of the Research and Development funding is dedicated to Africa (ACBF, 2017). It is also proposed in Science, Technology, Innovation Strategies for Africa (STISA) that each country dedicate 1% of their Gross Domestic Product in support of Water, Sanitation and Hygiene (WASH) activities, although this has yet to be followed through on (AUC, 2014).

Currently, as much as 80% of African students enroll in programs that are dominantly in the humanities and social science disciplines with the remaining students enrolled in Science, Technology and Engineering (ACBF, 2017). This is attributed to a lack of incentives for the science programs and a lack of funding for scholarships. More emphasis is needed to attract women into these fields to improve water efficiency, enhance social benefits, improve equitable use of water, and secure environmental sustainability (IWA, 2014; ACBF, 2017; ACBF, 2016).

1.2.3 Foreign Education

In today's world, if an African student wishes to learn applied, practical skills in hydrogeology or another water specialty, he typically leaves his home country in SSA to attend an expensive university program in North America or Europe. Many universities in the Global North offer scholarships for Africans, but many of these graduates do not return to their home countries because they find employment in the Global North. Also, in the big picture, the small number of foreign-educated professionals does not contribute significantly to the vast number of professionals currently needed in SSA. Additionally, there is a continuous migration of highly educated professionals from the African continent to the Global North (ACR, 2017; ACBF, 2017), referred to as the 'brain-drain'.

The ACBF note (2017) that short term training programs do not result in long term knowledge transfer when foreign professionals and expats are used on projects in Africa.

1.2.4 Working Professionals

Typically, working professionals in SSA do not receive continuing education throughout their careers. Many professionals are working in positions for which they are not educated (ie engineering positions filled with scientists, or university-level educated position is filled with a secondary school graduate (AFBF, 2017; IWA, 2014)). In a technically demanding field, particularly with the changing climate, this is a time when key positions need to be filled by qualified, educated people with up-to-date technical skills, and not those who may have learned on the job without access to updated technology. This has particular relevance for community water supply.

1.2.5 Community-based Projects

As illustrated in Figure 1, the large triangle represents all activity in the WASH sector. The small triangle at the top represents the upper government that sets the policy and direction for the country. The middle portion represents middle government, university education and regulators. The wide portion at the bottom of the triangle represents activity at the community level. Most of the funded projects in the WASH sector are at the community level where many people can benefit in the short term. This entails fixing or installing a new well, training drillers, or perhaps educating people to wash their hands. Installing a water well can provide thousands of people with access to safe water, it is relatively easy to do and relatively inexpensive. However, if the focus of the sector is on short term benefits, long term sustainable water management will not be achieved. Action is critically needed in the middle portion of the triangle whereby strengthening university education in science, technology, engineering, math (STEM) and innovation disciplines will promote more activity on a broader basis at the community level which in turn will lead to long term sustainable water management. Future water and environmental regulators and will play a key role as technical advisors to support government officials. A shift of resources to this area will promote a safe, secure water resource for future generations.

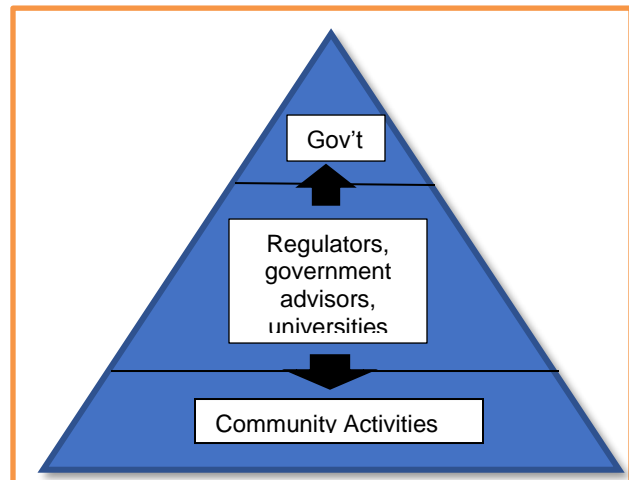


Figure 1: Activity in the WASH Sector

1.3 Critical Changes Identified

Changes need to occur if Africa is to move forward where access to water is equitable, industries can flourish, Africans are employed, and the environment is protected. These changes are as follows:

- a) More STEM and STI programs connected to WASH priorities are needed to educate Africans in Africa
- b) Opportunities are needed to balance gender inequities in education and employment

- c) Education of regulators and big-picture thinkers (middle of triangle)
- d) Connection between university hydrogeology programs and needs of industry
- e) Practical skills training for professors and working professionals
- f) Diaspora need to return to their home countries to help build skills and develop the economy for the future.

2 PROPOSED SOLUTIONS

To fill the gap in trained water professionals in Africa, training needs to be expanded and accelerated. Education programs in water resources at universities need to be practical, where professors possess experiential field skills, and where there are linkages between industry and what is taught in the classroom (Cap-Net et al, 2007).

For decades, universities in the Global North (particularly in Canada and the United Kingdom) have hosted STEM programs that focus on learning practical skills. Many universities offer Field Schools as an integral part of the classwork, and occasionally they may offer Co-op or internships where students work in industry for a portion of their formal education. These programs are critical for students to learn how to apply skills connected with the theory taught in class.

Professional associations can play an important role in continuing education of professionals throughout their careers. One option is to coordinate a series of professional seminars where consultants, government regulators, academics and students mingle and exchange knowledge. A mentorship program that links new career professionals with those with experience can help smooth the way for those beginning their careers.

Government, multi-national funding institutes and corporations all have a role to play in ensuring university programs are adequately funded and students are able to achieve scholarships to attend programs of their choice within Africa.

One example is provided where an NGO is working with Africa universities, government and industry to make a difference in this socio-economic climate. This organization is a Canadian charity by the name of UniWater Education (UniWater).

2.1 Practical University Programs

UniWater Education partners with African universities to enable more people to be trained in the WASH sector, to solve Africa's water challenges. UniWater works with their African university partners to get practical MSc programs in Hydrogeology and Water Resources Management established in Africa. Most times, these programs are based in the Geology or Civil Engineering departments. The curriculum is provided to the host university by way of a cloud-based software system that allows the material to be downloaded and customized as needed. This way, the host university 'owns' their program and it can be customized based on local needs and the expertise of the faculty. The program combines hydrogeology, hydrology

and water supply with modules in a variety of subjects pertaining to these specialties. The curriculum contains 'Best Practices' developed in Global North but adapted to African perspectives. A two-week long Field School is the pinnacle of the program. Support is provided by UniWater to provide training for professors to enhance the experiential skills needed to implement the Field School. UniWater also collects reference material in the form of text books from Canada and transports them to the African universities in need of books for their libraries. Each African university is paired with a mentor at a university with a similar program in the Global North which allows for problem solving during formation of the program and the potential for research partnerships or student exchanges. The current modules available include: Groundwater and its Occurrence; Borehole Drilling, Siting and Completions; Groundwater Flow in Aquifers; Groundwater Chemistry and Pollution; Integrated Water Resource Management; Groundwater Modelling; Research Methodology; and, Field School. Future modules will include Sanitation; Oil and Gas; Mining; and, Climate Change.

2.2 Field School

The Field School is a mandatory component of each program. The focus of the module can be customized to each university's program. The Field School could be operated as an income-generating activity for other university water-related programs or could incorporate industry participants. Current specializations for the Field School include:

- a) Hydrogeology – geophysics, surveying, well siting, borehole drilling, well installation, aquifer pumping tests and analyses, contaminant investigations, water sampling, and pump diagnostics and repair.
- b) Hydrology - weather station installation, sand dam construction, river basin characterization and hydraulic monitoring
- g) Water Supply – biosand filter construction, surveying, stakeholder consultations, installation of taps and protection of groundwater springs.

During the Field School, students live together, work in teams, and build collaborative relationships.

UniWater Education provides support for the Field School to ensure professors have the appropriate training needed to teach the Field School. Volunteers from industry are used to help with the Field School, as needed, with the intent being that Africans will be used as much as possible.

2.3 Industry interaction

There is currently a disconnect between what is taught in African universities and what is needed by industry related to water resources. There needs to be more integration between the two, with industry providing professionals to universities as instructors. Professional talks and seminars centered around the university would provide opportunities for academics and industry professionals to share experiences, and form alliances. Industry could provide paid co-op work opportunities where both the student and the employer could 'test drive' the relationship. Faux

conferences could be staged at the university where industry professionals act as judges for thesis presentations or posters, or inter-university competitions could be held to identify the best problem solvers. Industry could also sponsor scholarships for prospective high achieving students or employees.

The benefit to industry for this interaction is a more suitably trained workforce for their future operations. This interaction will also increase visibility within the WASH sector and the communities in which industry operates, ultimately improving their social license to operate.

2.4 Inclusion of Community Projects

Working with local NGOs to bring real projects into the classroom has benefits on several fronts. Students gain skills on projects with real impact and problems, and they gain experience communicating complex issues to community members, many of which may not have a secondary school education. The community benefits from having specialists-in-training working on their project while under the supervision of knowledgeable professors, ultimately resulting in the development of better quality infrastructure. The funding contributors receive better value for the money invested.

3 CURRENT AND FUTURE PARTNERSHIPS

UniWater is currently partnering with five universities in sub-Saharan Africa, in Tanzania, Ethiopia (2), Kenya and Nigeria. Of these, Sokoine University of Agriculture (Tanzania), Bahir Dar University (Ethiopia) and the University of Calabar (Nigeria) are working to launch their Field Schools in 2018 to support their MSc programs. Each of these programs will be able to enroll 10 to 25 students each year.

Once this pilot program has been assessed, it is anticipated that scale-up could include three new partnerships each year in the future.

4 CONCLUSIONS

For Africa to meet the SDGs (target 6.1) for universal access to sustainable water supplies there needs to be a paradigm shift in thinking. Groundwater needs to be acknowledged as the largest source of freshwater for the future. University programs in Africa need to become more practical in content, where hands-on skills are taught and where there is a direct connection between the content and what industry expects from graduates. This can be accomplished through increased collaboration between industry and the university community, and among individual universities. Increased levels of funding by government, international funding institutes, and industry will enable a greater number of students to attend classes.

The Global North has a part to play in this future for a stable and secure Africa by providing funding, volunteers, and reference material; by acting as mentors for both professors and students; and by fostering a climate of collaborative interaction built on mutual respect. In doing

so, the collective 'we' can make a difference on how the SDGs are achieved and how an era of cooperation can develop even under extreme environmental challenges.

5 REFERENCES

- ACBF, 2017. *Africa Capacity Building Foundation*. Africa Capacity Report 2017, Building Capacity in Science, Technology and Innovation for Africa's Transformation. <http://elibrary.acbfpact.org/acbf/collect/acbf/index/assoc/HASH01ad/e44e7241.dir/ACR2017%20English.pdf>
- ACBF, 2016. The ACBF Strategy for 2017-2021: Skilled People and Strong Institutions Transforming Africa, draft 4.3, 01 June 2016. *Africa Capacity Building Foundation* (www.acbf-pact.org)
- ACBF, undated. *Africa Capacity Building Foundation* (www.acbf-pact.org)
- AUC, 2014. *Africa Union Commission*. Science, Technology and Innovation Strategy for Africa 2024
- Cap-Net, UNDP and BGR, 2007. Capacity Building Actions in Groundwater Management Issues as an Aspect of IWRM for the Nile Region.
- Cooke, J.G. and Downie, R., 2014. *Center for Strategic & International Studies*. Africa at a Crossroads – Overcoming the Obstacles to Sustained Growth and Economic Transformation. May 2014
- Eduvie, M.O. and Ahmed, S.D., 2016. *7th Forum of the Rural Water Supply Network, Abidjan, Cote d'Ivoire*. The Need for Capacity Development to Enhance Rural Water Supply and Sanitation Service Delivery: The RWSSC/JICA Approach in Nigeria.
- FAO, 2015. *Food and Agriculture Organization of the United Nations, Groundwater Governance, a Global Framework for Action*. Groundwater Governance a call for Action: A shared Global Vision for 2030, Special Edition for World Water Forum 7.
- Hutton, G. and Varughese, M., 2016. The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation and Hygiene. Water and Sanitation Program Technical Paper 103171., *World Bank Group*.
- Ichang'I, Daniel, Pers.Comm, 2011. In discussion at the University of Nairobi, Kenya between Dr Ichang'I, members of Rotary International (West Virginia Chapter) and Hydrogeologists Without Borders. January, 2011.
- Kachika, T, 2010. Land Grabbing in Africa: A review of the Impacts and the Possible Policy Responses.
- IWA, 2014. *The International Water Association*. An Avoidable Crisis. WASH Human Resource Capacity Gaps in 15 Developing Economies. www.iwa-network.org/
- Maathai, W., 2009. *A Challenge for Africa*. Random House of Canada Limited, Toronto, Canada.
- Rulli, Maria Cristina, Savioli, Antonio, D'Odorico, Paolo, 2012. Global land and water grabbing. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 110, No. 3, pages 892-897. www.pnas.org/cgi/doi/10.1073/pnas.1213163110
- RWSN, 2010. *Rural Water Supply Network*, Perspectives No 4. Myths of the Rural Water Supply Sector. May,

2010. <http://www.rural-water-supply.net/en/other-topics/myths>
- UNEP, 2011. *United Nations Environment Programme. Water Issues in the Democratic Republic of the Congo. Challenges and Opportunities*, Technical Report.
- UNICEF/Skat Foundation, 2016. *Professional Water Well Drilling: A UNICEF Guidance Note, Cost Effective Boreholes Partnership of the Rural Water Supply Network by UNICEF and Skat Foundation*, Available from www.unicef.org and www.rural-water-supply.net
- WASH Liberia, 2012. *Capacity Development Needs Assessment*, July-October, 2012.
- WBG, 2017. *World Bank Group. A Thirst for Change. The World Bank Group's Support for Water Supply and Sanitation, with Focus on the Poor. An Independent Evaluation*.
- WEF, 2014. *World Economic Forum. The Global Competitive Report 2014-2015*. Geneva. http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2014-15.pdf
- WRG, 2016. *2030 Water Resources Group. Moving Towards Implementation – Water Security Partnerships for People, Growth and the Environment*. 2015 Annual Report.