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RESEARCH ARTICLE

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A proposal for an academy to deliver capacity building in agricultural water management with particular reference to irrigation

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Abstract

The paper proposes a capacity-building programme (CBP) on water for food/agricultural water management in sub-Saharan Africa contained within an academy on the water–energy–food (WEF) nexus. The paper is informed by a study funded by the International Water Management Institute and supported by the Water Research Commission of South Africa. It also reports on a stakeholder consultation workshop on 26 April 2023 in Pretoria, South Africa. It identifies key components of capacity-building design and delivery, including six teaching and learning pathways. These are managed ad hoc self-directed learning; continuing professional development; short-course training; vocational college training; part-time online postgraduate training; and full-time in-person postgraduate training. The accompanying budget analysis is speculative based on the size of the student cohorts per year for each of the six CBP pathways. The total budget of the academy is estimated at approximately US $60 million for a 10-year programme training 2,800 individuals. This works out at an average per-student cost of US$21,600. One question, debated at the stakeholder workshop but unresolved, was the emphasis on irrigation versus the agricultural water management continuum including rainfed agriculture.

KEYWORDS

Africa, budget, food security, knowledge, nexus, training, water for food

Résumé

Le document propose de créer un programme de renforcement des capacités (CBP) sur la gestion de l'eau pour l'alimentation et l'eau agricole en Afrique subsaharienne, contenu dans le cadre d'une Académie sur le lien eau-énergie-alimentation (WEF). Le document s'appuie sur une étude financée par l'Institut international de gestion de l'eau et soutenue par la Commission de recherche sur l'eau d'Afrique du Sud. Il rend également compte d'un atelier de

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consultation des parties prenantes qui s'est tenu le 26 avril 2023 à Pretoria, en Afrique du Sud. Il identifie les éléments clés de la conception et de la mise en œuvre du renforcement des capacités, notamment six voies d'enseignement et d'apprentissage. Ceux-ci sont; apprentissage autodirigé ad hoc; développement professionnel continu; formation de courte durée; formation collégiale professionnelle; et formation postuniversitaire comprenant une formation postuniversitaire en ligne, à temps partiel et à temps plein. L'analyse budgétaire qui l'accompagne est spéculative et se base sur la taille des cohortes d'étudiants par an pour chacune des six voies du CBP. Le budget total de l'Académie est estimé à environ US$ 60 millions pour un programme de formation de10 ans destiné à 2,800 personnes. Cela représente un coût moyen par étudiant de US$ 21.600. Une question, débattue lors de l'atelier des parties prenantes mais non résolue, était l'accent mis sur l'irrigation par rapport au continuum de gestion de l'eau agricole, y compris l'agriculture pluviale.

MOTS CLÉS

Afrique, budget, sécurité alimentaire, connaissances, liens, formation, eau contre nourriture/eau pour la nourriture/eau pour l'alimentation

1 | INTRODUCTION AND BACKGROUND

1.1 | Introduction

In the face of climate change, agricultural water management (AWM) in sub-Saharan Africa (SSA), including irrigation, needs to contribute to the continent's food security by producing large volumes of staple and cash crops (Fanadzo & Ncube, 2018; Matthews et al., 2022; Wiggins & Lankford, 2019). With a growing population, Africa needs productive agriculture (Malabo Montpellier Panel, 2018; Morris et al., 2009). However, irrigation systems are complex and need comprehensive understanding and tailored effective support to perform well (De Bont et al., 2019; Sikka et al., 2022). These engagement and advisory services, in turn, should be underpinned by and interlinked with appropriate research and education/capacity building (Ryan et al., 2012; Ritzema et al., 2008).

Furthermore, irrigation is a part of the water–energy–food (WEF) nexus, where policies or actions that help grow irrigation and its water consumption create negative trade-offs and externalities (Shah, 2023). Thus, irrigation significantly affects the water security of other sectors in arid and semi-arid river basins via water depletion. By reducing depletion, irrigation will be at the centre of water reallocation efforts (Garrick et al., 2020; Lankford & McCartney, 2024). Climate change will mostly be felt through increased water variability and resultant impacts on food security. Water for food (WfF) and AWM are synonymous topics within the wider WEF nexus that present significant challenges. Although energy use in the nexus will be part of a capacity-building curriculum, the main focus will be on WfF. This is because in many situations WfF/AWM can be delivered, researched and governed without recourse to energy dimensions.

The rebuilding of capacity in water management in agriculture, especially in irrigated agriculture, is a major policy question as it would renew the skills base in this sector (Kay & van Scheltinga, 2004; Ritzema et al., 2008). This skills base is significantly depleted. For example, there were once about eight dedicated irrigation master's degrees globally available in the 1980s to 1990s all of which have now been discontinued as donors pulled out of irrigation (Wiggins & Lankford, 2019). Current provisioning at the postgraduate (PG) level is relatively piecemeal and is found within a few modules and lectures at universities in the Netherlands, United States and United Kingdom.

WfF needs a capacity-building programme (CBP) (Fanadzo & Ncube, 2018; Franks et al., 2008) because, as indicated above, the subject is complex and can be contained in and reflected by a dedicated Master of Science (MSc)/Master of Engineering (MEng) degree. The proposed academy also reflects a current capacity concern; many early- and mid-career scientists working in water have knowledge gaps regarding irrigation systems, irrigated agriculture and other means of managing soils,

TABLE 1 Key terms and acronyms.

Cohort. The number of students in each pathway **course.** A single period of work consisting of modules **Credits**. A measure of the study hours to gauge the learning and teaching occurring in a module and across a degree or other qualification **Module.** A unit of work that makes up a course. It is usually a given number of hours and/or credits	**Pathway.** A route for an individual to undertake capacity building. There are six pathways, each of a different level and intensity of work **Student.** Given that professionals and staff members are in early- or mid-career, the word 'student' refers to when they are undertaking studying. 'Student' differentiates them from being a tutor, lecturer or teacher
AWM agricultural water management CBP capacity-building programme CPD continuing professional development FAO Food and Agriculture Organisation FSC field study centre FT full-time ICID International Commission on Irrigation and Drainage IPT in-person teaching IWMI International Water Management Institute OLT online teaching PG postgraduate	PMU programme management unit PT part-time SA South Africa SADC Southern African Development Community SCT short-course training SDL self-directed learning SSA sub-Saharan Africa VCT vocational college training WEF water–energy–food WfF water for food WRC Water Research Commission

crops and water. Furthermore, with renewed donor interest in irrigation and water security, we require a new generation of irrigation skills and specialists. With this investment, investors and other AWM stakeholders can avoid repeating many of the mistakes of the last 20–40 years. Furthermore, we cannot rely on irrigators alone to build their own farmer-led systems (Woodhouse et al., 2017), given the water regulatory problems that likely follow from over-abstraction of limited resources (Balasubramanya et al., 2024). Recognising these gaps, the International Commission on Irrigation and Drainage (ICID) organised a webinar (July 2022) outlining the worrying lack of capacity building in AWM. This ICID webinar is available online.[1]

Responding to the above concerns, this paper proposes a capacity-building programme (CBP) on agriculture water management (AWM) or 'Water for Food' (WfF) delivered via a yet-to-be-established academy. The paper is the product of consultancy work commissioned by the International Water Management Institute (IWMI) from October 2022 to May 2023, supported by the Water Research Commission (WRC) of South Africa and delivered by the two co-authors. The consultancy work and its putative WfF Academy, in turn, respond to the interests of the IWMI and the WRC in the WEF nexus field.

This paper outlines the design of the CBP, builds a budget depending on student recruitment numbers and reports briefly on the stakeholder consultation workshop held in Pretoria on the 26 April 2023. The academy emphasises SSA, but its design, applicability and student recruitment could encapsulate much of the Global South, given the significance of irrigation elsewhere. Organisations and institutions (including the two sources of funding for the study) named in this paper illustrate possible interests and arrangements, but their inclusion here does not in any way suggest a formally agreed endorsement, or financial liability, or official policy, partnership or delivery arrangement regarding this CBP. Table 1 provides the terms and acronyms employed in the paper.

1.2 | What questions and perspectives illustrate weak spots in AWM?

Capacity building is needed because irrigation is a complex system comprising many different scales and dimensions (Lankford et al., 2020; Uhlenbrook et al., 2022; van Oel et al., 2019). While scientists may agree on what sustainable, high-performing, river basin-fitting irrigation *should look like* (Lankford & Heaton, 2022), there are difficulties in designing cost-effective policies. Some questions illuminate these challenges. For example, how should those working with irrigators and irrigation define, reform and govern sustainable AWM at scale? In other words, how can investors and managers govern thousands of hectares of irrigation to optimally lift performance within budget and without affecting the water demands of other sectors? Within these questions are

[1]The YouTube video is found at https://www.youtube.com/watch?v=Gc0xQQhoquo

TABLE 2 Current and recent capacity building in water for food.

1. There is a virtual water academy based in Southern Africa funded by WRC and other donors (https://www.facebook.com/virtualirrigationacademy/)
2. Capacity building is part of this initiative (https://www.futurewater.eu/). This places some emphasis on agricultural water management (https://www.futurewater.eu/expertise/water-productivity-irrigation/)
3. The Nebraska Water for Food Institute provides some short courses (https://waterforfood.nebraska.edu/our-work/education/capacity-building)
4. WaterNet is perhaps one of the best-known models for capacity building in Africa (https://www.waternetonline.org/)
5. The network of AUDA-NEPAD Water Centres of Excellence (NEPAD Water CoE) is a network of higher education and research institutions conducting high-end scientific research on water and related sectors to provide government policy guidelines (https://nepadwatercoe.org/)
6. The International Centre for Water Resources Management (ICE WaRM) no longer has an active website, but it has a LinkedIn page (https://au.linkedin.com/company/the-international-centre-of-excellence-in-water-resources-management-ice-warm)
7. It is worth visiting NEWAVE for its capacity-building programme and networking for early career scientists (https://www.nextwatergovernance.net/training)
8. Another model to follow is WEDC, based at Loughborough University, which concentrates on domestic WASH and WATSAN. It ran many conferences that simultaneously aimed to build capacity in the Global South (https://www.lboro.ac.uk/research/wedc/)
9. The Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC) hosts capacity building in agricultural water (https://www.sesric.org/cbp-agricab.php)
10. Another model is at https://www.landportal.org/organization/regional-universities-forum-capacity-building-agriculture

Abbreviations: AUDA, African Union Development Agency; NEPAD, New Partnership for Africa's Development; NEPAD Water CoE, AUDA-NEPAD Water Centres of Excellence; WASH, water, sanitation and hygiene; WATSAN, water supply and sanitation; WEDC, Water Engineering and Development Centre; WRC, Water Research Commission.

perspectives and opinions that appear to provide good answers:

1. Let water accounting and water foot printing guide irrigation management.
2. Make sure water is priced correctly or is regulated via water rights.
3. Introduce drip irrigation as it is more efficient.
4. Focus on farmer-led irrigation.
5. Distribute soil moisture sensors to farmers to manage water.
6. Provide solar pumps to smallholders.
7. Manage irrigation via satellite imagery.

Let us take the first perspective on water accounting and footprints. While some claim these methods guide irrigation management and governance, others believe they are very limited for dealing with complex systems (Lankford, 2022; Wichelns, 2011).

In short, while each of the seven opinions above has a role, they are only partially correct. Or they miss important topics that are no longer fashionable or where skills no longer exist. One example is the subject of designing in accurate water manageability (Plusquellec et al., 1994). Or the seven perspectives bring consequences that need further management and monitoring. Taken together and given long-term support, multiple tools and dimensions are more successful. However, weaving together different tools and aspects tailored to different situations requires considerable skill, which invokes the need for dedicated PG training on AWM and/or irrigation.

1.3 | Current and recent capacity building in WfF and water

Setting aside the University degree courses referred to elsewhere, the current and previous provisioning for capacity building in WfF is provided in Table 2. At best it paints a mixed patchwork picture of current and recent training. At worst, it demonstrates the current global offering on training for irrigation and WfF is very poor.

2 | DESIGN OF THE CBP

This section outlines the major features and assumptions that feed into the design of the AWM CBP. Section 3 outlines some principles that inform the putative curriculum.

2.1 | Target/recipient groups and organisations

Four main target groups for capacity building were identified:

1. *Start-of-career scientists*. These individuals are either currently taking (or aim to take) bachelor programmes or vocational training to enter the AWM field in a few years.
2. *Early-career scientists*. These staff probably have science experience in water, ecology, economics and social science but have not fully applied this to an agricultural or irrigated agriculture problem and context.
3. *Mid-career scientists and experts* (e.g. *engineers)*. They may have more irrigation knowledge, which needs updating on the latest water/irrigation/AWM developments.
4. *Policymakers*. They may work on water, food and irrigation but require greater knowledge to question funding proposals and science and consultancy reports.

Community/irrigator representatives were identified as a possible fifth priority but their inclusion is likely subject to funding constraints.

There are many organisations whose staff could receive training (and/or contribute to funding) on AWM. Examples are the African Union, African Development Bank, Southern African Development Community (SADC) Secretariat and consulting firms.

2.2 | Six pathways of capacity building, teaching and learning

The study identified six main pathways an individual could follow to build WfF capacity. There will be hybrids and crossovers. The pathways are presented in subsections in order of complexity and cost. There are strengths and weaknesses/disadvantages with each one, as indicated. Cross-cutting activities involving all six pathways were also examined. The six pathways are described in the following subsections.

2.2.1 | Informal self-directed learning

This is the most informal and least costly of the pathways. While many versions might be available, it is envisaged as self-driven or self-directed learning (SDL). The students would agree on various topics to be covered with their team and/or manager. They would then keep a record/diary of work achieved to be reviewed in formal objective-driven supervision meetings with their manager. While its advantage is cost, its major disadvantage is that it depends on the staff member being mostly responsible for updating their skills. It is also difficult to objectively gauge the learning achieved.

2.2.2 | Continuing professional development

Continuing professional development (CPD), also known as professional development training (PDT), is usually an employer-monitored accreditation system to deliver 'on-the-job' skills learning. CPD usually works via a partnership between an employer and a professional body organisation. In the case of engineering, an example is an engineering company affiliated with the Institute of Civil Engineers based in London.[2] CPD also works via the employee and their manager agreeing to 'sign up' or undertake specific work tasks, or meeting tasks or learning tasks that acquire CPD credits. Our study into the academy envisaged two ways forward for CPD:

1. Centrally organised, externally sourced and formal. An organisation such as a university or an international science organisation such as IWMI (or a consortium) would build a formal, centralised, fully monitored and accredited CPD programme. This may require external partners to deliver such a CPD programme. The first formal version is the one that is in the proposed budget.
2. In-house, dispersed and less formal. Something less formal could be designed, managed in-house by each water organisation.

2.2.3 | Short-course training

Short-course training (SCT) is the third delivery pathway and can be mixed with the first two. Short courses can be provided by academic and professional staff hosted at universities in Europe/United States or SSA, which might contain field visits in SSA to complement them. Short courses usually last 1 week but can extend over 2-3 weeks. The costs that feed into a budget are:

1. Fees for short courses at European or US universities are between US$2,000 and US$6,000 depending on length and location.
2. Travel, visas, accommodation and subsistence also add to costs. The budget assumes US$2,000 as some of these costs will be covered in the fees.
3. The employer's organisation usually covers the costs of participants attending short courses. These are (1) fees paid to providers; (2) travel, visas, subsistence and accommodation; and (3) incidental field and course costs. If this involves travel to the United States or Europe, total costs might amount to about US $8,000 per person per course.

[2]See https://www.ice.org.uk/

2.2.4 | Vocational college training

In this pathway, prospective students attend vocational/technical colleges. In a year, students acquire a certificate or diploma depending on the study period and level attained. Vocational training would also provide an excellent practical foundation before moving on to a master's degree. South Africa already has technical and vocational education and training (TVET) colleges in places ready to run irrigation training. Key benefits include access to basic irrigation and agricultural training; local provision with fewer obstacles in terms of travel and visas; and highly economical fees compared to international rates overseas. One possible disadvantage is that vocational college training (VCT) might not engage students in academic and theoretical debates regarding AWM.

2.2.5 | PG degree part-time

Here, students would undertake part-time PG training mostly or totally via online teaching (OLT). The number of credits attained enables three exit points—certificate, diploma and master's degree, as explained here:

- Certificate 60 credits—if part-time, this can last 6–12 months
- Diploma 120 credits—if part-time, taking 12–24 months
- MSc 180 credits—if part-time lasting 24–36 months
- PhD level—part-time, lasting >50 months (likely not with this CPD programme)

There are additional considerations for PG training. Setting aside the PhD stream, the above three are modular or successive stages. Thus, the completion of the certificate could then lead to the diploma and then to the MSc. Embarking on, progressing through and completing each stage might be monitored by the host or management organisation, and final success could be rewarded via pay structures. Costs would have to cover part-time university fees, but expenses for travel and accommodation would be far smaller than those for the full-time equivalent (see next).

2.2.6 | PG degree full-time

This is the most formal and costly of the six pathways that envisage individuals signing up for a full-time (FT) in-person teaching (IPT) PG degree, most likely leading to an MSc or MEng degree. This pathway might also include progressing to PhD level, which is not considered in this CPD design. The budget for one person taking a residential 12-month PG degree at a European or United States university is likely US$30,000–50,000, covering fees, travel, accommodation, etc.

2.3 | Progressing through different pathways

With six different pathways, an individual scientist/staff member and their manager are presented with different ways of adding or merging pathways to build capacity from a basic to a more advanced level. For example, a person who has demonstrated good progress with SDL could then go on to do vocational training and then progress to a master's degree. This is why a programme management unit (PMU) and software are so important; tracking the activities of many individuals enables a whole cohort of hundreds of people to be managed thoroughly over a period of 1–5 years.

2.4 | Cross-cutting issues

Four cross-cutting themes apply to all of the six pathways, as identified here:

- A field study centre (FSC) could host short-course and field-based exercises and training. The FSC could be where practical exercises are conducted, such as soil infiltration tests, building small drip irrigation systems, measuring flows and land surveying. Practical work is beneficial as it allows students to see how easy or difficult it is to carry out their recommended water management practices and policies. The FSC could partner with other organisations in Southern Africa. The budget currently includes this provision.
- Staff exchange, where staff take sabbaticals from their workplace to spend 1–3 months, or more, with a different employer.
- Networking events are an important way to create and sustain momentum for a CBP. Meetings of early-career scientists allow them to present their research to each other. WaterNet has done this with its regular conferences based in SSA. Therefore, cross-cutting all of the six pathways is a provision for networking events such as symposia and conferences. The budget includes this provision.
- Networked collaborative problem-solving is another way to mainstream capacity building by encouraging those on the programme to share and solve problems.

3 | WFF CURRICULUM (PRINCIPLES/SUBJECTS)

3.1 | Principles of the curriculum for the WfF Academy

Befitting the sense that WfF is a complex topic, the design and delivery of the AWM CBP could consider the following ideas, objectives and principles:

- *Covering both established and new skills*. Teaching and learning should cover basic skills and address contemporary problems through new skills and methods.
- *Many disciplines and viewpoints*. Wherever useful, teaching and learning will be inter- and multi-disciplinary to see problems from different angles, perspectives and disciplines.
- *Practical and theory work are both informed by case studies*. Students benefit from a balance between classroom (theory and case studies) teaching and practical work based in the field.
- Course content will have to be identity, gender, race, poverty, class and age aware, recognising that farmers who irrigate are unique individuals and differ greatly from one another.
- Real-world. Wherever possible, learning will be backed up by (a) real-world problems and (b) fieldwork.
- By arguing and debating topics, students might welcome learning skills and understand that topics involve contentious debate requiring navigation between opposing views.
- Students within the academy accept that studying water and irrigation requires numeracy, delivered via research projects, Excel exercises and field measurements.
- Irrigation and WfF is highly nested and scalar. Students should work across all scales: soil, field, farm, system, river basin and global.
- Listening to/seeing unique problems and understanding farmers' viewpoints. Each water problem is unique. Students will be asked to consider the risks of applying blueprint solutions and becoming 'part of the problem' by dictating what farmers should do.

3.2 | Three levels of modules: foundational, integrated, advanced

Students often start with modules that cover basic/foundational teaching before taking more integrated, taxing, problem-oriented or academic modules. It is suggested that three levels are considered:

- *Foundational*. These are usually shorter or smaller credit modules designed to provide an introduction to a topic. Some students might choose to go directly to the next level.
- *Integrated, problem oriented*. These are larger credit modules designed to stretch an individual's learning fully. These are also called capstone modules designed to build a bridge between different knowledge and skills.
- *Advanced policy modules*. These modules are bespoke and are designed to integrate knowledge gained from prior studies.

3.3 | Module content

The subjects and content would be the same for each pathway, but there would be differences in hours spent (quantity of work) and engagement with the work assignments (quality of work). The CPD programme would have to consider how the modules fit together so that students progress smoothly and intellectually through them.

Foundational modules:

1. Soils, crops, agronomy, agrometeorology and land. For example: rainfall, evapotranspiration (ET), drainage, climate, soil moisture, slopes and gradients, and infiltration rate
2. Irrigation basics and numbers. Numeracy of irrigation. How irrigation is changing
3. Irrigation planning. Standard procedures for designing an irrigation system
4. AWM engineering. Basics of irrigation design and hydraulics: sprinkler, drip, flood irrigation. Soil, gradients and landscape engineering. Drainage planning
5. AWM social science. Types of irrigators, irrigator groups and irrigator rules/institutions, as well as gender and irrigation
6. AWM legal frameworks. Introduction to water law; rights and licences
7. AWM economics—theory and practice. Economic efficiency, valuing water, markets

Integrated modules, including case study material:

1. Irrigation reform planning. Advanced procedures for designing an irrigation system
2. AWM engineering. Design for management, schools of engineering thought
3. AWM social science. Common problems with collective management of water, gendered structures on small- and large-scale irrigation systems

4. AWM legal frameworks. Water law and irrigation from around the world
5. AWM economics. Difficulties in practice, case studies
6. AWM and context. River basin water security and allocation

Advanced policy modules, including case study and problem-solving:

1. Delivering sustainable irrigation and irrigation services at scale
2. Irrigation, AWM and the WEF nexus
3. Change management of large-scale irrigation, including funding
4. Writing coherent research proposals (frameworks of theory, methods, ethics and data)
5. Writing succinct journal articles; literature reviews, conceptual frameworks; evidence and argument

3.4 | Student-designed versus tutor-designed studying

At the centre of the CBP would be the question of 'who provides the material the students learn from?' There are two main answers to this. The first is a student-designed study, which involves work mainly designed by the students in consultation with their manager and team. It involves finding, studying, working through and reviewing teaching material via the following: (a) An individual navigates the web to examine a particular issue. Examples of browsing include YouTube, Google Scholar and organisations' webpages, which are examined to develop an informed overview of a subject. (b) The student watches pre-recorded online seminars.

In a second option, 'teacher-designed studying', the student studies and learns from materials designed by tutors, teachers, trainers and academics to fit an AWM curriculum. This will require partners to deliver these materials. The student would undertake the following:

- Live online seminars
- Individual formative assignments and assessments—are explained below
- Individual summative assignments and assessments
- Group assignments are usually formative
- In-person teaching sessions; usually 45–60 min

Each type of teaching/learning will suit the pathways in different ways. The matrix in Table 3 suggests a close fit between type and pathway.

3.5 | Assignments and exercises

The below provides examples of assignments and exercises that could be given to students:

- Testing applications of irrigation basics and numbers
- Irrigation planning; design an irrigation system
- Analysing causes of case study outcomes
- Contrasting the pros and cons of sprinkler, drip and flood irrigation for smallholders
- Irrigation/AWM social science; interviewing irrigators and irrigator groups to determine their key problems
- Showing how legal frameworks around AWM shape water security
- Writing a scientific paper on managing water productivity in a chosen irrigation scheme

3.6 | Formative versus summative assignments, coursework and exercises

The CPD programme would have to weigh the balance between formative and summative student assignments

TABLE 3 Content matrix of six pathways with main teaching and learning activities.

	SDL	CPD	SCT	VCT	PG-PT	PG-FT
Web browsing	●	●	●	●	●	●
Online seminars pre-recorded		●		●	●	●
Online seminars live		●		●		
Individual formative assignments	●	●	●	●	●	●
Individual summative assignments		●		●	●	●
Group assignments		●	●	●	●	●
In-person teaching sessions		●	●	●	●	●

Abbreviations: CPD, continuing professional development; PG-FT, postgraduate full-time; PG-PT, postgraduate part-time; SCT, short-course training; SDL, self-directed learning; VCT, vocational college training.

and coursework. Formative assignments are generally given as short pieces of work that are not marked. An example might be building a spreadsheet to calculate water requirements. Formative work might also be groupwork, allowing, say, a group of three students to develop a board game or short video about farmer-led irrigation.

Summative assignments are formal marked assignments, part of calculating a grade point average, that will eventually decide whether the student has passed, failed or excelled at their course. An example might be to write a 2,000-word policy brief on smallholder irrigation. These are usually individual assignments, not groupwork (groupwork can be difficult to mark because of the problems distributing marks according to the effort put in). Summative assignments are usually part and parcel of a master's degree to grade the student. Summative assignments are usually not part of SCT.

4 | PARTNERS TO DELIVER TEACHING AND TRAINING

The ambitious scope of the training, as outlined here, combined with the current lack of AWM training, suggests that the WfF Academy will best be served via developing partnerships in Africa and globally. The following three subsections break down the topic of partnerships.

4.1 | Partnerships for each pathway

Likely partnerships for each of the pathways are given in Table 4.

4.2 | University and research institution partnerships

Below are lists of possible partners to link with to provide the CPD (which can be added to).

Universities:

- Nebraska, United States
- Cranfield, United Kingdom
- International Institute for Infrastructural Hydraulic and Environmental Engineering (IHE) Delft, the Netherlands
- Wageningen, the Netherlands
- University departments working on WfF, such as in South Africa, Kenya and Tanzania

WfF research and professional institutions:

- WRC, South Africa
- Other Consultative Group for International Agricultural Research (CGIAR) organisations working on water and food
- ICID
- Food and Agriculture Organisation of the United Nations (FAO)/International Fund for Agricultural Development (IFAD)/United Nations (UN)-Water

4.3 | Support from stakeholders

Strong stakeholder support for the academy will help persuade funders to finance the academy. As an indication of this support,the participants at the April 2023 Pretoria

TABLE 4 Likely main partnerships for each of the six CPD pathways.

Main pathway	Partnership type and demands
Informal ad hoc personal updating	Minimal partnership is needed. Likely a core group. For example, IWMI, FAO, and universities in SSA, Europe and USA
Continuing professional development (CPD)	Likely a core group if formal provision of CPD is the objective. For example, IWMI, FAO, and universities in SSA, Europe and USA
Short-course training	Providers of short courses will need to be invited to develop short courses lasting 1–2 weeks in the field of agricultural water management. A field study centre would need a formal partnership. The trend these days is to hold the training in-country (meaning in SSA) rather than to travel to Europe or the USA
Vocational college training (VCT)	VCT already exists in South Africa
Postgraduate qualification pathway full-time	The most demanding of pathways, these two will need strong partnerships with a university or several universities based in Europe, the USA and Africa. Universities involved must lead on these postgraduate pathways, complete with budget development

Abbreviations: FAO, Food and Agriculture Organisation; IWMI, International Water Management Institute; SSA, sub-Saharan Africa.

meeting firmly expressed their approval of the programme. Support is likely to be found among:

- International, regional and national science institutes
- Government ministries and departments
- Colleges and universities
- The private sector working in agriculture
- Cities (mayors) concerned about water supplies and competition with irrigation

While many organisations understand the central role of AWM in food, water and energy security, this is not always the case. Irrigation is in a poverty trap with few friends to propel it to a brighter future. For example, irrigated agriculture was poorly expressed in the eight missions defined in IWMI's Transformative Futures for Water Security (TFWS).[3]

5 | ACADEMY DELIVERY, ADMINISTRATION AND MONITORING

This section outlines three important matters that can help deliver the WfF Academy.

5.1 | Portal, PMU and steering committee

A putative host of the CPD would have to consider three components to deliver the capacity building—software, a project/programme management unit (PMU) and an oversight or steering board:

1. *Software*. The academy must establish, buy or expand an online management portal to manage the provision of its skills. This portal provides information to prospective students, welcomes and tracks applications, tracks individual and cohort progress, monitors expenditure, administers qualifications, collates student feedback and helps adjust the programme. An example is https://www.classter.com/.
2. *PMU*. The academy would have to establish a PMU of four to six people (one senior manager, one senior administrator, one networking manager, one accountant, one or two secretaries and one website technician) to administer the academy. This PMU would provide over-arching management, expenditure control, further proposal writing, developing partnerships, managing networking events, monitoring student progressions, language translation (French/English), etc. The posts have been included in the budget presented in Table 6.
3. *Steering committee/board/oversight team*. In addition to the PMU, the academy must establish a steering committee or board and a PMU. This senior leadership team would guide the PMU and academy forwards. Ideally, this should be at least five to six people. Costs will accrue if meetings and time inputs are envisaged.

5.2 | Agreements on attainment, progression, procedures and standards

For Pathways 2–6, the academy would have to establish a legal/formal framework with its partners for two reasons: (a) to assure teaching quality via contractual mechanisms and (b) to meet and report against donor requirements. This framework would agree in a contract on the attainment of teaching and learning via a set of standards (facilities available, teaching contact hours, staff to student ratios, quality control, complaint procedures, etc.). This would need fleshing out in the first year of establishing the programme.

As a result of this legal framework, obligations will therefore be placed upon the academy and its partners to establish how an individual staff member finds out about, embarks upon, progresses through and formally completes their training programme. This legal framework will also support the PMU staff in dealing with positive feedback, especially complaints from applicants who fail to join, progress and attain a given qualification.

5.3 | Monitoring success: teaching results versus wider impacts

The PMU will also evaluate the success of the 10-year programme. Monitoring teaching results is relatively easy—this records the number of students attending different courses and acquiring different qualifications, plus a measure of their career advancement.

However, assessing the wider impacts of the academy CBP would be more difficult. For example, it would involve analysing how food and water systems across SSA were becoming more inclusive, productive and equitable, and less consumptive and competitive, as a result of enhanced capacity relative to a baseline. While this can be modelled, empirically differentiating the influence of the academy on these systems and their behaviours is probably very difficult.

However, in an intermediate step, the PMU could record the activities of graduates of the programme. Some

[3]https://tfws.iwmi.org/

consideration would have to be given to this—perhaps via recording how individuals are engaged in research, advisory and policy work—either via self-reporting or an objective bibliographic record of publications and reports. A smartphone or PC app connected to a central server would automatically collate and generate useful metrics of the work achieved by graduates over a given period.

5.4 | Cost–benefit analysis

In another, more advanced planning stage, the academy would build the economics case to take to funders. This may require a cost–benefit model to be built that examines whether the cost of the academy is paid for via benefits from water and food improvements across SSA.

5.5 | Horizon-scanning the future of the academy

We conducted some horizon-scanning to consider what problems may lie ahead. Various issues were identified: (1) The academy will need a long-term strategy and commitment from funders, aiming for at least 10 years. (2) Regarding succession planning, this programme should aim for a self-sustaining interest in irrigation study and qualifications. (3) Developing a website will establish how the academy will look from an external point of view and help recruit students. (5) Sustaining partnerships will be vital, especially over 10 years or more. This will likely need agreements on logistics, standards, work-sharing and memoranda of understanding. (6) The academy must provide quarterly reports and newsletters to circulate to relevant parties.

6 | ESTIMATED BUDGET FOR THE ACADEMY OVER 10 YEARS

6.1 | Introduction and design of spreadsheet

The cost of establishing the academy for its lifetime (of 10 years) was calculated using Excel. It shows how costs can be divided into fixed costs (which act as overheads) and variable student costs depending on enrolment numbers, as explained.

Starting assumptions:

- It is a 10-year programme, although this can be adjusted.
- The number of students can be adjusted, but the number per year per pathway is taken from the Pretoria 26 April 2023 meeting feedback.
- Overheads are applied to administration staff costs, currently 90%.
- An allowance for annual inflation is included and can be adjusted; set at 10.0%.

Fixed costs:

- These include establishment costs in Year 1, including a website/portal. Plus, recruiting staff for the PMU is factored in. Also, the budget includes travel costs associated with setting up partnerships, plus consulting fees for partners to create courses.
- The per annum management costs associated with the small PMU are also fixed costs. These can be adjusted depending on the staff's number, seniority and experience.

Variable costs:

- These comprise per-student costs: fees, attending meetings, other travel, subsistence, etc.
- These are then multiplied by the number of students in each of the six pathways.
- A correction factor is needed for students taking a part-time course lasting 2 years. For example, 10 students start in the first year, and then in the second year, there is a new intake of 10 students, and the 10 students completing their first year, in effect, makes the number of students 20.

Two scenarios are provided:

- Full enrolment is done using the input numbers inserted for each pathway.
- Corrected enrolment, correcting the budget for a fraction of the enrolled numbers. For example, 50%.

Other metrics include:

- Total student numbers per annum and the whole programme.
- Average cost per student (the grand total of the whole programme divided by the total number of students).
- The proportion of total costs that are fixed costs.

6.2 | Results: calculation of the budget

For each of the six pathways, the students per year enrolled are given in Table 5. This was informed by

TABLE 5 Student recruitment targets by April 2023 Pretoria workshop participants.

Pathway	Self-directed	CPD	Short course	Diploma	PG/PT/OLT	PG/FT/IPT
Name of participant						
Bruce (starting)	30	30	30	30	30	30
Amanda	40	20	40	20	20	20
Thabo	25	15	70	10	5	2
No name	20	50	50	32	16	16
Nobuhle	100	75	75	50	50	50
Botas	25	25	40	40	25	25
Rand	25	25	25	25	25	25
Tinashe	40	60	40	100	40	30
Nospho	50	30	50	80	10	40
No name	30	30	30	20	10	10
Maxwell	40	100	60	60	20	20
Aidan	20	20	80	30	15	15
Bezzel	20	30	50	20	40	20
Emmanuel	200	200	300	150	100	100
Average	48	51	67	48	29	29
For budgeting	50	50	70	50	30	30

Abbreviations: CPD, continuing professional development; FT, full-time; IPT, in-person teaching; OLT, online teaching; PG, postgraduate; PT, part-time.

student recruitment targets voted for by participants at the April 2023 Pretoria workshop.

The total budget is approximately US$60 million for a 10-year programme training 2,800 students, or at 50% recruitment of student numbers, it is US$37 million (Table 6). This works out at an average per-student cost of about US$21,600.

7 | DISCUSSION

7.1 | What should be the balance of emphasis on irrigation?

One major topic that the Pretoria stakeholder consultation discussed was the relative emphasis on irrigation in a broader spectrum or continuum of 'agricultural water management'. Two distinct emphases are possible. In the first, with an AWM emphasis, the putative academy would distribute its resources to curricula that fall across the continuum of soil water management options: from fully rainfed, to rainwater harvesting, to supplementary irrigation to full irrigation (Rockström, 2003; Rockström et al., 2002). The second would place more emphasis on irrigation. In the latter case, the academy emphasises the training and teaching of irrigation science, with a minor emphasis on other ways of managing soil, crop and water.

This question of emphasis was not resolved at the stakeholder consultation. Some participants wished to see the whole array of AWM taught. This means that the academy would focus on AWM. Others, including the authors of this paper, believe the academy should focus on irrigated agriculture. This is because (a) irrigation produces vital global food crops, such as rice, that cannot be grown well under rainfed conditions; (b) the problems seen in a blue water crisis can be tracked to irrigation issues such as over-depletion of water, poor productivity, equity and efficiency, and externalities arising downstream and on energy; and (c) Africa's plans for building a resilient agricultural sector are underpinned by expanding the area under irrigation. This is reflected in the African Union's Irrigation Development and Agricultural Water Management (AU-IDAWM) Framework, which emphasises irrigation development. Given the current global lack of master's degrees in irrigation, this paper's authors believe this emphasis should be prioritised.

Furthermore, rainfed farming is addressed in farm vocational training. If all AWM is taught, then by default, irrigation will be marginalised to one or two modules, which is not different from what is offered today. In other words, we would end up with an academy that provides little or no specialist knowledge in irrigation.

TABLE 6 Budget of proposed Water for Food Academy.

FIRST-YEAR ESTABLISHMENT COSTS—ALL PATHWAYS			Academy overheads				
Item	**Units**	**Base cost**	**Staff overheads**	**90%**	**Final cost**	**Notes**	
Staff costs	$/year	$130,000	$117,000		$247,000	All staff incl. consultancy	
Establish partnerships	$/year	$40,000	$36,000		$76,000	Travel, payments	
Course materials	$/year	$20,000			$20,000	Printing, etc.	
Website/portal	$/year	$30,000			$30,000	1st version; incl. staff	
Misc. and field study centre	$/year	$75,000			$75,000		
Total of establishment	$/year				$448,000		
PER ANNUM FIXED COSTS		**Annual salary**	**Staff overheads**	**No. of staff**	**Final cost**	**Notes**	
Senior manager/leader	$/year	$120,000	$108,000	1	$228,000	Academic/international?	
Manager/administrator	$/year	$55,000	$49,500	1	$104,500	Mid-senior position	
Accountant	$/year	$25,000	$22,500	1	$47,500	Mid-level but part-time?	
Networking manager	$/year	$40,000	$36,000	1	$76,000	Mid-position	
Website technician	$/year	$25,000	$22,500	1	$47,500	Shared position	
Secretary	$/year	$25,000	$22,500	2	$95,000	Junior position	
Software, IT, video, media	$/year	$10,000			$10,000	Licences and support	
Steering/board costs	$/year	$30,000	$27,000		$57,000	Staff time/meetings	
Misc. costs, travel etc.	$/year	$70,000			$70,000	Meetings, etc.	
In-house seminars	$/year	$50,000			$50,000	Training in-house	
Field study centre	$/year	$70,000			$70,000	Rent, cost, salaries	
Conferences/symposia	$/year	$100,000			$100,000	Networking events	
Subtotal	$/year				$955,500		
VARIABLE STUDENT COSTS							
Pathway		Self-directed	CPD[a]	SCT	Diploma SA	PG/PT/OLT[a]	PG/FT/IPT
Students enrolled/year		**50**	**50**	**70**	**50**	**30**	**30**
Duration per student	Years	1	2	1	1	2	1
Corrected student nos		50	100	70	50	60	30
Fees/meeting costs	$/year	$0	$1,000	$5,000	$2,000	$12,500	$25,000
Travel, visa, accommodation	$/year	$0	$1,000	$3,000	$250	$3,000	$15,000
Field work	$/year	$0	$1,000	$1,000	$500	$3,000	$3,000
Subtotal per student	$/year	$0	$3,000	$9,000	$2,750	$18,500	$43,000
Total for cohort	$/cohort	$0	$300,000	$630,000	$137,500	$1,110,000	$1,290,000
[a]Part-time students rolling nos, so need correcting to net							
Total students enrolled	280	Per annum		230	Excluding self-directed		
Total students enrolled	2,800	Per whole programme		2,300	Excluding self-directed		
GRAND TOTAL		**Fixed cost**	**Full cohort**	**Full cost 100%**	**Cumulative**	**x% cohort**	**Cost if x %**

(Continues)

TABLE 6 (Continued)

FIRST-YEAR ESTABLISHMENT COSTS—ALL PATHWAYS			Academy overheads				
Item	**Units**	**Base cost**	**Staff overheads**	**90%**	**Final cost**	**Notes**	
Interest rate per annum	10.0%			2,800		50%	1,400
Year 1 establishment	$/year	$448,000	$0	$448,000	$448,000	$0	$448,000
2	$/year	$955,500	$3,467,500	$4,423,000	$4,871,000	$1,733,750	$2,689,250
3	$/year	$1,051,050	$3,814,250	$4,865,300	$9,736,300	$1,907,125	$2,958,175
4	$/year	$1,156,155	$4,195,675	$5,351,830	$15,088,130	$2,097,838	$3,253,993
5	$/year	$1,271,771	$4,615,243	$5,887,013	$20,975,143	$2,307,621	$3,579,392
6	$/year	$1,398,948	$5,076,767	$6,475,714	$27,450,857	$2,538,383	$3,937,331
7	$/year	$1,538,842	$5,584,443	$7,123,286	$34,574,143	$2,792,222	$4,331,064
8	$/year	$1,692,727	$6,142,888	$7,835,614	$42,409,757	$3,071,444	$4,764,170
9	$/year	$1,861,999	$6,757,177	$8,619,176	$51,028,933	$3,378,588	$5,240,587
10	$/year	$2,048,199	$7,432,894	$9,481,093	$60,510,026	$3,716,447	$5,764,646
Costs per type	$/year	$13,423,190	$47,086,836	$60,510,026		$23,543,418	$36,966,608
GRAND TOTAL for whole programme of 10 years				$60,510,026			$36,966,608
Total cost per student for whole programme				$21,611			$26,405
Fixed cost % of whole cost				22.2%			36.3%

Abbreviations: CPD, continuing professional development; FT, full-time; IPT, in-person teaching; OLT, online teaching; PG, postgraduate; PT, part-time, SA, South Africa; SCT, short-course training.

7.2 | What emphasis on flexible problem-solving?

An important topic that cropped up at the stakeholder consultation was the vision of the AWM training seen in how it treats agricultural water systems. Distilling the many options available allows this paper to express two main directions given in the bullet points below. Although foundational topics will likely be the same for the two directions, the integrated and advanced modules will depend on the emphasis selected:

- In the first option, teaching concentrates mainly on technical knowledge transfer. Characterised as general, conventional and normative, this sees irrigation as an act, 'thing' or even a blueprint (e.g. a system, provision of water or act of watering). Here, irrigation science teaches normative technical and social knowledge. This is where staff and scientists are taught the 'proper' way of understanding soil, crops, water and farming, which then creates the extension services to ensure farmers properly undertake irrigation. The bias is towards the soil profile, field, farm and irrigation system but often less towards the river basin and other water-using sectors. This model is how irrigation has traditionally been taught, and, for example, can be seen in the FAO method for designing irrigation systems (FAO, 1999).
- In the second option, teaching builds knowledge services to deliver problem-solving to fit the situation and scale. With this option, irrigation is seen as a puzzle (e.g. dealing with water competition during a drought between farmers), often where other sectors urgently need water). Accordingly, irrigation and AWM science are taught as an ethos that imbues students to act as a service to support stakeholder knowledge and problem-solving across all scales—soil, field, farm, system, river basin and global. Thus, students are taught the science behind AWM but work as a team alongside farmers and other irrigation stakeholders to help solve problems across all scales. With this option, students are asked to question long-established practices (Lankford, 2004; Zoebel, 2002) and to tailor their solutions to the problems arising.

The authors of this paper believe the second option is the more desirable. This is because (a) it will be more flexible to unpack today's myriad water problems and (b) it responds to the many interests now focussed on irrigated agriculture, including the private sector.

7.3 | Getting the academy going—Big Bang or slowly?

Another critical question that could shape the long-term success of the academy is how to get it started. This part relates to the available funding and the scale of the vision for the academy. These two options describe why this is the case. In a Big Bang approach, a large amount of funding is needed to get the academy up and running relatively quickly and substantially to meet its capacity-building targets within a few years. On the other hand, in the absence of a large funding pot, a bootstrapping[4] pilot-testing approach starts with smaller amounts of funding which is utilised to conduct the initial pilot testing and growth of training.

The Pretoria stakeholder consultation decided both approaches had advantages. The Big Bang approach might take longer to get going (to find a willing funder) but could be more sustainable in the long-run. The pilot-testing bootstrapping approach could get going more easily but might struggle to hit the critical mass needed to be a game changer in AWM.

8 | CONCLUSIONS

A proposal to establish an academy to support capacity building in AWM, emphasising irrigation, was presented. This proposal aims to inform and facilitate ongoing discussions by funding and science bodies about the need for capacity building in AWM. Summarising, the objective of the WfF Academy would be to produce a new generation of highly skilled cross-disciplinary water professionals that build on the strengths and shoulders of previous generations. Graduates of the academy will (a) acquire new skills in understanding agricultural water and irrigation complexities from different perspectives and disciplines; (b) appreciate the unique systems nature of irrigation nested at different scales—field, farm, irrigation system, river basin, systems (water, energy, food, environment) and global; (c) recognise AWM systems are social as well as technical/technological; and (d) be capable of thinking beyond water. This also means seeing farmers and irrigators as people with knowledge and identities; they influence how agricultural water performs. This initiative should aim to have a multiplier effect. In other words, it should precipitate a growing interest in irrigation and agricultural water as a significant career pathway and encourage individuals worldwide to seek AWM and irrigation training.

[4]In management, the use of existing resources to grow a company is called 'bootstrapping'.

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The two co-authors declare they have no conflicts of interest regarding the authorship, submission and publication of this paper.

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Data availability and sharing not applicable - no new data generated. Data availability / sharing is not applicable to this article as no new data were created or analyzed in this study.

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