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Educating sanitation professionals: moving from STEM to specialist training in higher education in Malawi

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Abstract: *Achieving the United Nations Sustainable Development Goals (SDGs) requires effective changes in multiple sectors including education, economics, and health. Malawi faces challenges in attaining the SDGs in general, and specifically in the sanitation sector. This paper aims to describe the existing landscape within public universities in Malawi to build a framework for training a cadre of locally trained experts. This is achieved by reviewing science, technology, engineering, and mathematics (STEM) degree programmes and assessing the extent of inclusion of sanitation education. The historical compartmentalization of academic programmes has resulted in few programmes to build on. Deliberate investment is needed to build from the current STEM higher education landscape to an effective framework for training sanitation experts, especially female experts. For low-income countries such as Malawi, a cadre of ~17,600 locally trained sanitation experts may be needed, for which the current higher education landscape is not sufficient. Using the Centre of Excellence in Water and Sanitation at Mzuzu University in Malawi as a case study, this paper provides a model of sanitation education in low-income countries that: 1) provides an effective complementary contribution to delivering sanitation education; 2) links to overall SDGs, national policy, university goals, and localized needs; and 3) engages students, faculty, and communities in local research.*

Keywords: higher education, public health, sanitation, sub-Saharan Africa, sustainable development

Introduction

Achieving the United Nations Sustainable Development Goals (SDGs) requires effective changes in multiple sectors spanning education, economics, and health (United Nations, 2022). While these goals are sector-specific, they are interdependent

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and their attainment requires convergence. Effective sanitation can reduce health risks and promote productivity for communities and households in Malawi, Africa, but about one-third of households lack an improved toileting facility (Malawi Government, 2019; World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2021). This is related not only to specialist services but also to sanitation as a part of awareness and behaviour-change campaigns. However, action plans to build sanitation capacity in national policies and strategies require multi-pronged support underlying new African innovations (WSP-AFRICA, 2006; Malawi Government, 2019). To address this, multi-sector approaches require skilled engineers, well-trained practitioners, capable regulators, and a vibrant private sector to work in an enabling policy environment to offer affordable sanitation services while maintaining an economically viable business.

Malawi requires substantial investment in training institutions to improve sustainable shifts in the water, sanitation, and hygiene (WASH) sector (Luwe et al., 2021). However, internal capacities in sub-Saharan countries, such as Malawi, in science, technology, engineering, and mathematics (STEM) education is low (Mwamsamali and Mayo, 2014; Mbano and Nolan, 2017). While basic education attainment numbers remain low for both genders, more males than females have attended secondary school (Malawi Government, 2019). In Malawi, less than 0.5 per cent of the population has attended university (Malawi Government, 2019). A supportive environment for girls to enter a STEM higher education track is another gap that needs to be addressed concurrently (Mbano and Nolan, 2017).

Historically, specialists from other STEM backgrounds, such as civil and environmental engineering, would lead the sanitation sector as technical and engineering staff. With newer developmental challenges and dimensions in sanitation, such as faecal sludge and menstrual hygiene management, traditional engineering-based technical solutions may not support a multidisciplinary sanitation scope. Still, there are known gender gaps among technical and engineering staff in Malawi (Mwamsamali and Mayo, 2014); as a result, community-wide environmentally related health challenges are gendered. Creating this enabling environment presupposes the capacity to produce and sustain a critical mass of sanitation practitioners, which in turn depends on the capacity to train future sanitation specialists (Cavill and Saywell, 2009; Workman et al., 2021). Inclusive, gender-sensitive, and improved STEM education in higher education offers a key pathway for training a critical mass of sanitation experts.

In Malawi, as in many sub-Saharan African countries, behaviours around latrines are gendered, with women being responsible for the cleaning and management of household latrines. Sanitation for households in Malawi primarily consists of simple pit latrines (Malawi Government, 2019), a basic hole in the ground often surrounded by an enclosure made of local bricks, and either a grass or iron sheet roof. With increasing population density (Malawi Government, 2019), this technology is pushed beyond capacity by both high-volume usage (requiring routine pit emptying) and a lack of space for the construction of new pits, especially in urban areas. Thus, particularly, women and girls face health and safety risks as they are primarily seen as responsible for the management of household sanitation and require adequate infrastructure for menstrual hygiene.

Other issues, such as safe disposal of children's faeces, are also highly gendered. These challenges will require basic sanitation education at all levels of education and more investment in specialist training, especially among females.

The shortcomings of gender-inclusive trained specialists are recognized by the government of Malawi. The National Sanitation Policy acknowledges a countrywide gap in sanitation-related human capacity (Malawi Government, 2008). Furthermore, the National Education Policy asserts that quality, equitable, and accessible higher education should include both teaching and research (Malawi Government, 2013). Furthermore, the need for local research and effective dissemination of the findings is cited in the National Sanitation Policy (Malawi Government, 2008), National Water Policy (Malawi Government, 2005), and National Environmental Health Policy (Malawi Government, 2018), but they do not focus on working with universities for local solutions.

An improved and inclusive STEM and sanitation educational framework is a necessary precursor for women's involvement in decision-making, leading to other important health-seeking behaviours. This paper aims to review the existing STEM higher education landscape in public universities in Malawi to construct a conceptual framework for training a gender-equitable critical mass of future sanitation experts. It also critically reflects on the role of higher education institutions, building on the complementary experience within the framework of a Mzuzu University centre as a replicable model for capacity building of WASH research knowledge in low-income countries.

Materials and methods

2.1 Data

A list of public universities and degrees in Malawi, Africa, was obtained from publicly available Malawi Government National Council for Higher Education (NCHE) Accredited Institutions and Programmes (2020) records. While all six public universities offer some degree of basic coursework, each university has a distinct mandate and operates independently. Two of the accredited institutions, the Malawi College of Accountancy and Malawi Institute of Management, do not offer any STEM-related programmes. In 2021, the University of Malawi (UNIMA), the largest government institution of higher education in the country, was split into separate universities, namely the University of Malawi, Kamuzu University of Health Sciences (KUHeS), and Malawi University of Business and Applied Sciences (MUBAS), but this split was ongoing and thus not reflected at the time of data collection.

The authorship team further offered insights from their own first-hand experiences: data on the operational practices of the Centre of Excellence in Water and Sanitation (WATSAN Centre) were provided by RHH and BC.

Data analysis

The list of accredited universities and programmes was coded according to degree type (N = 325, total undergraduate and graduate-level programmes). Inclusion criteria for programmes deemed relevant for STEM higher education to build a

framework for training a cadre of gender-inclusive sanitation experts were: 1) any bachelor in science programme; 2) other bachelor programmes considered to be applicable based on their title (specifically, bachelor of civil engineering (water) (honours), bachelor of technical education (science), and bachelor of social science (gender studies)); and 3) graduate programmes (master's or doctoral level) based on a programme title in STEM, public health, or sanitation entrepreneurship. In total, 180 programmes were included. The number of degree programmes relevant to sanitation was based on the programme title, indicating it as a core focus.

Ethics

Data used in the analysis are available in public records.

Results and discussion

The opportunity for a gender-equitable critical mass of future sanitation experts

As of August 2020, accredited public higher education institutions offered a total of 325 study programmes. While there are several (N = 180) STEM-related degree programmes to support sanitation experts, only four of these have a core sanitation focus (Table 1). No university offers a four-year bachelor of science degree in sanitation. There are four sanitation graduate degree programmes (MPhil or PhD Applied Sciences in Environmental Sanitation at the Polytechnic, University of Malawi, and master's or PhD in Sanitation at Mzuzu University). Public universities' first year student admissions are coordinated at the national level by the NCHE. Graduate programmes have a decentralized admission process and Malawi does not have a graduate record examination or equivalent.

Historically, Malawi has imported the British higher education model, a highly selective system designed to accommodate few students, and has resisted localization (Holland, 2010). While some STEM-related programmes have coursework in sanitation (e.g. the bachelor degree in water resources management and development at Mzuzu University), the expansion of key concepts that address localized sanitation challenges is missing. Higher education curricula in traditional disciplines such as languages and arts are able to more universally be borrowed from western higher education models, whereas fields of studies such as emptying of pit latrines or menstrual hygiene management requires a local curriculum. The historical compartmentalization of higher education programmes in Malawi may have cut off innovative programmes dealing with localized problems and may be directly linked to the exclusion of sanitation in STEM-related academic programmes as emerging issues related to government priorities for policy intervention that have not yet caught up. Further, because of this historical framework, any modification to foster greater diversity in STEM undergraduate programmes is not realistic in the short term; thus, decentralized graduate programmes offer the greatest window for immediate admissions and curriculm changes. How the ongoing disbanding of the University of Malawi addresses the original specialization focus of each university should be followed for future research.

Table 1 Public institutions of higher education in Malawi, and number of science, technology, education, and mathematics (STEM), gender studies, and sanitation programmes

Name	*Training focus*	*Number of STEM or gender studies degree programmes*	*Number of core sanitation programmes*
College of Medicine, University of Malawi[1]	Training doctors and nurses	15	0
Kamuzu College of Nursing, University of Malawi[1]	Training nurses	22	0
The Polytechnic, University of Malawi[2]	Engineering, business, and applied sciences	32	2
Chancellor College, University of Malawi[3]	Social science, law, humanities, and education	32	0
Malawi University of Science and Technology (MUST)	Science and technology	9	0
Mzuzu University (MZUNI)	Teacher training, humanities, and health sciences	16	2
Lilongwe University of Agriculture and Natural Resources (LUANAR)	Agriculture, natural resources, environment, rural development, and human nutrition	54	0
Malawi College of Accountancy (MCA)	Accountancy	0	0
Malawi Institute of Management (MIM)	Business management	0	0

Notes: [1]Currently known as Kamuzu University of Health Sciences.
[2]Currently known as Malawi University of Business and Applied Sciences.
[3]Currently known as the University of Malawi.

The traditional 'development engineering' approach, i.e. the modification of infrastructure or equipment from high-income countries to address a gap in low-income countries, has not worked for sanitation in southern Africa, especially for poor communities (Muller, 2020; Workman et al., 2021). This has also been shown as a concern for humanitarian response engineers with a similar training challenge, where 'technical' qualifications require strong consideration of both proper training and experience (Reed and Fereday, 2016). The wide capacity gaps in the WASH sector include ineffective staffing (e.g. too few or too many untrained staff, staff with an inappropriate skill set, or unproductive staff), a lack of contextual awareness, and a one-size-fits-all approach to technology (Cavill and Saywell, 2009; Workman et al., 2021). However, recent global efforts with massive open online courses (MOOC) in sanitation, water, and solid waste for development are challenged by the under-representation of female students and primarily attract well-educated students, rather than increasing student diversity

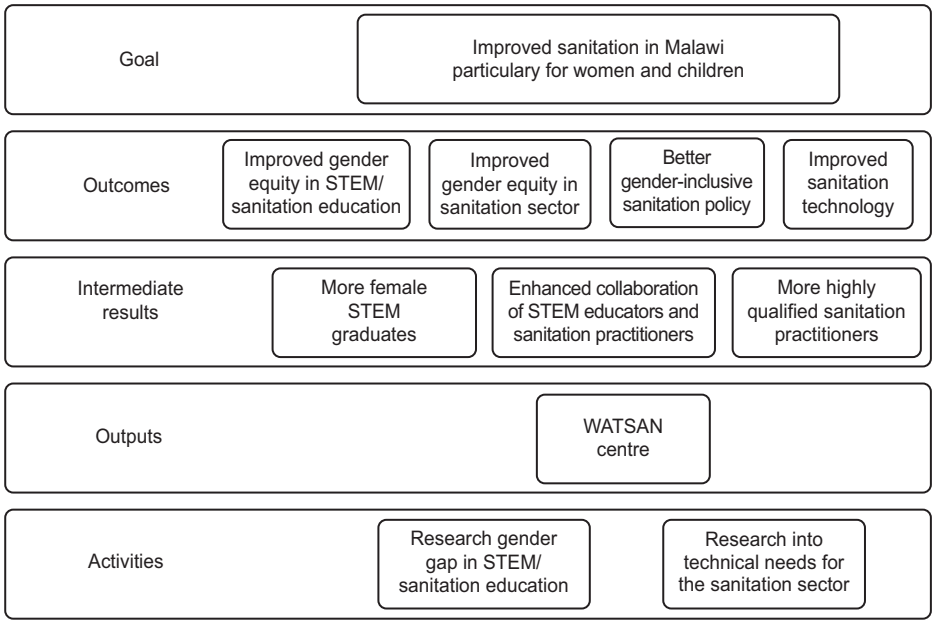

Figure 1 Logic model for the present research

(Suter and Lüthi, 2021). In Malawi, MOOCs are unlikely to play a positive role in the context of higher education because of the lack of accreditation by the NCHE, and access to online courses may be hindered because of poor internet connectivity or lack of computers among potential participants.

New policies, solutions, technologies, and gender-sensitive education initiatives should provide support to women and girls as future cadres of sanitation researchers, policymakers, nonprofit organization leaders, and business owners (Figure 1).

A replicable model for WASH research capacity building

Mzuzu University developed a model to promote sanitation education in low-income countries, an illustrative output under the umbrella of our logic model. While there are several higher education centres for the water sector throughout Africa, few sanitation-focused centres exist, with the most notable being the Water, Sanitation, and Hygiene Research and Development Centre at the University of KwaZulu-Natal, South Africa (Sindall et al., 2018).

The Centre of Excellence in Water and Sanitation (WATSAN Centre) at Mzuzu University was established in 2009 to fill the knowledge gap in water supply and sanitation based on practical and problem-oriented research within a narrow geographic area, mostly in the northern region of Malawi. It was started by a team of eight faculty members in the Department of Geography and was initially run by existing university staff members. In 2012, a full-time female manager (RHH)

was employed, and the centre was transferred to the Faculty of Environmental Sciences to allow greater flexibility for work across departments and faculties. The manager then had full reporting accountability and responsibility equal to a head of department.

In terms of a funding model, the WATSAN Centre is self-funded, which means that research is more often directed by funding agencies promoting development of relevant research programmes than university priorities. All research is contracted, with no staff paid by the university, and the WATSAN Centre is one of the top income-generators for the university. Finances run through university processes and pay 15 per cent overhead to the university, covering the cost of office space and access to university services. Additional building renovations for labs have been secured from within funded projects. At Mzuzu University, overall operations are controlled by a single bank account where the national government makes deposits; however, the WATSAN Centre has a dedicated bank account within the university financial system. This separate accounting practice allows for improved financial reconciliation and reporting, a common requirement for funding agencies, especially United Nations agency partners.

In a typical month, three to six project proposals are submitted by the WATSAN Centre, emphasizing the business side for continued operations. On a smaller scale, the WATSAN Centre has many similarities in self-funded operations within the higher education context to the Water, Sanitation, and Hygiene Research and Development Centre (Sindall et al., 2018); such centres also requires leadership that has recognized higher education teaching, research, and outreach in sanitation, as well as junior researcher mentorship.

One of the major projects to build a framework for training a cadre of sanitation experts in Malawi was undertaken when, in August 2013, the WATSAN Centre was awarded a USD$199,000 contract titled 'Solutions for pit desludging and subsequent sludge management in low-income urban areas in Malawi' by the Water Research Commission (South Africa) through a grant from the Bill and Melinda Gates Foundation. The contract provided an impetus for the WATSAN Centre to focus on sanitation in higher education, specifically at the graduate school level. Instead of using project-embedded scholarship funds to send Malawian students to study outside Malawi, Mzuzu University started its own master's and PhD programmes for students focused on producing local knowledge products in the sanitation field, specifically a variety of new, innovative, pit latrine emptying tools.

The academic programme was administered by the Department of Water Resources Management and Development, and was adopted from an existing university master's and PhD in theology programme, which had historically focused on indigenously developed curriculum and publication of books to fill a local knowledge gap in the theology field. Within the sub-Saharan region context, there is advocacy for theology training to remain in higher education to help local communities (Buitendag and Simut, 2017), and such pedagogical localization was thought to be applicable to, and critical for, training a cadre of sanitation experts. A specific example of the local sanitation focus includes field research data collection, where several Mzuzu University students were paired with private sector pit latrine emptiers

to work within communities near the university campus. Global partnerships have also been key in this framework, allowing Mzuzu University student networking within the wider global sanitation sector. North Carolina State University (USA), which has a track record of higher education sanitation programmes, served as a host site for the exchange visit of a Mzuzu University master's student for testing and troubleshooting innovative sanitation equipment, and North Carolina State University co-published peer-reviewed publications as outputs of the new academic programme. This is similar to the success of the Water, Sanitation, and Hygiene Research and Development Centre, where there is a strong focus on global partnership together with action reflection research within eThekwini communities (Sindall et al., 2018).

The new Mzuzu University academic programme embedded the sanitation master's and PhD students into the existing operations of the WATSAN Centre. While students were being empowered and educated as the next generation of sanitation professionals, they were also a source of relatively lower-cost research labour for sanitation projects, allowing students ample field experience beyond 'technical' qualifications. From 2015 to 2020, the WATSAN Centre had 27 peer-reviewed sanitation-related publications, which covered study sites throughout Malawi. Of these 27, 11 had a Mzuzu University student as the first author, six had a foreign first author, and 10 had a female first author. Beyond knowledge documentation through peer-reviewed publications, a gap remains in textbooks by and for sub-Saharan African academic higher education institutions used in sanitation coursework. Additional accomplishments include local innovations under the WATSAN Centre such as the low-cost no-cement corbelled latrine for rural households, the low-cost no-cement sandbag latrine for rural households in areas with sandy soil, and the pedal-powered gulper modification for emptying pit latrines. However, as of 2021, though there have been several graduates of the programme, only one female with a master's degree in sanitation has graduated from Mzuzu University. Mzuzu University graduates of the sanitation programme have gone on to work for the Ministry of Health, non-governmental organizations, and the private sector.

Although this is a strong start to developing future sanitation experts, a critique by the Mzuzu University administration of the WATSAN Centre is that it does not focus enough on bringing in female students or linking STEM and gender studies. This gender inequality may be the result of a significant lack of higher education role models for female students, with only one female faculty member at Mzuzu University with sanitation expertise. Research in the USA indicates that representation among faculty is important for student success (Borman et al., 2010). Further, sanitation leadership roles supporting achieving universal access to sanitation in communities are under-represented by black, indigenous, and other people of colour, and especially women, and additionally tend to over rely on individuals educated in high-income countries (Worsham et al. 2021). The most recent Mzuzu University sanitation-related faculty hire was in 2015, showing that changes in gender equity take time in an academic setting. While front-line community health workers in Malawi do not have a higher education requirement,

due to the expanded multidisciplinary approach needed for sanitation professionals we advocate the need for an additional level of training. For comparison, community health workers have been set at a ratio of one per 1,000 people (Malawi Government, 2017); a similar assertion can be made that specialist sanitation education is needed to attain SDG 6 and, based on the current census, a cadre of 17,563 locally trained sanitation experts may be needed, for which the current landscape in higher education is not sufficient. Specialists trained in sanitation through higher education should be multidisciplinary to include the sanitation value chain, fundamental physical/chemical/biological processes in treatment, public health and epidemiology, working with local communities, and local solutions. Prioritization needs to be both for rural and urban communities, as some issues, such as reducing challenges in menstrual hygiene management, are not location-specific. Future research is needed to quantify the extent of the under-representation of women sanitation specialists in Malawi, as well as how many women make up undergraduate STEM majors and STEM faculty members across public universities.

To further contribute to closing the gap between sanitation research and outreach, the WATSAN Centre initiated an annual STEM camp for local girls from the Mzuzu area aged 5–18, serving over 700 girls in six years. These efforts need to continue and be followed by campaigns to encourage women and girls to pursue STEM and sanitation education. To support the entry of female students, bridging programmes in STEM as a pre-entry course to university have been trialled on a limited basis in Malawi with some success (Mbano and Nolan, 2017). More role models may help girls and young women thrive and feel that they are up to the task of designing and implementing locally sustainable sanitation solutions.

Conclusion

Public higher education institutions are key capacity-building organizations in low-income countries. This critical discussion provides the first extended analysis of sanitation training in higher education in Malawi. The present study suggests that there is an inadequate gender-sensitive sanitation-specific specialist education, which is required to attain SDG 6. Approximately 17,600 locally trained sanitation experts may be needed, which will require many more higher education trained experts than the current landscape of limited local specialist academic programme offerings. In Malawi, a primary barrier to higher education training for solving local sanitation problems is the historical institutional compartmentalization of academic programmes, resulting in few options that are customized with a local curriculum. The gender gap in sanitation education is also a reflection of a wider STEM problem, and while sanitation is likely not a special case, it is certainly impacted. A replicable model to complementarily promote sanitation education within a narrow geographic area is presented, which also provides lessons on how to identify research and education programmes, align with university academic programmes, engage with communities, address the government development agenda, and produce knowledge products. Following the eThekwini partnership

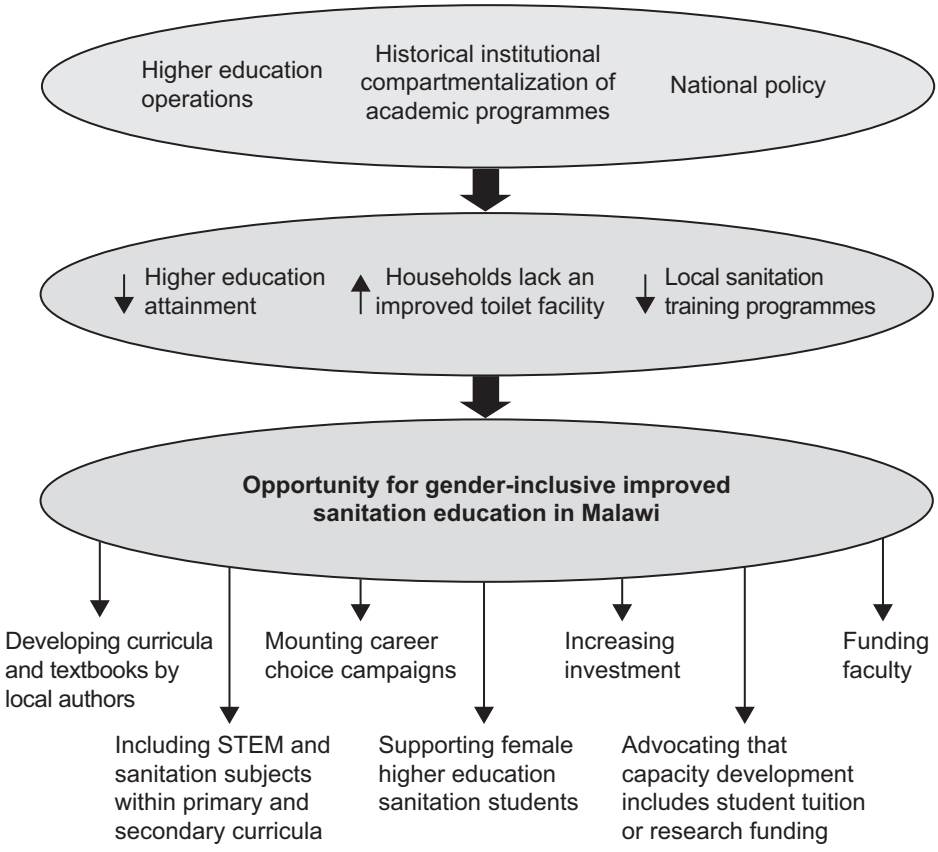

Figure 2 Visual presentation of moving from science, technology, engineering, and mathematics (STEM) academic programmes to an effective framework for training sanitation experts within higher education

model and working with the local government and sanitation service providers is also important for Malawi.

The gender gap in producing graduates and hiring faculty is large and persisting. Deliberate investment is needed to support local higher education centres in sub-Saharan Africa, building from current STEM education to a more effective framework for training a critical mass of talented local sanitation experts to spur sustainable development.

By connecting our logic model with lessons from the WATSAN Centre, we make the following recommendations (Figure 2):

- Higher education curricula and textbooks should be developed by local authors; these should be multidisciplinary and include the sanitation value chain, fundamental physical/chemical/biological processes in treatment, public health and epidemiology, working with local communities, and promoting local solutions.

- STEM and sanitation subjects should be included in the basic primary and secondary education curricula to provide students with a wide range of choices when entering higher education.
- Student awareness about various sanitation educational programmes should be generated through campaigns, providing information and guidance about choosing their careers. Depiction of local female sanitation professionals as role models should be encouraged.
- Female students in higher education should be supported to undertake research related to sanitation, sometimes together with students from external institutions. Integration with other departments should be promoted to give a more rounded approach to sanitation (e.g. agriculture for end-use and disposal, business administration for sanitation service providers, social science for user perceptions, epidemiology).
- A partnership model for higher education should be followed to increase investment in sanitation education and research by the government, funding agencies, and the private sector.
- Increased funding agency support for capacity development should be advocated, including supporting student bridging programmes, tuition, or research funding.
- Faculty should be funded to provide consistent leadership in sanitation education, such as centre managers.

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