No. 26 | **Sandec** Department of Sanitation, Water and Solid Waste for Development
08/25

sandec news

eawag
aquatic research

Content

Two new research groups have started this year in Sandec.

Photo: Linda Strande.

Welcome to the 26th issue of Sandec News, marking my first year as Head of the Sandec Department. Since Sandec's inception over 30 years ago, we have been committed to fulfilling the human right to safe sanitation and clean drinking water. Our work has contributed to practical solutions and informed policy decisions on sanitation, water, and solid waste management, with the aim to improve access to services for vulnerable populations. However, as we face gaps in achieving Sustainable Development Goal 6 by 2030, climate change poses an additional threat to equitable access to services.

Water is at the core of the climate crisis, with precipitous and intense changes in climate patterns negatively impacting the environment, infrastructure, and health. At Eawag, we are committed to a global perspective on climate change adaptation to assist in the mitigation of these threats. In the past year, Eawag had an interdisciplinary cluster hire of tenure track researchers with research expertise on climate in relation to health, biodiversity, and resource cycles.

The result has made for an exciting year at Sandec, with the formation of two new research groups. It is with great pleasure that I can introduce Dr. George Wainaina, who will be leading the Organisational Dynamics and Climate Adaptation Group (See p. 57), and Dr. Karin Gallandat (See p. 58), who will be leading the Public Health, Infrastructure and Climate Group. Karin's expertise includes how water and sanitation infrastructure in humanitarian and resource limited settings can provide climate-resilient services in protection of human health. George's research interests include the dynamic capabilities of water, sanitation, and solid waste organisations in the uptake of climate resilient solutions.

Karin and George will be conducting inter- and transdisciplinary research together with all the research groups in Sandec. In addition to their forthcoming research, other Sandec groups are also making strides in climate resilient sanitation, water, and solid waste management.

In Brazil, we are investigating systemic challenges in water governance in the watershed of Palmas, the capital of Tocantins, where water supply and water quality management have been increasingly affected by changes in precipitation patterns and drought. This analysis identified challenges and potential mitigation measures in water service management (See pp. 48–49).

Vermifiltration of wastewater is being used as a nature-based treatment method that is low-cost, requires minimal energy, and climate resilient. It is already showing potential in Switzerland, India, and other countries worldwide (See p. 22).

In Uganda, we are monitoring pathogens in drainage water, with the aim to develop frameworks for environmental surveillance of public health in urban areas with non-sewered sanitation (See p. 28).

We look forward to an exciting year ahead and welcome your feedback on our work!

Best regards – **Linda Strande, Head of Sandec**

Photo by Paul Donahue.


VOLVO
BOMAG

Solid Waste Management

Solid waste management (SWM) is one of the key environmental challenges associated with urbanisation. In collaboration with local partners, Sandec's SWM research focuses on developing applied and context-appropriate solutions that safeguard human health and the environment, while promoting principles of the circular economy. Special emphasis is placed on:

- Exploring treatment and management approaches for biodegradable (organic) solid waste and applying suitable technologies to produce valuable end-products – thereby, creating incentives and business opportunities within the waste management sector.
- Providing decision-makers with practical tools to implement sustainable and integrated SWM systems. This includes support in situation analysis and monitoring, assessment of strategic alternatives for long-term planning, and designing financial mechanisms for cost recovery.
- Conducting research to better understand the behavioural drivers and barriers influencing waste segregation at source, with the aim of designing effective interventions that promote long-term changes in waste-related practices.

Photo: Solid waste landfill disposal in Cape Town, South Africa.

Photo by Dorian Tosi Robinson.

Rural Solid Waste Management in Latin America and the Caribbean

The SIRWASH programme assessed rural solid waste management services in nine countries, and identified the need for an in-depth rural perspective on tailored solid waste improvement solutions. Adeline Mertenat[1], Dorian Tosi Robinson[1], Martín del Castillo[2], Carlos Garcia[2], Sergio Morales[2], Mariana Daza[2], Nexan Herrera[2], Claudia Calderon[2], Christian Zurbrügg[1]

Introduction

Although information on solid waste management (SWM) exists for the Latin American and the Caribbean region, data specific to rural areas is limited. The sector lacks the detailed indicators and comprehensive data to fully understand rural SWM needs, and to develop effective plans for improving quality and efficiency. A diagnostic study of SWM in rural areas of nine countries in Latin America and the Caribbean (LAC) was conducted between April 2023 and March 2024 in Peru, Bolivia, Haiti, Colombia, Honduras, Guatemala, Belize, El Salvador, and the Dominican Republic as part of the SIRWASH programme (See Info Box).

The study focused on rural population centres with fewer than 2,000 inhabitants, excluding dispersed rural areas. Secondary data collected by SWM experts in the countries highlight rural SWM trends in the region. This article summarises key findings from the final report prepared by HELVETAS Swiss Intercooperation and Eawag for the Inter-American Development Bank (IADB) [1].

Methodology

The project involved an analysis of secondary sources from the nine LAC countries. This included documents from sectoral authorities, universities, civil society organisations, and cooperation agencies, and information from key stakeholder interviews done by the local consortium partners. The secondary information was reviewed and data compiled into a structured database, and is the basis of the Country Diagnosis reports. These cover such aspects as solid waste generation, planning, regulations, budgets, and costs, as well as environmental education, and the development level of services, including stages of solid waste valorisation.

Governance aspects

Over the past decade, all nine studied countries have made significant progress in establishing SWM standards and policies (Figure 1). Although regulations in Central America and the Caribbean have mainly focused on environmental issues, SWM aspects are being now more comprehensively addressed. Honduras and Guatemala led the way in legislative development, while El Salvador recently updated its regulations. Today, all nine countries have a regulatory framework for Integrated Solid Waste Management (ISWM), which sets broad policies and assigns responsibilities at central and local levels. In some cases, technical guidelines supplement the regulations, but these often focus on urban services – for example, in Bolivia.

No specific standards exist for rural SWM. Although sector plans in the Dominican Republic and Guatemala, along with new regulations in Peru and El Salvador, mention concentrated rural areas, they lack detailed, rural-specific measures, limiting their practical application. Legislative SWM responsibilities rarely distinguish between urban and rural areas, only El Salvador clearly defines roles for both. Belize stands out with well-defined financing and public-private partnerships for rural waste management.

Although municipal agencies exist that are responsible for water and sanitation, SWM is not integrated with them. This limits coordination and effectiveness. Adjusting institutional structures to include dedicated SWM units could improve management and resource use.

In addition, strategic planning often overlooks the unique needs of rural areas, which are comprised of dispersed populations, limited infrastructure, and local cultural practices. These areas require solutions that consider rural challenges and opportunities to improve service delivery and sustainability. This is another reason why rural waste management systems are frequently underdeveloped.

In most countries, rural SWM continues to be neglected, and SWM services, even in urban and peri-urban areas, remain weak, particularly in terms of financing and means to effectively address informal waste practices.

Technical aspects

In the nine countries, the average urban waste generation is around 0.7 kg per person per day, while rural areas generate a slightly lesser amount – about 0.46 kg per person per day. Although waste composition varies between countries, 60 % of the waste on average is made up of recyclables or organics (ranging from 39 % to 85 %), highlighting the strong potential for recovery.

Waste collection coverage in rural areas remains low – generally under 20 % – due to dispersed settlements and difficult road access. El Salvador and the Dominican Republic are exceptions, thanks to their smaller size and better road infrastructure. Where formal collection services are lacking, rural populations often manage waste themselves (see Figure 2). Harmful practices, such as open dumping and burning, are particularly widespread in Peru, Bolivia, and Guatemala.

Although some residents engage in informal recovery, e.g. composting or animal feed, these practices tend to be unsafe, as waste is rarely sorted. Contaminants are often still in the waste, posing risks to human and animal health. Other examples of unsafe behaviours are the reuse of dirty containers or open burning of waste to extract metals and/or reduce volume.

Conclusion and outlook

Rural areas are not prioritised in SWM services. This results in the lack of available data and information about them, limiting the possibility to provide country-specific recommendations.

Although low collection coverage rates could represent a major challenge, our analysis showed a predominance of organic materials in the waste, showing the potential of on-site treatment and recovery. This also highlights the need to train rural households on safe organic waste treatment practices. They could then directly benefit from

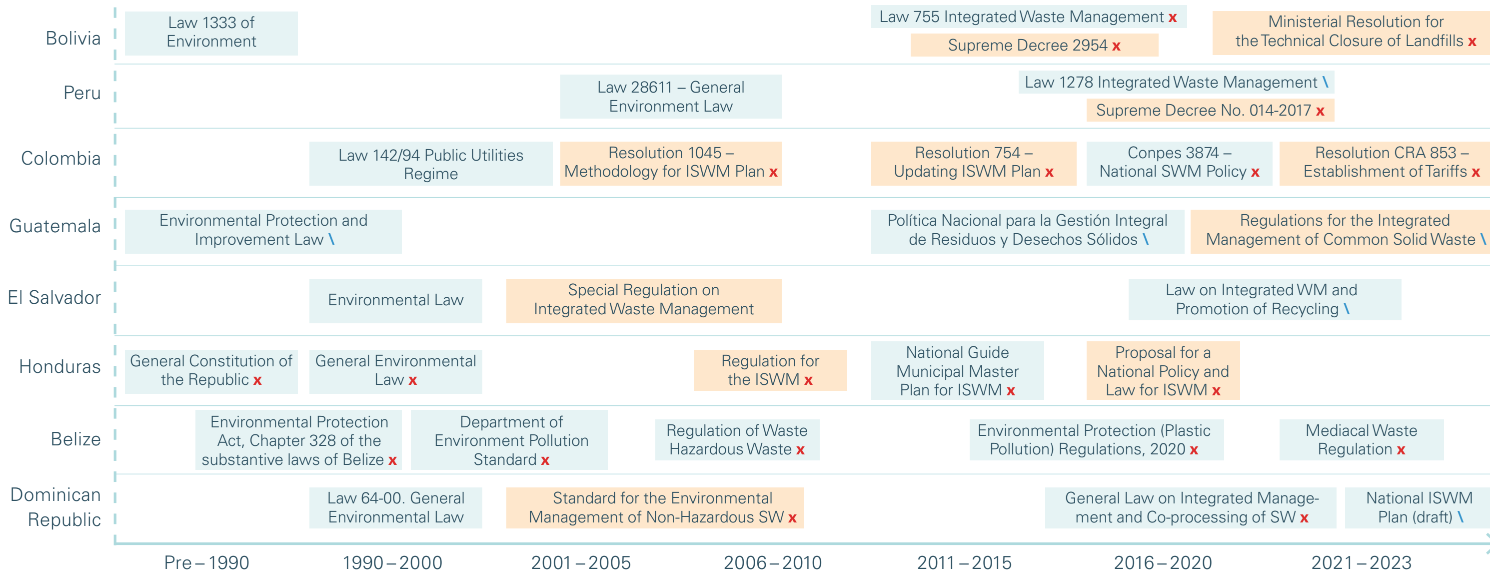


Figure 1: Chronology of the normative and regulatory development on SWM (only countries with available data).

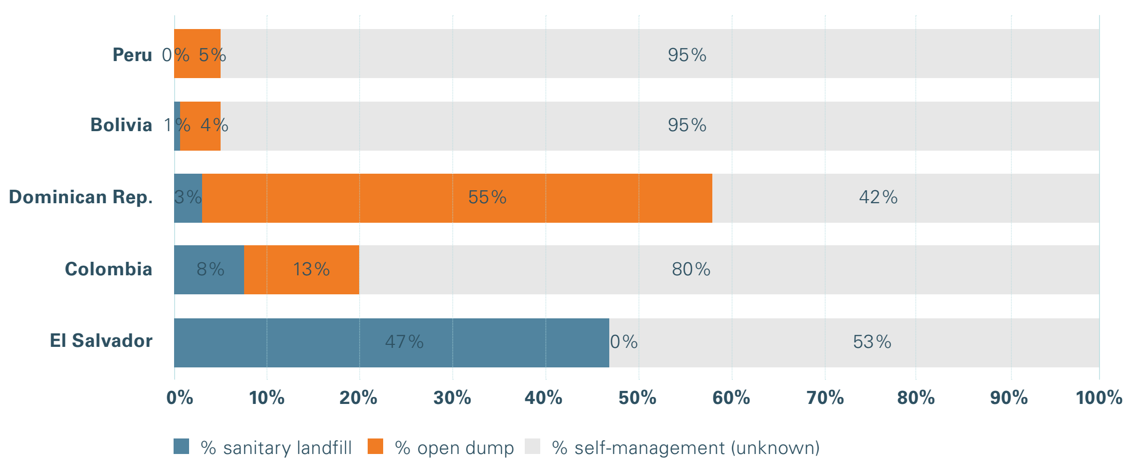


Figure 2: Final disposal in rural areas per country (only countries with available data).

improved self-management practices, as well as raise awareness about unsafe practices.

From a governance perspective, the study identified three key areas for improvement. First, the need to adapt norms and regulations to better reflect a rural perspective. Second, adjustment of institutional structures to explicitly include dedicated SWM units within agencies responsible for water and sanitation. Finally, the study calls for clear and differentiated strategic planning of services for rural areas, ensuring that rural specificities, opportunities, challenges, and local experiences and practices are fully considered when making policies and recommending solutions.

Pooled solutions can be a viable alternative for joint final disposal, but its success depends heavily on distance and accessibility. In El Salvador, this works well due to the country's small size and good road connections. In contrast, this approach faces limitations in Bolivia, Peru, Guatemala, and Honduras. In these countries, the emphasis could be on community-based solutions rather than traditional urban or peri-urban collection, transport, and disposal methods. This community focus may be the key method to adopt when addressing rural service limitations. Next steps could include exploring community-based models, with IADB and Helvetas as potential partners for future rural solid waste management efforts. •

References

[1] HELVETAS Swiss Intercooperation, Eawag, *'ESTADO DEL ARTE' en la prestación de servicios de gestión integral de residuos sólidos a nivel rural en latinoamérica y el caribe, (Switzerland, 2024).*

[1] Eawag / Sandec, Switzerland
[2] HELVETAS Swiss Intercooperation, Switzerland

The **Sustainable and Innovative Rural Water, Sanitation, and Hygiene (SIRWASH)** program, supported by the Swiss Agency for Development and Cooperation (SDC), aligns with the UN 2030 Agenda by promoting policy, innovation, and knowledge sharing. It aims to strengthen capacities for delivering sustainable, quality services to rural communities, with a focus on vulnerable populations. Implemented by the Inter-American Development Bank (IDB) in Bolivia, Brazil, Haiti, and Peru, the program addresses rural service gaps in acceptability, affordability, and sustainability.

Piloting Organic Waste Composting in Tuy Hòa City, Vietnam

Tuy Hòa City has successfully piloted new systems for collecting and composting organic waste, as well as home composting, marking a significant step toward improved waste management.

Dorian Tosi Robinson[1], Laura Nelly Velásquez[1], Caroline Huwiler[2], Vincent Decroocq[2], Tien Nguyen Thi Hanh[3], Christian Zurbrügg[1]

Vincent Decroocq

Photo 1: Pilot composting plant in Tuy Hoa City.

Tien Nguyen Thi Hanh

Photo 2: Home composting bin.

Why the project was needed

Vietnam's rapid urbanisation has sharply increased solid waste generation, straining infrastructure and causing pollution. Tuy Hoa City exemplifies these challenges; while most waste is collected and landfilled, limited resource recovery is causing the controlled landfills to fill up quickly. Notably, 56.1 % of the waste reaching the sites is organic, underscoring the need for separate treatment. Additionally, Vietnam's Environmental Protection Law 2020 requires all households and businesses to segregate waste at the source by 1 January 2025 – necessitating the dedicated management of organic waste and other fractions.

What was implemented

A pilot system for sorting at source and separately collecting organic waste was implemented as part of the REPIC-funded 'Phú Yên for Zero Waste' initiative. The Amplifying Waste Recovery Solutions (AWARE) project also introduced home composting in its waste segregation and behaviour change campaign. The former focused on waste segregation and composting organics from a food market and 150 households from Ward 7 (300 kg / day). 200 market vendors and 150 residents received training and sorting bins to segregate the waste at source. A dedicated composting facility (Photo 1) was constructed near the current landfill and the local waste management staff was trained to operate it. AWARE also organised trainings for 260 households in Ward 7 and Hoa Kien communes; 90 participants received home composting bins (Photo 2).

Building momentum: Overcoming barriers to scalable organic waste composting

Ensuring segregation at source was a major challenge. Sustaining market vendors, managers, and households' participation required ongoing education and incentives. Collecting and treating the segregated organics was another challenge. Although the 11-month pilot was successful, it was suspended due to lack of incentives, showing the need for consistent funding and institutional support, and a perception shift of waste as a resource. Despite these obstacles, it demonstrated that treating organics separately is possible and high-quality compost was produced. Most importantly, it provided evidence to the local waste management company and government on how to prepare for effective implementation of the new Law on Environmental Protection. Community engagement in household level composting was strong. Hundreds were trained in source segregation, and increasing demand for household compost bins reflected clear local interest in scaling-up composting.

Looking ahead

Today, Tuy Hòa City is taking significant steps to improve its waste management system. Thanks to extensive stakeholder consultations, the city is finalising a comprehensive plan that strongly emphasises separated collection and enhanced composting. Securing long-term agreements with the Provincial Government and its financial support will be crucial to scale up and ensure the sustainability of separate organic waste management. To address the urgent need for landfill alternatives, the authorities consider constructing a new waste treatment facility that combines an incinerator and a large-scale composting plant to process 240 tons of waste per day. •

[1] Eawag / Sandec, Switzerland
[2] Institute for Development, Environment and Energy (IDE-E), Switzerland
[3] Phenikaa University, Vietnam

Funding: REPIC, Swiss Agency for Development and Cooperation (SDC), Swiss National Science Foundation (SNF), and National Foundation for Science & Technology Development (NAFOSTED)

Partners: Green Hub, Vietnam

More information: https://www.eawag.ch/en/department/sandec/projects/amplifying-waste-recovery-solutions-towards-a-circular-society-aware/
https://www.repic.ch/en/ide-e-vietnam/
https://www.ide-e.org/phu-yen-zero-waste

Contact: christian.zurbruegg@eawag.ch, dorian.torirobinson@eawag.ch, laura.velasquez@eawag.ch

The Compendium of Solid Waste Management in Humanitarian Contexts

The *Compendium of Solid Waste Management in Humanitarian Contexts* is a comprehensive and structured manual and planning guide. It provides a systematic overview of appropriate technologies and approaches for solid waste management in humanitarian contexts. Adeline Mertenat[1], Dorian Tosi Robinson[1], Sara Ubbiali[1], Christian Zurbrügg[1]

Introducing a new resource for solid waste management in humanitarian contexts

Solid Waste Management (SWM) plays a critical role in protecting public health and the environment in crisis settings, but remains commonly overlooked in humanitarian response. The *Compendium of Solid Waste Management in Humanitarian Contexts* (Figure) addresses this gap by providing a comprehensive overview of SWM approaches and technologies tailored for humanitarian needs. As part of the WASH in Emergencies series, this resource equips practitioners with the tools to plan, implement, and adapt context-specific SWM interventions across emergency, stabilisation, and recovery phases. Crucially, it also serves as a bridge to post-emergency recovery and development efforts, promoting continuity and resilience in affected communities.

Who is the Compendium for?

The compendium is intended for WASH professionals and decision-makers engaged in humanitarian operations, including staff from governmental agencies, non-governmental organisations (NGOs), international organisations, and multilateral institutions. It also serves a broader network of users – from academic institutions and training bodies to private sector actors and donors that support or influence SWM in emergencies. Additionally, it is relevant to professionals working in intersecting sectors, such as Health, Shelter, Logistics, and Camp Coordination and Camp Management (CCCM), where solid waste considerations are increasingly recognised as essential for coordinated, cross-sectoral response.

Structure and content of the Compendium

Organised in a practitioner-friendly format, the Compendium presents a structured overview of SWM components – from collection and transport to treatment and final disposal – along with planning approaches and cross-cutting themes. It offers clear, concise descriptions of technologies and decision-making tools that support context-adapted solutions for rural, urban, and camp-based settings. Drawing on field experience, sector consensus, and up-to-date evidence, it encourages informed choices, promotes a shared terminology, and integrates SWM more firmly into the wider humanitarian-development-peace (HDP) nexus.

Looking forward

By embedding SWM into humanitarian WASH from the outset, the Compendium supports efforts to improve public health outcomes, environmental protection, and community well-being over both the short and long term. In doing so, it contributes to more resilient and sustainable responses. This publication invites practitioners to adopt a more integrated and forward-looking approach to SWM – one that supports immediate needs, while laying the groundwork for long-term recovery and development. •

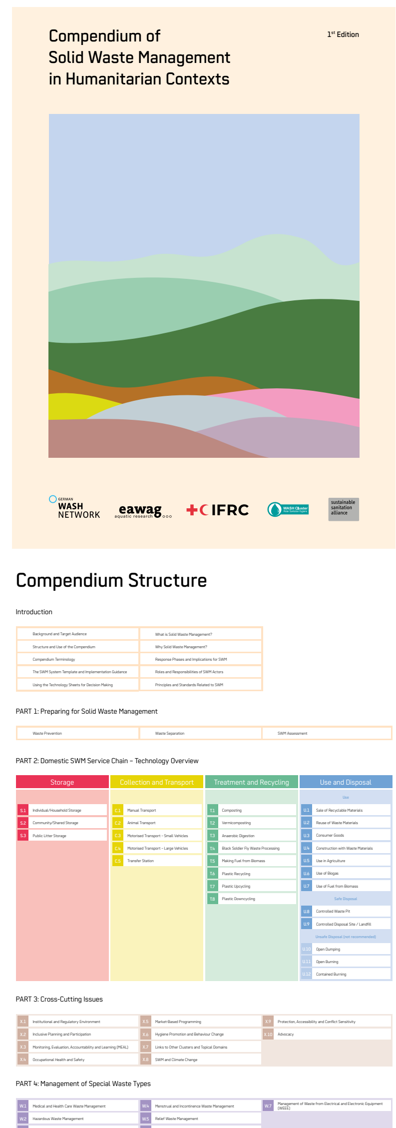


Figure: Cover page and structure of the new *Compendium of Solid Waste Management in Humanitarian Contexts.*

[1] Eawag / Sandec, Switzerland

Funding: German Federal Foreign Office and Swiss Agency for Development and Cooperation (SDC)

Partners: UNHCR, Geneva Technical Hub

Find the publication: emergency-wash.org

More information: eawag.ch/en/department/sandec/projects/wash-in-humanitarian-contexts

Acknowledgement: The Compendium authors team: Lorenz Ewers (arche noVa), Robert Gensch (GTO), Sarah Hayman (Swedish Red Cross), Manuel Krähenbühl (SHA), Marta Kucharski (WFP/Logistics Cluster), Alexandra Machado (IFRC), Adeline Mertenat (Eawag), Dorian Tosi Robinson (Eawag), Farah Salem (IFRC), Sara Ubbiali (Eawag), Christian Zurbrügg (Eawag)

Contact: christian.zurbruegg@eawag.ch, dorian.torirobinson@eawag.ch, sara.ubbiali@eawag.ch

Policies, Power, and Potential: Insect Farming in Malawi

A policy brief is in production, calling for targeted policy action to promote Black Soldier Fly farming in Malawi. This climate-smart solution would assist in preventing food insecurity and livestock feed shortages and improve waste management. Daniela A. Peguero[1], Frank Mnthambala[2], Christian Zurbrügg[1]

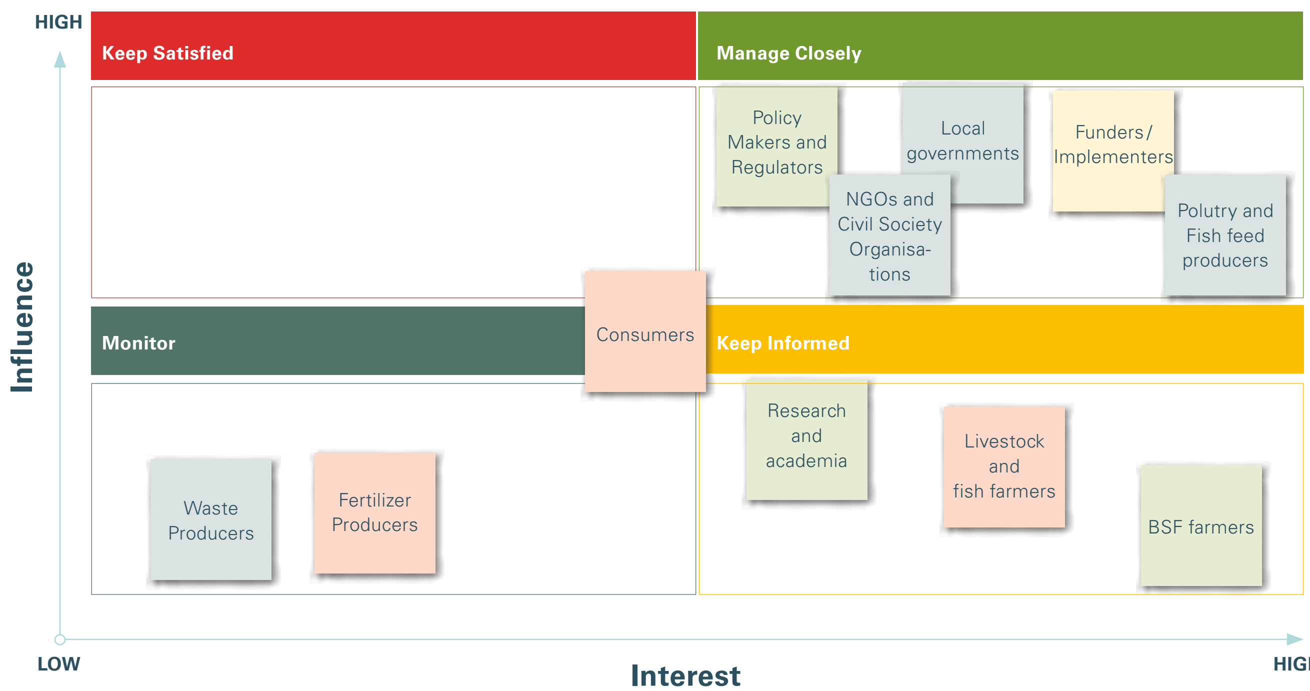


Figure: Stakeholder mapping of the actors involved in BSF farming.

Background

Malawi is facing growing pressures from food insecurity, poverty, and poor waste management. Organic waste comprises up to 85 % of all municipal solid waste, but is a largely untapped resource, even as the cost of inorganic fertilizers and livestock feed rises. A promising solution is the Black Soldier Fly Larvae (BSFL) that transform organic waste into nutrient-rich fertilizer and high-protein feed for livestock.

Insect farming addresses two pressing challenges: organic waste treatment and food insecurity. BSFL, specifically, can convert organic waste into biomass with up to 65 % protein (dry weight), while frass (the residual waste mixed with excreta of larvae) is a nutrient rich organic fertilizer. Evidence from Kenya show that BSFL farming can increase smallholder incomes by 20 %, while processing over 50,000 tons of waste annually [1]. Can this be replicated in Malawi?

The Sustainable Waste Based Insect Farming Technologies (SWIFT) project is piloting BSFL farming in Malawi as a dual-purpose solution: to create economic opportunities and address critical environmental challenges. SWIFT research is looking at understanding and creating an enabling environment for insect farming. This involves assessing the legislative, institutional, and financial conditions necessary for the sector to thrive through tools, such as community engagement, governance assessment, and innovation in financing models. As part of this effort, stakeholder analysis and policy mapping were conducted to identify the key actors and existing regulatory frameworks that either support or restrict the growth of insect farming in Malawi. This work lays the groundwork for informed policy interventions.

Methodology

The analysis used a mixed methods approach to assess the policy and stakeholder landscape for insect farming in Malawi. The methods included desk reviews of relevant policies and stakeholder consultations. Over 30 semi-structured interviews were conducted with stakeholders from government ministries, non-governmental organisations (NGOs), development partners, academia, and the private sector. These interviews offered diverse insights into policy gaps, institutional roles, and stakeholder influence.

Policy gaps and opportunities

Although Malawi has supportive policies in place for waste management and agricultural development, none explicitly mention insect farming (Table). This presents a barrier to establishing standards, securing investments, and creating awareness among government bodies and producers for this sector. Our findings highlight the need to revise and expand existing policies in Malawi to formally incorporate insect farming as a strategic component of its waste management, agriculture, and livestock sectors.

Policy	Policy Goal	Impact on insect farming
National Waste Management Strategy (2019–2023):	*Improves waste collection and promotes responsible waste treatment*	**Supportive:** recognises biological waste treatment
Local Government Act (1988):	*Enables local councils to manage public services, including waste management*	**Partially restrictive:** may limit if perceived as public health or environmental risk
Environmental Management (Waste Management and Sanitation) Regulations (2008):	*Regulates handling, storage, and disposal of waste for environmental protection*	**Neutral:** recognises importance of waste segregation
The National Livestock Development Policy (2021–2026):	*Promotes sustainable livestock farming and improvement of feed production*	**Neutral:** does not explicitly identify insects as livestock feed source
National Agriculture Policy (NAP) 2016:	*Drives sustainable agricultural transformation and enhancement of soil fertility*	**Supportive:** insect farming can be used for organic fertilizer generation
National Fertilizer Policy (2021):	*Supports production and use of high-quality organic and bio-fertilizers*	**Supportive:** aligns with the use of insect-based frass as fertilizer input

Table: Key policy insights and implications for insect farming.

Stakeholder dynamics: Power, influence, and awareness gaps

Stakeholder mapping results show that high-interest actors (e.g. farmers or researchers) lack influence, while high-influence stakeholders (e.g. government ministries) remain unaware of Black Soldier Fly (BSF) farming's potential despite their interest in it (Figure). This imbalance highlights the need for targeted capacity-building and policy engagement across all stakeholder levels.

Key findings include:

- **Government ministries** have regulatory authority with much influence and interest, but limited understanding of insect farming.
- **Local governments** are central to waste management and are highly interested with influence, but lack technical capacity to support insect farming initiatives.
- **NGOs and civil society organisations** show high interest and potential for scaling-up pilot projects.
- **Private sector actors** are interested, but held back by unclear policies.
- **Farmers and end-users** are motivated to adopt BSFL products, but need demonstrations and evidence of affordability, and have limited influence.
- **Waste producers** have low interest and influence in BSFL farming due to the perception that waste disposal is someone else's responsibility.
- **Consumers** are potentially influential in shaping market dynamics and acceptance, but currently passive in engagement. Safety concerns affect their interest.

Financing landscape: Bridging the gap

Insect farming in Malawi remains underfunded due to its novelty and limited public awareness. While international donors (e.g. FAO, UNDP, and UNHCR) offer grants, local financing options are scarce. The National Economic Empower Fund (NEEF) and commercial banks often require collateral for loans, and do not recognise insect farming as a formal agri-business. The absence of regulation further limits credit access. Policy reforms can bridge this financing gap by recognising insect farming as a viable sector and developing tailored financial products.

Conclusion and key recommendations

BSFL farming offers Malawi a sustainable solution to organic waste management and an alternative protein source for livestock feed. However, to scale its impact, the sector should be supported through government policies, financing, and institutional capacity.

The aim of our policy brief will be to recommend:

- **Policy and regulatory framework:** Establish specific policies and safety standards to formalise BSF farming and ensure safe production and market access.
- **Funding and investment support:** Introduce incentives, such as grants, low-interest loans, and subsidies, and encourage public-private-research partnerships to scale up innovation and resource-sharing.
- **Awareness, training, and capacity building:** Conduct nationwide awareness campaigns, integrate insect farming into agricultural curricula, and implement training programmes for all actors.
- **Research and development (R&D):** Invest in localised research on BSF technologies and market feasibility to attract investors and demonstrate economic viability.

These actions could assist Malawi in turning insect farming into a driver of food security, income generation, and climate resilience. •

References

[1] Food and Agriculture Organization of the United Nations, *Increasing Smallholder Productivity and Profitability in Kenya*, (Rome: FAO, 2020).

[1] Eawag / Sandec, Switzerland

[2] Mzuzu University, Malawi

Funding: SDC and SNSF – Solution Oriented Research For Development (SOR4D) under grant agreement no. 400440_213241/1

More information:
https://www.eawag.ch/en/department/sandec/projects/swift/

Contact: daniela.peguero@eawag.ch

The Overlooked Role of Physical Properties in Insect Bioconversion

Years of focus on nutrition in biowaste has overlooked fundamental pieces of the puzzle. Research shows that the physical properties of biowaste – such as particle size and bulk density – greatly affect the efficiency of Black Soldier Fly Larvae bioconversion. Maja L. Schøn[1,2], Adrian Fuhrmann[2,3], Daniela A. Peguero[1], Moritz Gold[2,3], Alexander Mathys[2,3], Christian Zurbrügg[1]

Background

Black Soldier Fly Larvae (BSFL, *Hermetia illucens*) offer a practical solution for sustainable agriculture by converting organic waste into valuable products: protein-rich larvae for animal feed and frass for use as organic plant fertilizer. Biowaste may seem abundant, but sourcing large volumes of usable material for BSFL bioconversion remains challenging. To make BSFL biowaste treatment a dependable part of feed production, bioconversion processes must be optimised to deliver consistent performance across varying biowaste types and qualities. While nutritional composition traditionally has guided insect bioconversion research, new work from Sandec and ETH Zurich show that the physical properties, such as particle size and bulk density, can be just as important for optimising BSFL bioconversion.

Challenges

One of the major challenges in BSFL production is biowaste variability. Biowastes vary considerably in both nutritional and physical properties – even when from the same source. When formulating BSFL substrates, operators need to manage this variability by accounting for changes in feedstock properties, such as particle size, bulk density, viscosity, water-holding capacity, and porosity. These physical properties influence larval mobility, microbial activity, oxygen diffusion, metabolism, and heat generation – factors that can ultimately affect bioconversion efficiency, production costs, emissions, and the quality and quantity of the final products. A better understanding of the underlying processes driving these changes is important for achieving more reliable BSFL bioconversion.

Complex bioconversion

BSFL bioconversion is shaped by a complex and dynamic interplay of climatic, biotic, and substrate-related factors. While BSFL are remarkably resilient and capable of processing a wide range of biowaste types, their actual growth performance depends heavily on their environment. The biowaste plays a central role in this process, as it is a source of nutrients and water, and also is the physical habitat where larvae and microbes interact throughout the bioconversion process. In the Table, the main factors expected to influence the dynamic system are summarised. Because most factors are interconnected, a change in one parameter will influence others through feedback loops. For example, climatic conditions, e.g. temperature, humidity, and substrate moisture content, affect larval development, feeding behaviour, microbial growth, and evaporation rates. Biotic factors, such as high larval density, can increase metabolic heat, raise substrate temperatures, and further accelerate moisture loss. These changes can impact nutrient and oxygen competition between larvae and microbes, influencing development and overall system performance. At the same time, such characteristics as substrate height and particle size also influence how heat and moisture are retained or lost within the system. Altogether, the interactions between climate, substrate, and organisms in BSFL rearing systems are highly complex, and the dynamic relationships make it difficult to isolate single drivers. This highlights the importance of the new research on physical properties being conducted by Sandec and ETH Zurich to better understand these interactions and improve the consistency and efficiency of BSFL production.

	Abiotic factors		Biotic factors
	Climatic properties	Substrate characteristics	Larvae & microbiomes
Large-Scale Dynamics	Air temperature Air humidity Water content pH Light Airflow & air exchange rate	Nutrition Particle size [#] Bulk density [#] Substrate height [#] Viscosity [#] Texture & consistency [#]	Larval density Larval behaviour Larval life stage and age Larval physiological state Larval biomass assimilation
Fine-Scale Dynamics	Substrate temperature Water availability Water evaporation (cooling) Gas diffusion O_2 availability CO_2 concentration	Nutrient bioavailability Particle digestibility [#] Water retention [#] Porosity & aeration [#] Thermal capacity [#] Interparticle interaction [#]	Microbial abundance & community Anaerobic & aerobic digestion Energy use (growth & movement) Metabolic heat generation Interactions (symbiosis & competition) Genetics

Table: Overview of factors expected to affect BSFL bioconversion, categorised as abiotic (climate or substrate-related) and biotic (larvae and microbiomes), and further grouped by the scale at which each factor operates (large or fine). Physical biowaste characteristics are marked with a hashtag. (Schøn *et al.*, in preparation).

Influence of particle size

Our research investigated the effect of particle size on BSFL performance, using spent grain and grass clippings [1]. The results showed that finer particles led to improved bioconversion efficiency in both substrates. Grass clippings with smaller particles also showed higher microbial activity in the larvae in the early stages of the trial. Reducing particle size lowered bulk density and improved larval performance. However, there may be a minimum particle size threshold required to maintain adequate pore space and structural stability for effective water retention within the substrate.

Influence of bulk density

In addition, our research investigated how changes in bulk density affect BSFL performance, while keeping nutrient levels constant [2,3]. Adding a fibre-based bulking agent to food waste altered the physical properties of the substrate, including free air space. Results showed that higher bulk density (less fibre added, more compact substrate) was associated with better bioconversion efficiency and greater final larval mass (Figure A). At lower bulk densities, microbial respiration increased significantly in the first days of bioconversion (Figure B), likely due to improved oxygen availability resulting from increased free air space. The observed trends in CO_2 production were mirrored by the trends in substrate temperature (Figure C), pointing to a direct link between respiration and microbial heat production. This early rise in microbial activity raised substrate temperature and is expected to have increased competition for nutrients between microbes and larvae, resulting in less energy being available for larval growth later, as more energy was initially diverted to microbial metabolism and heat production.

Outlook

Collectively, these studies show that physical substrate properties profoundly influence BSFL bioconversion systems, and that the role of physical properties can no longer be overlooked. Optimising these traits can boost biowaste treatment and livestock feed production and modulate greenhouse gas emissions. Advancing knowledge in this area is essential for enhancing the reliability, reproducibility, and profitability of BSFL production. This foundation supports BSFL's growing potential as a sustainable solution benefiting agriculture, the environment, and global development. •

References

[1] Peguero, D. A. et al., 'Physical pretreatment of three biowastes to improve black soldier fly larvae bioconversion efficiency', *Waste Management*, 178, (2024), 280–291.

[2] Fuhrmann, A. et al., 'Comprehensive industry-relevant black soldier fly bioconversion characterisation by a novel chamber system', *Waste Management*, 193, (2025), 409–418.

[3] Fuhrmann, A. et al., 'Physical Properties of Food Waste Influence the Efficiency of Black Soldier Fly Larvae Bioconversion via Microbial Activity', *Journal of Environmental Management*, 387, (2025), 125777.

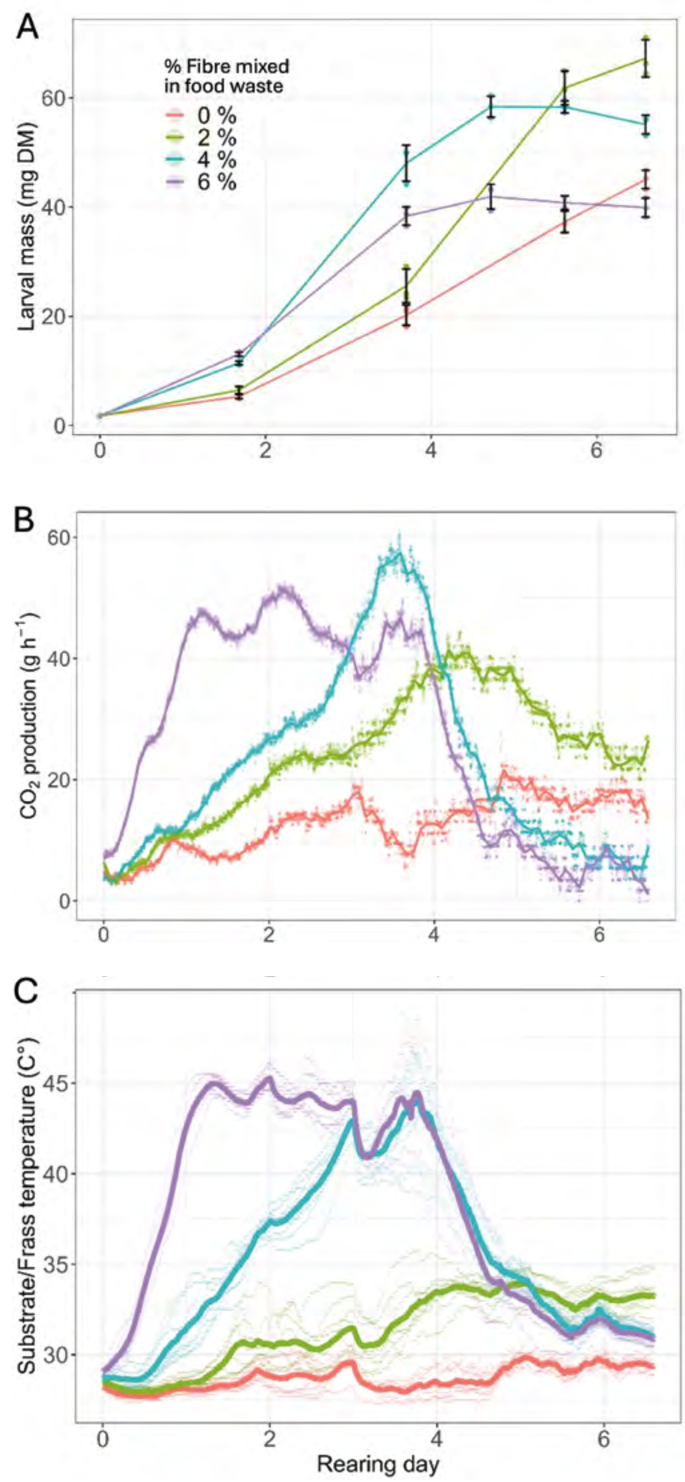


Figure: Time series data from BSFL bioconversion of food waste with varying addition of a fibre-based bulking agent. A) Larval growth curve, B) CO_2 production from the system, and C) Substrate temperature. Points show measurements; lines show means or smoothed trends.

[1] Eawag / Sandec, Switzerland

[2] ETH Zurich, D-HEST, Sustainable Food Processing, Switzerland

[3] Singapore-ETH Centre (SEC), Singapore

Funding: National Research Foundation Singapore under the CREATE program. Singapore-ETH Centre Intra-CREATE Thematic Grant 2020 Call 03 "Science of Sustainable Cities (Food)". European Union's Horizon 2020 Research and Innovation Program project SUStainable INsect CHAIN (SUSINCHAIN).

Contact: maja.schon@eawag.ch

River Revitalisation by Integrating Waste Infrastructure and Behaviour Change

A village-scale waste management pilot combines new infrastructure with an evidence-based behaviour change approach to reduce waste pollution in the Citarum watershed in Indonesia. The project serves as a model towards achieving broader river revitalisation goals. Laura Nelly Velásquez[1], Isna Muflihah Mulyaningrum[2], Fictor Ferdinand[2], Nanda Astuti[3], Tanvi Maheshwari[3], Reni Suwarso[4], Diego Ramirez-Lavering[4], Christian Zurbrügg[1]

YPBB

Photo: Door-to-door education during a household visit in Desa Padamukti, Indonesia.

Background

The Citarum River in West Java, Indonesia, is an example of the complex and dual nature many rivers face worldwide. It provides vital resources to millions of people and sustains ecosystems; yet, it threatens human and environmental health because it is one of the most polluted rivers in the world [1]. Those are the consequences of insufficient solid waste (SW) and sanitation services, which are worsened by growing urbanisation and climate change [2].

Over the past decade, the Indonesian government has launched several river revitalisation initiatives. Supporting these efforts, Universitas Indonesia and Monash University initiated the Citarum Action Research Program (CARP): a transdisciplinary, socio-technical research programme guided by co-creation efforts to ensure community ownership. It focuses on the five principles as shown in the Figure, including improved sanitation, solid waste services, and climate adaptation. To address the solid waste management component, Sandec and the local NGO Yaksa Pelestari Bumi Berkelanjutan (YPBB) launched a village-scale 'Waste to Resource' pilot project in Desa Padamukti, a village located along the Citarum River. It includes interventions across SW infrastructure, collection systems, and behaviour change tailored to the local context [2].

Reimagining local waste infrastructure

At the core of the pilot project is the design, construction, and evaluation of a model TPS3R+, an enhanced version of Indonesia's *Tempat Penampungan Sementara Reduce, Reuse, Recycle*. TPS-3Rs are government-led community-based waste management facilities aimed at reducing landfill waste and improving local resource recovery. The upgraded TPS3R+ in Desa Padamukti processes several waste fractions:

- Organic waste is separated into two streams: food waste is processed using Black Soldier Fly Larvae (BSFL) biowaste conversion, while woody organic and garden waste are treated by composting.
- Since high-value hard plastics are already collected by the informal sector, the TPS3R+ focuses on low-value soft plastics. They are processed using "Precious Plastics Bandung's" shredding and extrusion technologies for local recycling.
- Residual waste is currently incinerated as a temporary measure, although the long-term goal is to minimise or eliminate this step.

What makes the TPS3R+ unique is that it integrates supporting infrastructure, including a renovated fishpond that uses BSFL as feed and makes use of an existing previously unused building repurposed as the organic treatment centre. Wastewater and leachate from organic waste processing are managed on-site using nature-based solutions to reduce environmental impact. Besides waste management, the TPS3R+ serves as a space for knowledge sharing, awareness raising, and community engagement on circular economy practices.

Segregated waste collection system

The effectiveness of the TPS3R+ relies on the quality of waste it receives. Clean, well-separated waste fractions are essential for efficient processing and reuse or recycling. In Desa Padamukti, waste was previously collected as mixed waste for a small fee by informal workers and youth groups, and transported to an uncontrolled dumpsite. As part of the pilot, the collection system was redesigned based on negotiations with all stakeholders. In three pilot RWs (*Rukun Warga*, or neighbourhood units), households subscribing to the TPS3R+ service by paying a monthly fee, receive a segregated waste collection service. Waste is collected by fraction – organics and non-organics – before being delivered to the TPS3R+ for further processing.

Beyond infrastructure: Behaviour change

Infrastructure success depends on how people use it. The TPS3R+ performance and segregated collection system are directly affected by the segregation practices of the households. Rather than relying only on general awareness raising, the pilot included a behaviour change strategy to understand what drives or hinders household-level segregation and to design tailored interventions. For this, the RANAS framework was applied – a structured, evidence-based approach that focuses on five key psychological factors: Risk, Attitude, Norm, Ability and Self-Regulation. A baseline survey revealed significant differences between households that regularly segregate waste ("Doers") and those that do not ("Non-Doers"). Key drivers included positive feelings towards segregation, confidence in performing it correctly, and perception of supportive social norms. On the other hand, low confidence in maintaining the behaviour and difficulty in remembering to segregate were identified as the main barriers.

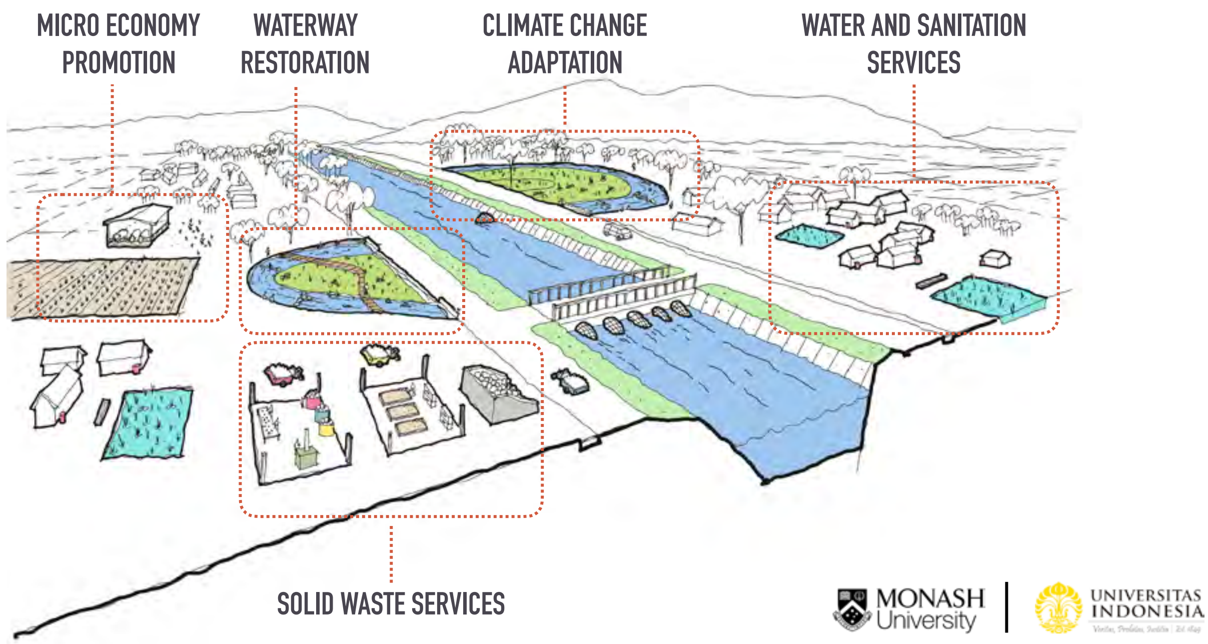


Figure: The integrated model for community and river revitalisation of the Citarum sub-watershed [3].

The campaign

Based on the identified factors, a campaign was designed using tailored behaviour change techniques. These consisted of three main interventions, each targeted to address specific drivers and barriers to waste segregation.

1. TPS3R+ Demo Day

A first event was held to raise awareness about the new waste management system and encourage household sign-up. Over 80 participants took part in a three-step training held at the TPS3R+ facility. Activities included discussions on why segregation matters and demonstrations on how to segregate waste correctly. Participants also viewed recycled products and were invited to a community celebration.

2. Door-to-door education

The YPBB team visited households to boost motivation and address individual practical challenges of waste segregation (Photo). During the visits, they explained how to segregate and store waste, discussed environmental and health risks of improper disposal, and helped households improve their container setup to suit their specific needs. Participating households also received a sticker with a QR code, allowing them to register for monitoring and to give them the opportunity to provide feedback to improve the collection system.

3. Digital Campaign

To maintain engagement and communicate important messages, a digital campaign was launched through a WhatsApp group. It featured six short videos, highlighting best practices in waste segregation, each starring local and trusted champions. The WhatsApp group has since been handed over to local representatives who continue to share supportive messages and reminders.

Evaluation of waste to resource pilot

To ensure the long-term success of the TPS3R+ system, behaviour change interventions in Desa Padamukti have been extended to a one-year evaluation and transition phase. This will allow focusing on monitoring and improving waste processing and collection operations, using key performance indicators, such as segregation rates and safety standards. A detailed follow-up RANAS survey will then assess how household segregation behaviours evolve over time, identifying which behavioural factors were most influenced by the campaign and where additional interventions may be needed. By the end of the evaluation period, the goal is to address ongoing challenges and fully transition the TPS3R+ and its supporting systems to community management. The experience and lessons learned from Desa Padamukti will support broader river revitalisation efforts in the Citarum river basin and beyond. •

References

[1] Monash University, ‘Citarum Action Research Program (CARP)’ [webpage] (2025) <https://www.monash.edu/mada/research/project/citarum-action-research-program>; accessed 10 July 2025.

[2] Hadfield P. et al., ‘Citarum Living Lab: Co-creating visions for sustainable river revitalisation’, *PLOS Water*, 3/8, (2024), e0000200.

[3] Prescott M. et al., ‘The integrated model for community and river revitalisation of the Citarum sub-watershed’, *Bridges*, Deposited June 19, 2024.

[1] Eawag / Sandec, Switzerland
[2] Yaksa Pelestari Bumi Berkelanjutan (YPBB), Indonesia
[3] Monash University, Art, Design & Architecture, Australia
[4] Universitas Indonesia, Depok, Jawa Barat, Indonesia

Funding: Indo-Pacific Plastics Innovation Network (IPPIN), Koneksi, and WABES Integrate project (SDC).

Partners: PRO-BSF, Precious Plastics Bandung, Universitas Padjadjaran, and CSIRO

More information:
https://www.monash.edu/mada/research/project/citarum-action-research-program
https://www.eawag.ch/en/department/sandec/projects/enhancing-waste-segregation-behavior/

Contact: citarum.research@monash.edu, laura.velasquez@eawag.ch, christian.zurbruegg@eawag.ch

SIMBA: A Simplified Process for Organic Waste Conversion by BSF

SIMBA simplifies Black Soldier Fly farming, streamlining methods to maintain lifecycle and waste treatments to just two days a week. It makes it feasible for small-scale farms and communities with limited resources.

Daniela A. Peguero[1], Stefan Diener[2], Bram Dortmans[2], Rowland Watipaso Mhone[3], Laifolo Dakishoni[3] and Christian Zurbrügg[1]

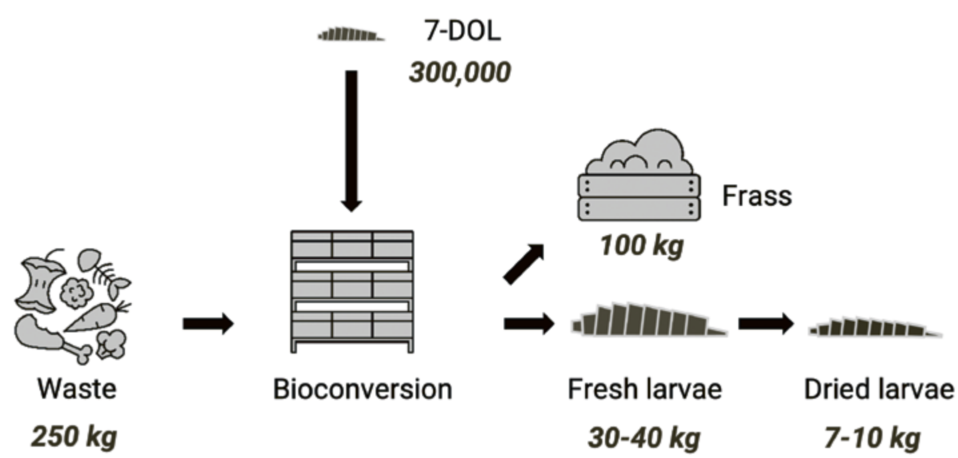


Figure 1: Conversion of organic waste into valuable products using the SIMBA approach

Background

A promising biological solution for organic waste management lies in using the Black Soldier Fly (BSF), *Hermetia illucens*. This fast-growing insect is capable of converting organic material into a high-protein biomass for animal feed and nutrient-rich residue for a soil amendment.

However, establishing a full-scale BSF farm can be complex, costly, and beyond the reach of many people, particularly in low-resource settings. To unlock the potential of BSF technology for smallholder farmers and communities with limited means, the Sustainable Waste-based Insect Farming Technologies (SWIFT) project developed SIMBA – a Simplified BSF Approach – to reduce technical barriers and enhance local adaptability. Two practical SIMBA guides have been developed: the Reproduction Unit Guide and the Treatment Unit Guide. They outline standard operating procedures, equipment, and a structured operational schedule that requires just two working days per week. SIMBA was developed to make BSF technology both accessible and practical for smallholder farmers and communities. The goal is to empower local actors – farmers, waste managers, communities and small-scale entrepreneurs – to turn organic waste into a resource, while reducing environmental impact.

Using the SIMBA approach, it is possible to treat approximately 250 kg of waste per week as shown in Figure 1, roughly equivalent to the weekly manure output of nine pigs. This treatment requires around 300,000 seven-day-old larvae, which can be produced in a reproduction unit on-site, or the small larvae can be obtained from a partnering nearby facility. Based on this input of substrate waste, farmers can expect to harvest around 30 – 40 kg of fresh larvae and produce around 100 kg of frass, the nutrient-rich residue, per week.

SIMBA Reproduction Unit Guide

The SIMBA Reproduction Unit Guide focuses solely on the reproduction unit of the SIMBA system, offering a simplified approach to maintaining the entire BSF lifecycle. It breaks down the rearing process into clear, practical steps that require minimal time, space, and labour, making it suitable for small-scale or part-time operation. The Guide explains that operation and maintenance of the lifecycle process requires only two days per week with just a few hours of labour each day. Figure 2 shows an overview of the reproduction unit, i.e. the three key life stages of BSF (egg, larvae, and adult).

1. Egg unit:
This is where eggs hatch and newly hatched larvae (e.g. neonates) receive their first feeding. Adult flies are housed inside nets known as "love cages" (further discussed in step 3), where they lay eggs onto small egg collection devices called "eggies," made from wood, cardboard, or plastic. Workers collect the eggies and place them above moist feed with 70 % water content in hatchling boxes.

2. Larvae unit:
This is where larvae grow until they are ready to pupate. Newly hatched larvae fall from the eggies into the hatchling box below. This setup is referred to as the "hatchling shower". The following working day, the hatchling box is removed from the hatchling shower, and the larvae continue feeding for another few days. By the next workday, the larvae are around seven-days old (7-DOL).

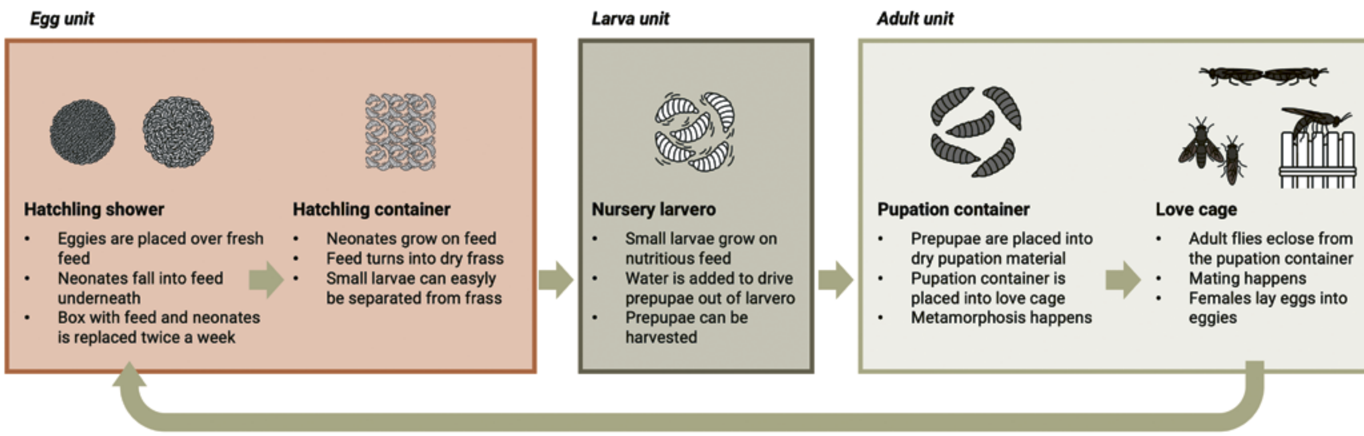


Figure 2: Overview of the tasks performed within the egg, larva and adult units.

To maintain the lifecycle, 80,000 7-DOL need to be set aside each week for pupation. The 80,000 7-DOL are put into nursery containers, fed twice, and grown over 14 days until they reach the prepupal stage. By adding water, the mature prepupae naturally separate themselves from the substrate for easy collection.

3. Adult unit:
This is where the adult flies emerge, mate, and lay new eggs, completing the BSF life cycle. The prepupae from step 2 are placed in pupation containers filled with moist sawdust (50 % water, 50 % sawdust), where they safely transform into pupae. Pupation containers are placed into the love cages where after two to three weeks, new adult flies emerge, ready to continue the system.

To operate at this scale effectively, the reproduction unit requires around 30 square metres of covered space, ideally divided into separate areas for larvae and adults. This separation helps prevent scent-related distractions for the flies. Maintaining an ideal climate – between 25–32°C with 50–60 % humidity – is critical to ensure stable and well-performing reproduction. It is not a strict blueprint, as adjustments will be necessary to account for waste substrates, i.e. the larvae feed and seasonal variations. Nevertheless, following the guide, using common sense, and having a good understanding of the BSF life cycle will ensure a well-functioning reproduction unit.

Monitoring is integral to the SIMBA Reproduction unit. Tracking metrics, such as the number of 7-DOL resulting from a given number of pupae, indicate reproductive performance. Inconsistency in such performance indicators can point toward issues that must be addressed quickly.

SIMBA Treatment Unit Guide

The SIMBA Treatment Unit Guide focuses solely on the treatment unit aspect of the SIMBA system. It is designed to simplify the treatment of organic waste into clear, manageable steps that require minimal time, space, and labour. Below is a brief overview of the treatment unit divided into three main stages:

1. Waste Pre-Processing
This involves receiving and storing incoming organic waste. If necessary, the waste is then shredded, to reduce particle size for even feeding. Once prepared, the substrate is mixed and dosed into containers, ready for the larvae to process.

2. Treatment Phase
In this stage, 7-day-old larvae (7-DOL) produced in the SIMBA Reproduction Unit or sourced externally are added to the small "incubation containers" and given a small amount of substrate to promote even growth for the first three days. After this initial period, the larvae are moved to larger containers, where they continue to feed on the bulk of the waste substrate for the remaining seven days. This staged feeding method helps ensure healthy larvae development and efficient waste breakdown.

3. Harvesting
After 10 days, the larvae are harvested by separating them from the frass – the nutrient-rich residue left behind. The result is a dual product stream: fresh larvae that are suitable for animal feed, and frass, a high-quality organic soil amendment.

Conclusion

The SIMBA approach provides a simplified, low-labour solution for Black Soldier Fly farming. The Reproduction Unit Guide instructs how to maintain the BSF lifecycle, and the Treatment Unit Guide outlines a process of organic waste conversion by the larvae into valuable resources. These units can be used together or independently, offering centralised or decentralised, scalable solutions that empower farmers and communities to manage waste, while producing high-quality products, i.e. larvae and frass. Both Guides are available on the SWIFT webpage for free download and use at the link below. •

Acknowledgement
SWIFT project team members: Allan John Komakech, Isaac Rubagumya, Simon Kizito, Florence Lwiza, Frank Mnthambala, Gift Chawanda, Esther Lupafya, Konstantin von Hoerner, Sheila von Hoerner.

[1] Eawag / Sandec, Switzerland
[2] Eclose GmbH, Switzerland
[3] Soil Food and Healthy Communities (SFHC), Malawi
Funding: SDC and SNSF – Solution Oriented Research For Development (SOR4D) under grant agreement no. 400440_213241/1
Webpage: eawag.ch/en/department/sandec/projects/swift
Contact: daniela.peguero@eawag.ch


eawag
aquatic research
Truly 200
Nitrile Powder Free

Management of Excreta, Wastewater and Sludge

Globally, sustainable solutions that are equitable and safe are required for urban sanitation. Access to safely managed sanitation can be achieved through implementation of a range of appropriate technologies tailored to the realities of climate change and rapidly growing cities, with integrated combinations of sewered and non-sewered, and onsite, decentralised, and centralised technologies. Monitoring and environmental surveillance are important for assessing public health, and to identify priority areas for interventions. Sandec's Management of Excreta, Wastewater and Sludge (MEWS) research in this area includes:

- **Collaborative research:** Conduct applied research to develop the fundamental knowledge required for integrated management and technology solutions.
- **Technology innovation:** Research the development and monitoring of safe and effective management of excreta, wastewater and sludge to meet treatment and resource recovery goals with industrial and implementation partners.
- **Facilitating sustainable implementation:** Uptake of research by integration of knowledge into policy through dissemination and strategic partnerships.

Photo: Technicians Jessica M. Yajah and Gibril M. Kamara are measuring pH in the liquid after the dewatering of faecal sludge at the Kingtom Faecal Sludge Treatment Plant in Freetown, Sierra Leone. They work for the SEDUP project, a collaboration between Eawag, GOAL and the Freetown City Council that has the aim to validate and scale low-footprint, low-energy dewatering technologies. Read more about SEDUP on pp. 24–25.

Photo by Michael Vogel.

Optimal Vermifilter Design: Insights From Three Full-scale Installations

A comparison of three full-scale vermifilters gives perspective on how optimal vermifilter design can be adapted to context. Kayla Coppens[1,2], Linda Strande[2]

Photo: Full-scale vermifilters in Geneva, Switzerland (left), in Jaipur, India (middle), and Pune, India (right).

Introduction

Due in part to complexity and lack of investment, sanitation is alarmingly off-track regarding the objectives stated in SDG6, which aim to ensure the availability and sustainable management of sanitation for all. To meet these goals and overcome global challenges, including rapid urban densification and aging treatment infrastructure, nature-based solutions (NBS) for sanitation are being explored. NBS offer low-investment costs, use locally available material, and require minimal energy and chemicals. Vermifiltration is an example of NBS that uses earthworms to treat wastewater [1].

Over the past 20 years, Switzerland has implemented over 15 full-scale vermifilters. Curious about the long-term viability of vermifiltration to treat wastewater, I started a research project in 2022, monitoring the largest vermifilter installation in Switzerland. Located in Geneva, the two vermifilters treat black- and greywater from a housing complex with 100 people since January 2017. So far, my research results demonstrate that with appropriate design and operation, vermifiltration can meet discharge standards, even in Switzerland's temperate climate with four distinct seasons [2]. Additionally, the observed removal efficiencies for organic matter degradation were higher than those reported in the literature, and the vermifilters remained clog-free, a known shortcoming of vermifiltration. With such optimistic results, I wondered: should this design be replicated worldwide?

Where context meets design

In March 2025, I visited two full-scale vermifilters in India, each with distinct treatment configurations, opening my perception of optimal design and operation. As vermifiltration systems use locally available materials, different filter media were employed across the three full-scale systems: vermicompost in Geneva, a combination of coconut biochar and vermicompost in Jaipur, and coconut chips in Pune. The differences in these materials, such as pore size, structure, and density, made it necessary to adjust the operational parameters at each site, including hydraulic loading rates (HLR). For example, using coconut biochar in Jaipur reduced hydraulic retention time, and, therefore, required lower HLRs to maintain targeted performance. Although the HLRs in Geneva were approximately ten times lower than those in Jaipur and Pune, all three systems met their performance goals. Variable HLRs achieving comparable performance may be attributed to differences in filter material, local climate (Jaipur and Pune, for example, recorded higher ambient temperatures than Geneva) or a combination of both factors.

The three vermifilters also differed in pre-treatment approaches. In Geneva, the vermifilter was installed without additional pre-treatment, while Jaipur used settling tanks and Pune used grit chambers to decrease solid loads. Solid load variations influenced wastewater dispersion system choices. In Jaipur and Pune, low solid loading allowed for sprinkler systems, whereas in Geneva, higher solid loads required a shredding pump and 10 mm plumbing tubes.

Conclusion

My key takeaway is that using local resources and expertise is crucial, and that there is no single optimal vermifilter configuration. Future research should identify effective design and operational configurations for specific contexts. These insights also led to the development of a discussion group between researchers in India, Mexico, and Switzerland to foster exchange and advance vermifiltration knowledge. •

References

[1] Arora, S. et al., 'Vermifiltration as a natural, sustainable and green technology for environmental remediation: A new paradigm for wastewater treatment process', *Current Research in Green and Sustainable Chemistry*, 4, (2021).

[2] Coppens, K. et al., 'Performance analysis and impact of operating conditions on the treatment capacity of two full-scale vermifilters', (Manuscript submitted for publication, 2025).

[1] University of Geneva, Switzerland
[2] Eawag / Sandec, Switzerland
Contact: kayla.coppens@eawag.ch

Lessons Learned From Planning for PhD Fieldwork

Planning and strong collaboration is essential for successful fieldwork – especially when conducting research in a new environment. From obtaining permissions to sourcing materials and managing logistics, the fieldwork journey for my PhD has been anything but straightforward. Ednah Kemboi[1,2], Dr Linda Strande[1]

Anonymous

Part of the team that made fieldwork in Kampala a success (from left to right): Jafari Matovu, Chairperson, Emptiers' Association, Uganda; Ednah Kemboi the PhD Researcher; Prof. Charles Niwagaba, our Research Collaborator; Mathias Kasirye, Research Assistant.

Introduction

My PhD research investigates how the level of stabilisation of faecal sludge (FS) received at treatment facilities impacts solid-liquid separation (dewatering), and the biological treatment of the resulting liquid (supernatant). FS is the wastewater from non-sewered sanitation (NSS) facilities that is stored until it can be transported to treatment [1]. My research findings shall inform the design and optimisation of low footprint FS treatment systems.

To capture real world FS variability, I collected samples in Eldoret, Kenya, and Kampala, Uganda. I spent ten-weeks in Kampala collaborating with Prof. Charles Niwagaba at Makerere University, in order to collect and analyse faecal sludge and dewatering properties from 33 different types of onsite containments. The lessons I learned in planning and project management along the way surprised me and are a big part of my learnings that I will take forward in my research career!

Planning hurdles and adaptive strategies

I had a number of planning setbacks, from starting out with overly optimistic sampling plans, to sourcing of consumables for laboratory analysis in a timely fashion. I worked closely with Prof. Niwagaba and my supervisor, Linda Strande, to iteratively adjust my plans to find working solutions.

I ordered the consumables two months in advance from Germany to be delivered to Kampala. However, problems with international supply chains resulted in their arriving in three months. To accommodate this delay, I reshuffled my research schedule to keep my PhD project on track, advancing some tasks originally planned for later. This experience taught me about adaptive management, how to shift prioritisation of tasks depending on current realities, and to build in buffer time into project management, especially where international procurement is involved.

Realistic plans and strong collaboration as a cornerstone

When I first developed my sampling plan, I had not realised how much time things would take logistically on a day-to-day basis. Prof. Niwagaba iteratively guided me through the process resulting in a realistic sampling plan. His expertise on faecal sludge management (FSM) in Uganda, and his local networks, were instrumental in navigating administrative and logistical challenges, such as obtaining access to treatment facilities, liaising with the Emptiers' Association to arrange sampling from trucks, and recruiting research assistants and laboratory space at the Department of Civil and Environmental Engineering of Makerere University. This taught me that strong collaborations wherever you are working are critical for successful research.

Unforeseen challenges in the field and flexibility

Although most days went according to plan, unexpected disruptions occurred, including traffic congestion, heavy rain, equipment failure, defective reagents, and power outages, all of which required ongoing flexibility. At one point, a reagent box for total nitrogen analysis failed to perform, and we had to prioritise analysis of the supernatant following dewatering over the untreated FS, based on what data was most critical for the next research phase. These experiences reinforced the importance of having a strong planning document that one can revisit on a weekly basis to evaluate progress. Also, recording and processing data in real time is important to enable plausibility checks and repetition of analytical tests when needed. Overall, flexibility in research timelines proved necessary to account for the inevitable interruptions that can affect laboratory workflow.

Key takeaways

From my experience, I learned several critical lessons:

- Plan conservatively for delivery times based on other's experience when sourcing consumables – supplier or shipping delays could happen.
- Stay adaptable and plan for buffer time – fieldwork rarely goes exactly as planned.
- Anticipate utility issues – power and water outages can affect laboratory work.
- Include contingency time for wrap-up activities – such as unforeseen tasks, cleaning the laboratory space to avoid leaving work for your research partners, and a proper thank-you meal for the team.

Final reflections

Fieldwork in international contexts is complex and full of uncertainties. However, with timely planning, strong collaboration on site, and adaptability to disruptions, it becomes manageable. Despite the setbacks, the fieldwork campaign concluded successfully and provided essential data for the ongoing research. Stay tuned here for upcoming research results! The challenges notwithstanding, the experience was incredibly rewarding, and I would do it again, but better! •

References

[1] Strande L., 'Integrating Recent Scientific Advancees to Enhance Non-sewered Sanitation in Urban Areas', *Nature Water*, 2, (2024), 405–418.

[1] Eawag / Sandec, Switzerland
[2] ETH Zürich, Switzerland
Funding: Swiss National Science Foundation (SNF)
Contact: ednah.kemboi@eawag.ch

Solutions for Low-footprint, Low-energy Dewatering in Dense Urban Areas

A commercially available dewatering press was adapted for local fabrication in Freetown, Sierra Leone, and validated at the Kingtom Faecal Sludge Treatment Plant. There were many benefits resulting from the use of a collaborative and iterative development process. Michael Vogel[1], Ebenezer Appiah[2], Jemil Bangura[2], Linda Strande[1]

Introduction

In dense urban areas of lower- and middle-income countries, the majority of sanitation provision is through non-sewered sanitation. This is commonly referred to as faecal sludge management (FSM), with the wastewater stored in onsite containments having to be transported by road to a treatment facility, which is energy-intensive.

When the faecal sludge (FS) arrives at a treatment facility, it is often first dewatered to enable complete treatment of the resulting liquid and solid streams. Established dewatering technologies at treatment facilities are passive, and land intensive (settling tanks, drying beds, etc.), and their performance is not predictable. This makes dewatering a limiting factor for low-footprint treatment.

In sewer-based wastewater treatment, low-footprint technologies include adding conditioners to the FS together with mechanical dewatering. However, conditioners are expensive, energy intensive to produce, rely on international supply chains, and not adaptable for highly variable FS [1].

The SEDUP (Scaling Efficient Dewatering for Urban Practitioners) project is a consortium of GOAL, Freetown City Council, and Eawag Sandec. The goal was to learn from three different commercially available technologies used for dewatering in other fields, adapt them for FS dewatering, build them locally, and evaluate their costs and treatment performance. The project adopted a collaborative and iterative technology development approach to promote rapid adaption of the technology to the specific use case, as well as a user-centric design. These technologies included:

- **Dewatering press:** Manually operated presses can be manufactured locally in Freetown and operated with low electricity demand.
- **Turbidity sensors:** Low-cost sensors can be replicated based on open-source design principles and used to optimise dosing of conditioners.
- **Conditioner:** Chitosan can be produced from fishing industry waste and is an alternative to imported synthetic conditioners (See the article on pp. 26–27).

Proof of concept: Testing commercially available dewatering presses

SEDUP started its analysis with a laboratory size filter press and a commercially available fruit press (Figure 1 from left to centre) in order to confirm that a manually operated press can be used to dewater FS. The tests revealed a high solids removal and a sludge cake formation from the presses that was, however, made possible only by using a conditioner. Tests were then done with a larger fruit press (50 L) at the Kingtom Faecal Sludge Treatment Plant (FSTP) to get buy-in and project participation from the treatment plant operators and the potential press manufacturers (Figure 1 right). This also led to insights into the operational requirements and design of a press that would work with FS, such as:

- The correct dosage of conditioner is critical to avoid filter clogging.
- A durable filter material is needed to keep the operational costs low.
- The entire process from filling to emptying of the press must be optimised to maximise capacity.
- Operators of the press should be protected from direct contact with the faecal sludge.

Building a manual dewatering press in Freetown

The SEDUP project team then developed a first design of the manual press in a collaborative workshop. Key aspects of the design (Figure 2 left) included a threaded rod, a press plate and a cylinder to press the sludge into the filtration drum (bottom part). The cylinder and the filtration drum can be separated from the press for easy removal of the dewatered solids. The next step was validating the technical drawings with a metal workshop in Freetown. However, since the workshops are not used to working with CAD generated drawings, a 3D-mockup was produced that could be replicated (Figure 2 centre). Our project showed that using a mix of 3D-drawings, mockups, photos, and actual prototypes for co-designing a technology with multiple stakeholders worked very well.

Piloting the locally manufactured manual press

The first locally manufactured press prototype was tested in a pilot setup at the Kingtom FSTP, which included a flocculation tank and an effluent pipe transporting the effluent wastewater back into the existing FSTP (Photo). Faecal sludge was pumped directly from the receiving tank of the FSTP into the flocculation tank of the pilot.

The press was piloted over many weeks with two different conditioners, polyacrylamide and chitosan. The local availability of the materials and the short transport distances to the manufacturers allowed ongoing, iterative modifications of the press during the piloting, leading to the quick development of a fully operational pilot-size manual press. The piloting also revealed that the press can dewater up to 5 m^3 FS per day, with two workers required to operate it. Total solids removal was in the range of the commercially available press (> 90 %). The cake solids content was lower (15 % total solids) than that obtained with commercially available technologies (> 20 % total solids), but more than 90 % of the liquid was separated with a setup that had a footprint lower than that required for sand drying beds or geotextiles. The next iteration will scale the press to a capacity of 15 m^3 FS per day and will use a manual hydraulic press system. The data obtained during the piloting is the baseline required to estimate how this technology can be scaled and multiplied at other locations.

Michael Vogel

Figure 1: Laboratory filter press (left), commercially available fruit presses with a volume of 3 L in the laboratory (centre) and 50 L at Kingtom FSTP (right).

David Hasler and Josch Stricker

Figure 2: From 3D-drawing, to 3D-mockup, to manufacturing of the press in Freetown (left to right).

Michael Vogel

Photo: A manual dewatering press pilot with a flocculation tank (white IBC tank) and the manual press (red) with the effluent pipe draining through a hole in the concrete structure back to the existing FSTP.

Conclusions

Testing a commercially available product and adapting it to requirements in Freetown had multiple benefits, such as:

- The rapid transfer of the laboratory tests to a pilot size press at an FSTP made it possible to avoid unnecessary iterations in the laboratory, while still revealing the technology's potential and drawbacks.
- All the involved technicians and materials were located close to the pilot facility, allowing for fast iterations during the development and piloting processes.
- Inexpensive maintenance and repair of the technology was possible due to the above, reducing the need for international technicians.
- Engaging the manufacturers and FSTP operators in the development process greatly increased the practicability of the press and facilitated communication between the involved groups.

These learnings highlight that co-creation can be a central aspect of technology design and when preparing a technology for scaling.

At the end of the project, SEDUP will produce guidelines on how to independently build and operate a dewatering press for faecal sludge that includes information on operational expenses, power consumption, and labour requirements. •

Acknowledgement

Individuals whose effort and time were instrumental in the manufacturing and piloting of the press include: Joseph Kamara, Tamba Sinah and Andruga Williams (Freetown City Council), Gibril Mohamed Kamara, Alan Reade, and Jessica Moyatu Yajah (GOAL), David Hasler and Josch Stricker (Eawag), and participants from Kassa Enterprises Freetown.

References

[1] Shaw, K. et al.,'Towards globally relevant, small-foodprint dewatering solutions: Optimal conditioner dose for highly variable blackwater from non-sewered sanitation', *Journal of environmental management*, 321, (2022), 115961.

[1] Eawag / Sandec, Switzerland
[2] GOAL, Sierra Leone
Funding: www.repic.ch
More information: www.sandec.ch/mews_sedup
Contact: michael.vogel@eawag.ch, linda.strande@eawag.ch

Locally Produced Bio-conditioners for Faecal Sludge Dewatering

Bio-conditioners were successfully produced and tested in Switzerland, Zambia, and Sierra Leone to see if they could be made locally to avoid complex and expensive supply chains. This article highlights preliminary results.

Nienke Andriessen[1], Michael Vogel[1], Irene Muscas[2], Celestine Uwanyirigira[3], Benjamin Bockarie[4], James Madalitso Tembo[5], Linda Strande[1]

Irene Muscas

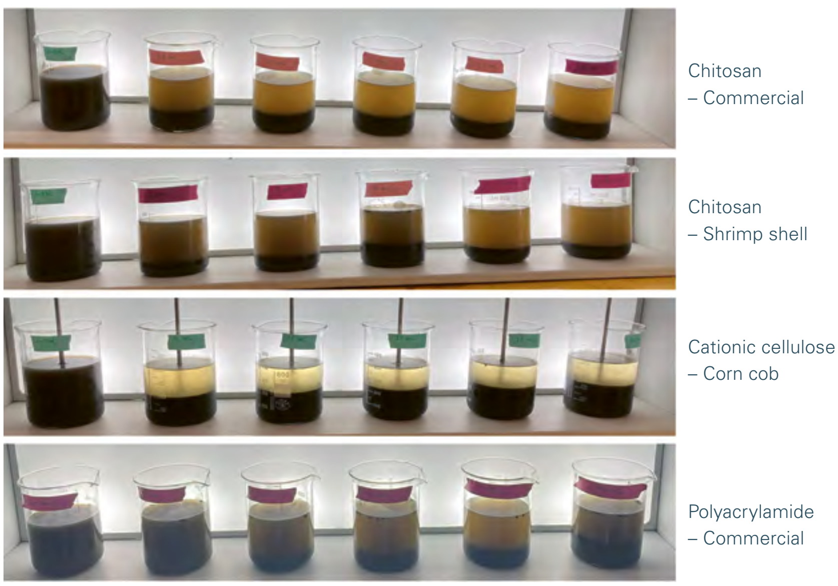


Photo 1: Jar tests of faecal sludge conditioned with various dosages of bio-conditioner (increasing dosages from left to right).

Linda Strande

Photo 2: Fishermen in Freetown, Sierra Leone, bringing in their catch at the end of the day.

Introduction

Conditioners can make dewatering of faecal sludge (FS) more efficient, which is highly needed in dense urban settings. Conditioners are flocculants or coagulants that improve the formation of flocs and the settleability of suspended particles in wastewater or FS. They are used widely in wastewater treatment, but for FS, their use is still growing.

Conventional conditioners (often petroleum-based with polyacrylamide) are expensive and frequently need to be imported. It is also not clear how they affect the environment after use in treatment. The unavailability of conditioners due to complex international supply chains and customs procedures are frequently a reason for treatment failure. To address these problems, this study tested locally produced bio-based conditioners made from organic waste sources for FS dewatering.

Existing knowledge

First, we conducted a literature review to identify possible options for conditioners and existing production methods. This included investigating options from other sectors, such as the wastewater and drinking water sectors, and the food industry. Options identified included chitosan, modified (cationic) starch and cellulose, and isolated proteins from seeds (such as from *Moringa oleifera* seeds, which we have used in past research [1]). We also compared the performance of commercially available bio-based conditioners with conventional petroleum-based conditioners for use with FS in laboratory and pilot tests [1,2].

Laboratory-scale bio-conditioner production

Following the literature review, we decided that cationic cellulose and chitosan had the highest potential at this time for FS dewatering. Cationic cellulose was made from corn cobs, and chitosan from shrimp waste. Various methods from the literature were tested for both of these in the laboratory at Eawag iteratively to produce the most effective conditioner (Photo 1). To understand dosing and efficacy, jar tests were done that compared various dosages, while measuring capillary suction time (CST, a measure of dewaterability) and supernatant turbidity. The results are presented in the Figure for five conditioners. The lowest dose that achieved an 85 % reduction in CST and turbidity was classified as the optimal dose (the red line in the Figure).

Since FS is highly variable, we then tested the produced conditioners on faecal sludge with varying characteristics (e.g. total solids content) in Lusaka, Zambia. The production process was also successfully replicated in the laboratory at the University of Zambia.

From the laboratory tests, we learned that:

- Although it is possible to make effective cationic cellulose and chitosan bio-conditioners worldwide, production methods are not yet fully optimised for scaling up. The strength and size of flocs from cationic cellulose and chitosan are clearly lower than with conventional polyacrylamide, which might impact dewatering performance. This could mean that locally made conditioners might not be suitable for dewatering technologies that apply high sheer forces (e.g. presses), but are better suited for technologies that use settling.

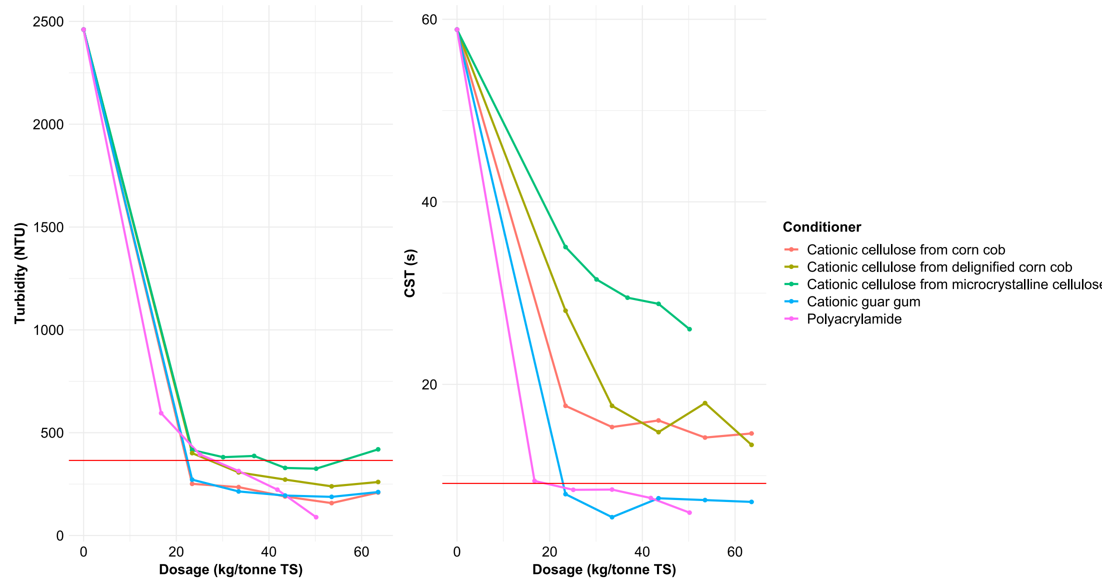


Figure: Supernatant turbidity after settling (left) and capillary suction time (right) of varying conditioner dosages. The red line indicates a 85% reduction compared to the control jar.

- Production conditions (e.g. temperature) have a big influence on the resulting conditioner performance. It is, therefore, important to develop a robust production process before scaling to worldwide implementation.
- Most chemicals used for the production of conditioners are commonly available acids and bases, but the monomer used for cationic cellulose could be difficult to obtain or require importation, which is counter to the benefit of local production. Its environmental impact is also not yet known; we are currently assessing these aspects and possible alternatives.

Chitosan production: Freetown case study

Scaling chitosan production is realistically only feasible in locations with a (shrimp) fishing industry. An example is Freetown in Sierra Leone, which has a large fishing industry (Photo 2). The city's first and only faecal sludge treatment plant also uses conditioner for dewatering. As part of the SEDUP project, we explored the feasibility of making chitosan in Freetown to replace the imported polyacrylamide conditioner (See pp. 26–27).

Commercially available chitosan was used with a pilot-size filter press. The required dosage varied between 10–20 g chitosan per kg TS of FS, which roughly equals 250 g chitosan per m^3 of treated FS. Assuming a yield of 2 g dried shrimp shells per shrimp, and a yield of 20 % of chitosan from the dried shrimp shells, it requires the waste of roughly 625 shrimps to condition 1 m^3 of FS. To assess the availability of this amount of shrimp waste, we conducted a market study with a survey among restaurants, hotels and fish markets. Visits to fishing villages and fish markets revealed that there is no central location in Freetown where large amounts of fish waste accumulate. Even though shrimp are abundant, most people in the fishing communities rely on subsistence fishing due to the lack of refrigeration. People sell their catch on demand, unprocessed, to restaurants or hotels. We are currently investigating business models on what could motivate waste collectors to collect and transport shrimp waste separately. The results will provide a first estimation if chitosan could fully and cost-effectively replace polyacrylamide conditioners in Freetown.

Outlook

Several research questions prior to scaling remain to be answered, including:

- What is the environmental impact of the production process compared to commercial conditioners?
- Is it financially advantageous to produce conditioners locally?
- Is it possible to use other organic waste sources as input material (e.g. rice husks instead of corn cob)?
- Are the required chemicals for production globally available?
- What is the optimal scale and business model for local bio-conditioner production?

These questions will be answered by our research in the coming year. MEWS will be publishing a variety of resources to help practitioners select conditioners and dewatering technologies, and to learn how to produce conditioners. Keep an eye out on our website in the coming year! •

References

[1] Gold, M., et al., 'Locally produced natural conditioners for dewatering of faecal sludge', *Environmental Technology*, 37/21, (2016), 2802–2814.

[2] Shaw, K., Vogel, M., et al., 'Towards globally relevant, small-footprint dewatering solutions: Optimal conditioner dose for highly variable blackwater from non-sewered sanitation', *Journal of Environmental Management*, 321, (2022).

[1] Eawag / Sandec, Switzerland
[2] University of Geneva, Switzerland
[3] University of Basel, Switzerland
[4] GOAL, Sierra Leone
[5] University of Zambia, Zambia

Funding: This work was funded by the Swiss Agency for Development and Cooperation (SDC) and Repic.

Contact: linda.strande@eawag.ch

Monitoring Community Health Through Drainage in Kampala

This study explores how pathogen monitoring in drainage water could provide early warnings of disease outbreaks in densely populated urban areas with non-sewered sanitation. Seju Kang[1,2], Rosi Siber[3], Jude Zziwa Byansi[4], Gloria Mirembe[4], Flavia Zabali Musisi[4], Annet Kagene Kyeyune[4], Christopher Kanyesigye[5], Gava Job Ssazi Pius[5], Charles B. Niwagaba[6], Timothy R. Julian[2], Linda Strande[1]

Seju Kang

Photos: *Left:* Drainage channels in Kampala, Uganda; *Right:* Ten drainage sampling points (white circle) with the corresponding micro-catchments (grey region) and two wastewater sampling points at centralised treatment plants (red circle) across five divisions of Kampala.

Introduction

Wastewater-based surveillance (WBS) has been acknowledged as an unbiased and affordable approach to track the spread of infectious diseases in urban populations. It proved particularly valuable during the COVID-19 pandemic, when the levels of SARS-CoV-2 in wastewater closely mirrored trends in clinical cases [1]. However, this monitoring strategy depends on sewer infrastructure, and nearly half of the global population is served by non-sewered sanitation [2], making it difficult to trace how diseases circulate within these communities. This study has adopted a new approach to environmental surveillance for urban areas without sewers.

Methodology

Our study focuses on Kampala, Uganda, a rapidly growing city, where over 80 % of the residents rely on non-sewered sanitation. It is evaluating whether monitoring open drains from micro-catchments (Photo, left) – defined as small, local hydrological catchment areas typically serving tens of thousands of people – can serve as a proxy for understanding public health trends. Drawing on existing research tools, such as the Excreta Flow Diagram (SFD) and the Quantities and Qualities (Q&Q) approach [3], we identified potential sampling locations throughout the city. Key informant interviews and field observations led to the selection of ten drainage sites, representing a range of housing types, building use, income levels, and sanitation management. Wastewater sampling was also done at two centralised sewage treatment plants as a basis for comparison (Photo, right).

Sampling took place on ten weekdays in March 2025, marking the start of the rainy season. At each location, several indicators of human faecal contamination: *E. coli*, total suspended solids (TSS), and pepper mild mottle virus (PMMoV) – a common marker virus found in human faeces, were measured. Using digital PCR assays, tests for the presence of a range of enteric and respiratory viruses, including Norovirus, Rotavirus, SARS-CoV-2, influenza A and B, and respiratory syncytial virus (RSV) were done.

Current and future work

A comparison between drainage and wastewater samples revealed higher concentrations of human faecal indicators and pathogens in centralised influents, as expected. While pathogens were detected in drainage samples, their levels were typically lower, suggesting that monitoring open drainage can still provide valuable insights into pathogen presence. Norovirus and Rotavirus were always detected, and SARS-CoV-2 and influenza A were often detected at low levels. Because influenza B and RSV were rarely or not detected, their absence may reflect lower levels in the population. Nonetheless, the detection of some pathogens, even at lower concentrations, suggests that drainage monitoring can be used for either routine surveillance to identify trends and changes in the incidence of endemic diseases with a relatively high, constant burden, or for early detection of outbreaks, which requires the ability to detect signals from a small number of infected individuals.

Ongoing analysis aims to understand how differences among drainage sites correlate with upstream sanitation infrastructure and population density. This will help refine the sampling strategy and evaluations of how reliable drainage-based surveillance reflects community-level health trends. Ultimately, our aim is to develop a reliable framework for using drainage to monitor health in urban areas with non-sewered sanitation. Drainage-based surveillance could offer a practical and affordable alternative for monitoring community health. By adapting existing tools to local realities – taking into account geological and sanitation differences across cities and countries – this approach could strengthen public health systems. To be effective, it must be supported by robust infrastructure, trained personnel, and strong community trust. As urbanisation continues in many low- and middle-income countries, scalable and inclusive public health tools will be increasingly important. •

References

[1] Ciannella, S. et al., 'Recent progress on wastewater-based epidemiology for COVID-19 surveillance: A systematic review of analytical procedures and epidemiological modeling', *Science of the Total Environment*, 878, (2023), 162953.

[2] Strande, L., 'Integrating recent scientific advances to enhance non-sewered sanitation in urban areas', *Nature Water*, 2/5, (2024).

[3] Strande, L. et al., 'Methods to reliably estimate faecal sludge quantities and qualities for the design of treatment technologies and management solutions'. *Journal of Environmental Management*, 223, 898–907. (2018).

[1] Eawag / Sandec, Switzerland
[2] Eawag / Umik, Switzerland
[3] Eawag / Siam, Switzerland
[4] Kampala Capital City Authority (KCCA), Uganda
[5] National Water and Sewerage Corporation (NWSC), Uganda
[6] Makerere University, Uganda
Funding: Eawag Discretionary Funding
More information: eawag.ch/emoch
Contact: seju.kang@eawag.ch

Molecular Approaches to Understanding Greenhouse Gas Emissions in Sanitation

Why pair qPCR with next-generation sequencing to understand methane emissions in sanitation systems? This study highlights the critical intersection of public health and engineering in generating evidence to inform future climate mitigation strategies. Kelsey Shaw[1,2], Caetano Dorea[2], Linda Strande[1]

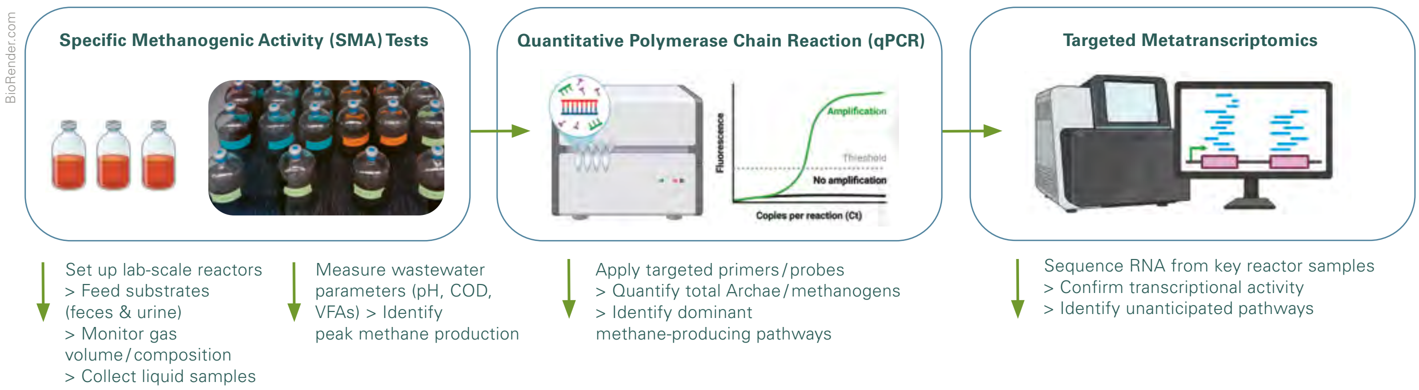


Figure: Combining molecular and analytical techniques into an integrated workflow.

Introduction and context

As global efforts to address climate change intensify, the role of non-sewered sanitation (NSS) systems in greenhouse gas (GHG) emissions is gaining attention. Although nearly half the world's population is served by NSS [1], their methane emissions are still poorly characterised [2]. While current discussions around sanitation and climate often focus on technologies for methane capture or reduction, there is a great need to first understand how the emissions are generated. This is where molecular tools offer exciting potential. By unravelling the microbial mechanisms behind methane production, the evidence base required for targeted, effective climate action in the sanitation sector can be developed. Our study is evaluating the methanogenic activity potential and microbial community dynamics of wastewater stored in NSS containments (i.e. tanks and pits) in anaerobic conditions in the laboratory.

Methodology overview

Our study combined molecular and analytical techniques into an integrated workflow (Figure).

- Laboratory-scale anaerobic serum-bottles were used to assess the methanogenic activity of wastewater collected from NSS containments. Reactors were fed with faeces and urine, and included positive and negative controls. Gas volume and composition were monitored and liquid samples collected throughout the methane production curve to analyse key wastewater parameters (i.e. pH, COD, alkalinity, and volatile fatty acids (VFAs) and ammonia) to provide a controlled yet representative view of potential methane production pathways.
- qPCR effectively measures the copy number of specific DNA regions, such as functional or taxonomic marker genes, to get quantitative information on the absolute abundance of target microorganisms or genes within a sample. It was applied to the reactor time-series samples, using targeted primers and probes. This cost-effective method enables high-resolution, replicated analysis of microbial abundance and dynamics. While less comprehensive than next-generation sequencing, it yields key insights into temporal shifts in total archaea methanogens, and into dominant methane-producing pathways.
- Metatranscriptomics reveals active gene expression by sequencing RNA transcripts to profile mRNA expression levels. Our study applied this to a selected subset of reactor samples to confirm whether transcriptional activity aligned with qPCR trends, and to identify unanticipated pathways and organisms. Targeting samples from peak activity or key transitions, identified with qPCR, enables deeper functional insight at a fraction of the cost of full-scale sequencing, and allowed us to validate and extend our findings.

Implications

Integrating these tools can lead to better understanding of the microbial processes behind methane emissions in sanitation systems. This is essential for three reasons: 1) identifying dominant methanogenic pathways helps determine the biological drivers of emissions, which vary by system type and management conditions, 2) our findings will provide a more robust evidence base for deciding whether interventions, i.e. alternative treatment technologies or operational changes, are needed to reduce emissions, and 3) combining microbiology, environmental engineering, and public health supports a holistic understanding of NSS systems within the broader climate context. •

References

[1] Strande, L., 'Integrating Recent Scientific Advances to Enhance Non-Sewered Sanitation in Urban Areas', *Nature Water*, 2/5, (2024), 405–18.

[2] Shaw, K., et al., 'Non-Sewered Sanitation Systems' Global Greenhouse Gas Emissions: Balancing Sustainable Development Goal Tradeoffs to End Open Defecation', *Sustainability*, 13/21, (2021), 11884.

[1] Eawag/Sandec, Switzerland
[2] University of Victoria, Canada
Contact: kelsey.shaw@eawag.ch


Inadequate Chlorine
Water
2. Contaminated Water
Wate
4. Intermittent Supply
Water

Strategic Environmental Sanitation Planning

As the world becomes progressively more urban, and humanitarian needs increase, the challenge to provide safe and effective sanitary arrangements becomes even greater. Sandec's research on Strategic Environmental Sanitation Planning (SESP) aims to address the complexity of urban sanitation systematically. Our research combines aspects of engineering with planning methods and social science approaches and includes four fields of activity:

- Developing and validating comprehensive approaches for planning Citywide Inclusive Sanitation that includes a variety of technologies and service delivery mechanisms.
- Exploring the governance and enabling environments necessary for sustainable local service delivery (including financial, technological, socio-cultural and institutional issues).
- Validating appropriate, cost-effective sanitation systems in peri-urban, slum, small town, and refugee camp settings.
- Providing backstopping services to humanitarian aid partners on water, sanitation, and hygiene in emergencies.

Photo: A WABES Integrate project stakeholder workshop in Kakooge, Uganda in March 2025.

Photo by Marisa Boller.

Strengthening Stakeholder Engagement in our Applied Research in Uganda

Active and meaningful stakeholder engagement in the WABES Integrate research project in Uganda has been key to achieving impactful research outcomes. The participatory research strategies, methods, and benefits are explored in this article. Abishek S Narayan[1], Charles B. Niwagaba[2], Ronald Sakaya[2], Abubakar Batte[2], Christoph Lüthi[1]

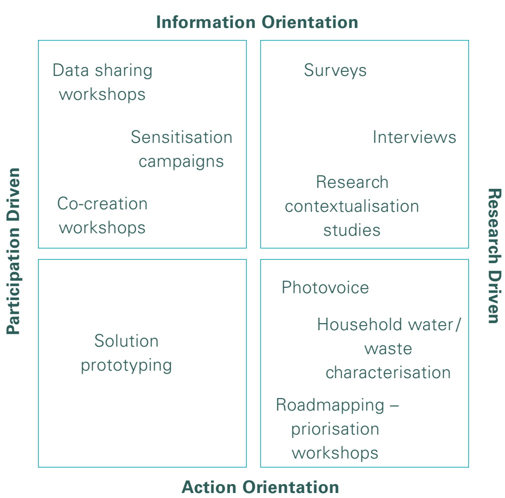


Figure: Various activities of the WABES Integrate project mapped in the 2 x 2 participatory research framework [2].

Introduction

Stakeholder engagement is crucial in any development research project, particularly, in the Water, Sanitation, and Hygiene (WASH) sector, because it ensures that the needs, priorities, and perspectives of all relevant stakeholder groups are integrated into the project design and implementation [1]. By involving local communities, government agencies, and other relevant actors from the outset, projects are more likely to align with local realities, foster a sense of ownership, and address the actual challenges faced by the local communities.

A participatory approach, especially in water research, enhances the relevance and impact of research findings, and improves decision-making, accountability, and the sustainability of project outcomes [2]. It also fosters stakeholder engagement in the four main project objectives, i.e. normative, substantive, social-learning, and implementation [3]. There are several approaches to stakeholder participation. According to a 2 x 2 participatory research framework (Figure), these approaches are generally oriented either towards information or action, and driven by a participation focus or a research focus [2].

Participatory strategies and methods

The WABES Integrate project, which brings together several interdisciplinary groups, focusses on understanding interlinkages between the water, sanitation, and solid waste sectors, and developing an integrated planning approach for these services [4]. Our geographic focus is two towns in Uganda – Kakooge and Wobulenzi (20,000 – 30,000 residents), where we have been working since 2022. (See the article on pp. 52–53 for more information about WABES Integrate.)

Building on the above participatory principles, the WABES Integrate project adopted a tailored approach to stakeholder engagement, translating theory into practice in the two towns. Several early and inclusive steps were taken that ensured the appropriateness of the research questions, suitability of methods, reliability of the results, and sustainability of the project outcomes. Some of these strategies were:

1. Selection of case study sites: Carried out with guidance from representatives of the Ugandan Ministry of Water and Environment.

2. Engagement with various levels of government: Entailed working closely with the relevant national, district, and town level officials on data exchange and research plans, and visits.

3. Mandatory research approval: Received ethics, health, and safety approvals from the relevant Ugandan agencies, and approval of data collection strategies from the respective jurisdictions.

4. Engagement in national workshops: Participation of research teams, and local and national stakeholders in annual high-profile events, such as the Uganda Water and Environment Week (Photo 1).

5. Practitioner-oriented data formats: Apart from the usual scientific formats, policy briefs, research briefs, photo exhibits, and 1-1 meetings were carried out to share data and learnings as much as possible in the local language and using jargon-free explanations (Photo 2).

6. Advisory board: Representatives with expertise on the research topics, experience with the research context, and familiarity with science to policy processes provided guidance on the direction of the research and regular feedback on the results.

7. Co-creation workshops: Several co-creation workshops for trainings, prioritisation, solution profiling, etc., ensured the integration of local knowledge, demand-driven activities, and higher ownership of the project outcomes.

8. Participatory research methods: Use of inclusive research methods for data collection, research formulation, contextualisation, and corroboration.

Benefits observed from the participatory approach

In the case of WABES, our stakeholder engagement allowed us to gain a deeper understanding of the nuanced WASH practices within communities and their interconnections. We observed that this involvement not only motivated stakeholders within the project, but also inspired positive changes beyond its immediate scope. For example, there were visible and reported improvements in sector services, such as increased solid waste collection in the towns, and an immediate uptake of the project results when they were shared, including improved chlorination practices. In addition, we noted enhanced cooperation among local actors and this improved local data management and maintenance work.

Abishek Narayan

Photo 1: A group discussion from a workshop on Science to Policy co-convened by Eawag at the Uganda Water and Environment Week 2025.

Our experience demonstrated that local communities and non-technical stakeholders developed a greater appreciation for the complexity of WASH services and the various factors influencing them through the use of the participatory approach. This trend is evident in other research studies [5]. Our aim is that this foundation will foster greater local ownership of future activities and support the long-term sustainability of the project goals. •

References

[1] Tsekleves, E. et al., 'Community engagement in water, sanitation and hygiene in sub-Saharan Africa: does it WASH?', *Journal of Water, Sanitation and Hygiene for Development*, 12/2, (2022), 143–156.

[2] Roque, A. et al., 'Participatory approaches in water research: A review', *Wiley Interdisciplinary Reviews: Water*, 9/2, (2022), e1577.

[3] Schmidt, L. et al., 'The objectives of stakeholder involvement in transdisciplinary research. A conceptual framework for a reflective and reflexive practise', *Ecological Economics*, 176, (2020), p.106751.

[4] Narayan, A.S. et al., 'Research Integrating Water, Sanitation and Solid Waste for Development', *Sandec News*, 24, (2023), 34–35.

[5] Valcourt, N. et al., *Assessment of Shifts in Stakeholder Understanding of WASH Systems*, (Sustainable WASH Systems Learning Partnership, 2021).

Abishek Narayan

Photo 2: A photovoice exhibition at the Ministry of Water and Environment, Kampala, Uganda.

[1] Eawag / Sandec, Switzerland

[2] CEDAT Makerere University / Uganda

The WABES Integrate project is a partnership between Eawag and Makerere University. It follows a transdisciplinary approach and involves research groups from Sandec and other institutions.

For more information: www.sandec.ch/integrate

Contact: abishek.narayan@eawag.ch

Improving Sanitation Services in Greater Tirana, Albania

Albania strives to meet EU standards for wastewater management. Sandec is contributing to an integrated sanitation and stormwater strategy for Greater Tirana, focussing on decentralised wastewater treatment and septage management in the peri-urban and rural areas. Philippe Reymond[1], Christoph Lüthi[1]

Photo: Aerial view of part of Tirana East Gate peri-urban area, featuring a mix of settlement types.

Context

As a prospective candidate for EU accession, Albania is working to align its wastewater management practices with the European Urban Wastewater Treatment Directive (UWWTD). The National Agency of Water Supply and Sewerage Infrastructure (AKUK) is spearheading these efforts together with the water and sewerage utilities. Funded by the Swiss State Secretariat for Economic Affairs (SECO), this project focuses on non-sewered areas in the municipalities of Tirana, Vora, and Kamza, which include large rural areas in a mountainous landscape. These areas can be characterised as fast-growing peri-urban areas with a wide variety of rural settlements (Photo). This project, following a Citywide Inclusive Sanitation (CWIS) approach, is complementary to another assignment led by project partners that focusses on understanding and modelling the sewer and stormwater networks in the urban core of Tirana.

Beyond Albania, in the countries of the Balkan region, even those that are already members of the European Union, wastewater management for small settlements with populations under 2,000 inhabitants also remains a challenge.

Different settlements, different solutions

Based on field visits, interviews with key informants, and a literature review, a typology has been established that unbundles the diversity of settlements to be served. These range from high-end real estate developments to small rural villages and individual housing. This typology will be used as the basis for the development of a catalogue of sanitation options for these contexts. There is no one-size-fits-all solution, and each context presents opportunities and constraints. The project will draw on past experience from other European countries, and the latest developments at Eawag and Switzerland.

Septage management

In non-sewered areas, individual buildings are mandated to have a septic tank. However, our analysis shows that septage management is not a big market in Tirana, at least formally. Three main reasons can be identified: **1)** most buildings discharge their wastewater in nearby drains or streams, with or without a holding/septic tank on the way, **2)** the obligation to have a properly designed septic tank is currently not enforced in most cases, and **3)** formal septic tank emptying service providers are very expensive. The lack of a formal septage disposal site in Tirana is seen as the main bottleneck, as the only permitted disposal point is around 40 km away. The project will formulate recommendations on how service costs could be reduced, how the future Wastewater Treatment Plant (WWTP) of Tirana could best receive the septage from the municipality, and how to enable the formalisation of a wider segment of the market.

A participatory strategy development process

The new strategy to be developed under this mandate is a unique opportunity to adjust to the latest urban developments, fill in the missing gaps from past projects and master plans, and create a common vision among the key stakeholders. Stakeholder involvement is an important component of the next project phase. Topics range from the discussion of options for selected urban areas, decentralised treatment for real estate development projects, septage management, and solutions for small rural villages.

The strategy developed will be the basis for master planning and investments under the lead of the World Bank. It may also lead to regulatory adjustments and capacity-strengthening initiatives. From an academic perspective, this initial engagement of Sandec in the Balkan region will help to deepen the understanding of how to operationalise CWIS, and the barriers and opportunities for decentralised wastewater management schemes. •

[1] Eawag / Sandec, Switzerland
This project is funded by the Swiss State Secretariat for Economic Affairs (SECO).
Webpage: www.sandec.ch/tirana
Contact: philippe.reymond@eawag.ch

Looking Back at Ten Years of Humanitarian WASH at Eawag-Sandec

Initiated by the Swiss Humanitarian Aid Unit, Sandec's engagement in humanitarian contexts has blossomed over the past decade into multi-faceted institutional backstopping, collaborations with various organisations, and active participation in the main humanitarian WASH platforms. Sara Ubbiali[1], Philippe Reymond[1], Christoph Lüthi[1]

Introduction

Traditionally working in development contexts, Sandec's entry into the humanitarian sphere started when the Swiss Humanitarian Aid (SHA) recognised the potential of its resources and research to address pressing humanitarian challenges in what would today be labelled the 'humanitarian-development nexus'. A first sanitation evaluation and training in North Korea (Photo) was followed by other assignments in the then under-recognised refugee camps of Cox's Bazar, Bangladesh. These initial collaborations quickly turned into a formal backstopping mandate, boosting Sandec's presence and outreach in the humanitarian landscape.

The Compendium as a catalyst

The Compendium of Sanitation Systems and Technologies rapidly became a powerful tool to train WASH specialists in a sector that was still very much focused on building latrines. With SHA's support, the Compendium was translated into new languages relevant for humanitarian contexts, such as Arabic, which significantly broadened its global reach. Soon after, a new milestone was achieved with the publication of a dedicated Compendium of Sanitation Technologies in Emergencies in collaboration with the German WASH Network. This collaboration led to a series of Compendia for use in emergencies, published in several languages: Water, Hygiene, and finally Solid Waste Management in 2025. All of these can be used interactively on web-based platforms, greatly facilitating access to WASH knowledge to practitioners.

The faecal sludge field laboratory

An innovation, which strongly benefitted from the SHA partnership, is the Faecal Sludge Field Laboratory (FSFL), a cost-effective and portable solution for faecal sludge analysis, co-developed with the Austrian Red Cross. This collaboration enabled the deployment of FSFLs in Bangladesh (Cox's Bazar), Uganda (Imvepi refugee camp), and Malawi, among other countries. The portable laboratory allows for measuring faecal sludge characteristics and treatment plant performance in locations that would otherwise not have access to a laboratory.

Philippe Reymond

Photo: Training North Korean engineers on how to use the Compendium in Pyongyang, North Korea, in 2013.

Backstopping for UNHCR

In 2021, SHA formally established Eawag's direct backstopping mandate for UNHCR through the newly formed Geneva Technical Hub (GTH). This led to the collaborative production of technical guidelines for sanitation and solid waste management (e.g. on lime treatment of faecal sludge in partnership with Oxfam, and on solid waste disposal). Among others, these resources have been presented in Community of Practice sessions organised by UNHCR, fostering direct engagement with field colleagues.

Capacity-building and global platforms

Beyond desk and field support, Sandec has provided several WASH trainings to SHA's expert pool and partners, and established long-term teaching collaborations with Swiss partners, such as an online course with the International Committee of the Red Cross (ICRC) and a Certificate of Advanced Studies with the University of Applied Sciences and Arts of Southern Switzerland (SUPSI) and the University of Neuchâtel. It also actively engaged in technical working groups of the Global WASH Cluster (GWC), the humanitarian coordination platform led by UNICEF. A landmark achievement was Eawag becoming an official GWC partner in 2023, culminating in hosting both the GWC cluster coordination meeting and the Emergency Environmental Health Forum (EEHF) in 2024. These events brought together over 250 participants.

After launching the Sanihub platform with partners, which aims to be the main repository for humanitarian sanitation knowledge, Eawag is currently engaged in the development of the WASH Hub. This umbrella platform should become the one-stop shop for humanitarian practitioners. And it will ensure that Eawag's extensive knowledge base is fully integrated into the humanitarian WASH sector.

At a time of humanitarian budget crises and increasing humanitarian needs, the availability of sound, practice-oriented technical guidance and tools, as well as effective cross-sector collaborations, are more relevant than ever. •

[1] Eawag / Sandec, Switzerland

For more information:
sandec.ch/humanitarian
emersan-compendium.org/
https://sanihub.info/

Contact: philippe.reymond@eawag.ch

Recent Developments in Climate Resilient WASH Planning and Financing

Increased recognition of the key role of WASH services in climate resilience to ensure public health, a strong economy, and environmental protection, has resulted in efforts being made to understand the complex interconnections that exist and levers to take action. Abishek S Narayan[1], Christoph Lüthi[1]

Abishek Narayan

Photo: An underground water well system in a water scarce region in Northern Africa.

In recent years, the WASH sector has been working towards integrating climate adaptation into its planning and financing strategies. There is also a growing recognition in the climate sector to integrate WASH into climate resilience strategies. Such shifts are seen in major climate agreements, including the UAE Global Climate Resilience Framework at COP28 and the Baku Declaration on Water for Climate Action at COP29.

The Sanitation and Water for All partnership, through a stakeholder driven process, defines Climate-Resilient Water, Sanitation and Hygiene (WASH) as 'services anticipate, respond to, cope with, recover from, adapt to or transform based on climate-related events, trends and disturbances, all while striving to achieve and maintain universal and equitable access to safely managed services, even in the face of an unstable and uncertain climate, where possible and appropriate, minimising emissions, and paying special attention to the most exposed vulnerable groups' [1].

The Green Climate Fund (GCF) through a collaborative process, including consultations with the Climate Resilient Sanitation Coalition (a voluntary working group in which Eawag-Sandec is also a member), launched the 'Practical guidelines for designing climate-resilient sanitation projects' (Annex III of their water security sectoral guide). The aim was to support governments and partners secure funding for climate-resilient sanitation projects [2]. This guide has helped to unlock climate financing towards the WASH sector, especially the sanitation sector, which receives only a trickle of global climate financing [3].

Sandec's *Compendium of Sanitation Systems and Technologies* is a useful tool in sanitation planning, but lacks information about climate resilience. A detailed literature review was done to systematically assess and document the vulnerabilities and adaptive capacities of select sanitation systems and technologies to droughts and floods. It was found that the most common technologies with climate resilience aspects were at the user interface, collection, and conveyance stages, and that proposed solutions for climate mitigation had contradictions between them. Some emergency-context technological advancements and problems were also identified. For example, although rapidly deployable toilets for disaster relief provide short-term support in emergencies, they are not suitable for the long-term.

From a planning perspective, such assessments can identify areas of high risk, but often overlook feedback mechanisms within the service chain. A systems perspective is needed to evaluate cascading effects and ensure that adaptive measures at one stage do not create challenges elsewhere (e.g. water-less toilets can cause problems in piped transport). Furthermore, the resilience of systems directly depends on the application context, where user adaptation can increase or decrease resilience irrespective of the systems [4]. In scenario-based planning, the selection of sanitation technologies must be based on a comprehensive understanding of their climate resilience, as well as social and economic considerations.

It is encouraging to see increased international commitment, clearer climate finance guidance, and stronger evidence for climate-resilient WASH. Research will be key in driving innovative solutions and effective planning. •

References

[1] *Definition of climate-resilient water sanitation and hygiene services* (Sanitation and Water for All and UNICEF, 2024).
[2] *Annex III: Practical guidelines for designing climate-resilient sanitation projects Water Security Sectoral Guide* (Green Climate Fund, 2024).
[3] Dickin, S. et al., 'Sustainable sanitation and gaps in global climate policy and financing', *npj Clean Water*, 3/24 (2020).
[4] Ahmed, T. et al., 'Discussion Paper: Climate resilient urban sanitation: From ideas to action', (IWA Publishing, 2025).

[1] Eawag / Sandec, Switzerland
Contact: abishek.narayan@eawag.ch

The Facility Evaluation Tool for WASH in Institutions

Sustainable Development Goals 4 and 6 include monitoring institutional WASH services in schools, healthcare facilities, and juvenile detention centres. The Facility Evaluation Tool is an easy-to-use mobile data collection tool developed to support this monitoring task. Vasco Schelbert[1], Pierre-Louis Bercion[2], Bruno Pascual[2], Christoph Lüthi[1]

Figure: Example of the FACET Analyzer Dashboard on Power BI showing overall results for healthcare facilities (left) and a comparison of multiple datasets, including baseline, multiple midlines, and endline datasets (right), facilitating comprehensive analysis over time.

Introduction

Institutional water, sanitation and hygiene (WASH) infrastructure in detention centres, schools, and health care facilities are key elements of sustainable development and significantly improve people's health and well-being worldwide. Monitoring their conditions is essential to maintain and improve these facilities.

The Facility Evaluation Tool for WASH in Institutions (FACET) is designed to support field practitioners – such as programme managers, enumerators, and data analysts – and institutions, monitor, evaluate, and gradually improve WASH services. Structured along the JMP laddered approach, FACET is based on globally recognised indicators. It supports both humanitarian and development actors by leveraging real-time mobile data collection and interactive dashboards that align with global Sustainable Development Goal (SDG) indicators and are adaptable to varied field conditions. FACET has been jointly developed by Eawag and Terre des hommes, with support from the UNICEF/WHO Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) and the Federal Department of Foreign Affairs Switzerland.

FACET 3.0 – What's new?!

Since the first release in 2017, FACET has been applied in over 50 projects in 25 countries. Based on field experiences and practitioners' feedback, the tool has now been comprehensively updated and expanded. FACET version 3.0 provides an enhanced, user-centred toolkit designed to monitor WASH services across institutions. Aside from schools (WinS) and healthcare facilities (WinH), it now also includes (juvenile) detention centres (WinD).

FACET comprises three integrated core components:

1. Easy data collection on the go: Survey forms for mobile data collection tools (XLSForms) compatible with open-source platforms and tools, such as KoboToolbox and ODK Collect, allow for flexible online and offline data collection.

2. Visual insights at your fingertips: An advanced PowerBI-based analysis dashboard enables dynamic, visual exploration of collected data (Figure).

3. Comprehensive guidance for all users: Comprehensive technical manuals and tailored online training materials can address specific user needs and roles.

Surveys are available in a short version (JMP core indicators assessment) and an expanded version (additional indicators). Monitored service areas include water supply, sanitation, hand hygiene, and solid waste management. FACET WinD additionally allows for the assessment of living conditions, whereas the WinS module now includes the Blue Schools approach developed by the Swiss Water and Sanitation Consortium. It can assess broader educational, environmental, and behavioural WASH components. Tailored for field users, data managers, and IT support staff, the manuals provide step-by-step guidance for implementing surveys, contextual adaptations, team training, data management and analysis, as well as reporting frameworks. For deeper insights, the FACET Analyzer features advanced data visualisation and analysis through an interactive PowerBI dashboard, supporting dynamic exploration of survey results.

Building skills and knowledge

Newly developed digital training materials are available to support users in mastering FACET. These resources are suitable for self-paced learning or for facilitating workshops, providing practical walkthroughs, interactive explanations, and adaptable survey examples.

Open, accessible, and ready to use

All FACET materials – updated manuals, guides, and training resources – are professionally laid out, available in English and French, and freely accessible as open-source tools at:
www.sandec.ch/facet and https://facet.tdh.org

[1] Eawag / Sandec, Switzerland
[2] Terre des hommes, Switzerland
Contact: christoph.luthi@eawag.ch

Water Supply and Treatment

A safe and reliable drinking water supply is a foundation of health and well-being. The Water Supply and Treatment (WST) group examines treatment technologies, monitoring systems, and training tools in support of extending and sustaining access to safe drinking water. Current projects focus on:

- Implementing in-line chlorination at scale.
- Strengthening water quality testing laboratories in remote rural areas.
- Evaluating integrated approaches for water supply, sanitation, and solid waste planning.
- Developing experiential measures for assessing institutional WASH.

Photo: Amrita Kumari Rana, the operator of a rural water supply system in western Nepal constructed by Helvetas Nepal, conducting routine monitoring of basic water quality parameters.

Photo by Sara Marks.

Optimising Chlorination Methods in Rural Nepal: A Scoping Study

Passive chlorination shows promise for delivering safe drinking water in rural areas in Nepal. Sandec and Helvetas Nepal researchers are developing guidance on selecting appropriate chlorination technologies and arrangements for rural piped water supplies. Rachel Boyer[1], Marsia Boller[1], Bal Mukunda Kunwar[2], Madan Bhatta[2], Sara J. Marks[1]

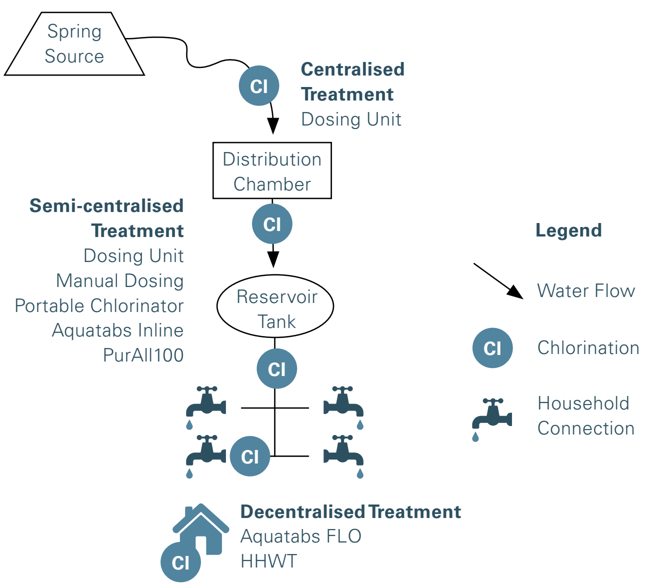


Figure: Schematic of a typical water scheme in northwestern Nepal, with study variables.

Introduction

Globally, piped drinking water supplies are becoming more prevalent to support access to on-demand and safe drinking water. However, an estimated 57 % of piped supply users in rural areas rely on microbially contaminated water (globally, as of 2020), leaving them susceptible to waterborne illnesses [1]. Passive chlorination is a promising way forward, since it can be retrofitted to existing systems, minimises operational requirements, and does not require behaviour change or electricity. Yet, its widespread adoption and full health gain realisation is limited by the absence of guidance on how to select appropriate chlorination technologies and installation locations. There is also a lack of performance evaluation and sustainable operation studies [2].

Objectives

This SDC-funded study under the WABES Integrate project will assess and compare the cost efficiency, treatment efficacy, managerial feasibility, and user acceptance of ten rural water schemes in the Surkhet and Dailekh districts in the northwestern, hilly region of Nepal. It builds on over a decade of collaboration on safe drinking water solutions in rural Nepal (See p. 41). The schemes differ by where the chlorinator is installed (i.e. level of centralisation) or which chlorination mechanism/technology is used [i.e., passive erosion, semi-automated injection (dosing units) or manual chlorination], as shown in the Figure. A community practicing household water treatment (HHWT) is also included in the study, since HHWT is still common worldwide.

Methods

Over eight weeks, operational water quality parameters are being regularly monitored at key points in the distribution system. Operators will be surveyed (1–2/scheme) to understand how easy/difficult their role is in maintaining the system, total costs, and chlorine availability. Households will be surveyed (29/scheme) to assess overall user satisfaction. This mixed methods approach facilitates a comprehensive evaluation of each scheme, while adhering to resource constraints.

Study considerations

This study will be the first to systematically compare more than two chlorination mechanisms and consider the degree of centralisation outside of emergency contexts. In a centralised scheme, one chlorination unit is purchased and maintained. However, since the chlorinator is placed relatively far from the users, higher chlorine doses may be needed, risking wastage where water stagnates or is bypassed in/before a reservoir. Operation and maintenance can be complicated due to increased travel distances. Alternatively, decentralised chlorination systems minimise wastage and recontamination with precise dosing. However, as the number of units increase, operation and maintenance needs and upfront costs also do so concomitantly. Semi-centralised treatment offers a combination of these benefits and drawbacks.

Conclusion

This study aims to elucidate the key factors involved in the sustainable implementation of chlorination systems in rural settings. The results will highlight the trade-offs between emerging (i.e. passive chlorinators or semi-automated injection systems) and conventional systems, such as manual chlorination and HHWT options. •

References

[1] Cherukumilli K. et al., 'Estimating the Global Target Market for Passive Chlorination,' *Environ. Sci. Technol. Lett.*, 10/1, (2022), 105–110.

[2] Lindmark M. et al., 'Passive In-Line Chlorination for Drinking Water Disinfection: A Critical Review,' *Environ. Sci. Technol.*, 56/13, (2022), 9164–9181.

[1] Eawag / Sandec, Switzerland
[1] Helvetas-Nepal
Contact: sara.marks@eawag.ch

A Decade of Rural Water Quality Monitoring and Management in Nepal

Over the past decade, Helvetas Nepal and Sandec have collaborated to strengthen water quality monitoring and management in rural Nepal. A recent workshop in Kathmandu showcased key insights from a risk-based approach for achieving safe water.
Marisa Boller[1], Bal Mukunda Kunwar[2], Madan Bhatta[2], Katrina Charles[3], Saskia Nowicki[3], John Brogan[4], Sara Marks[1]

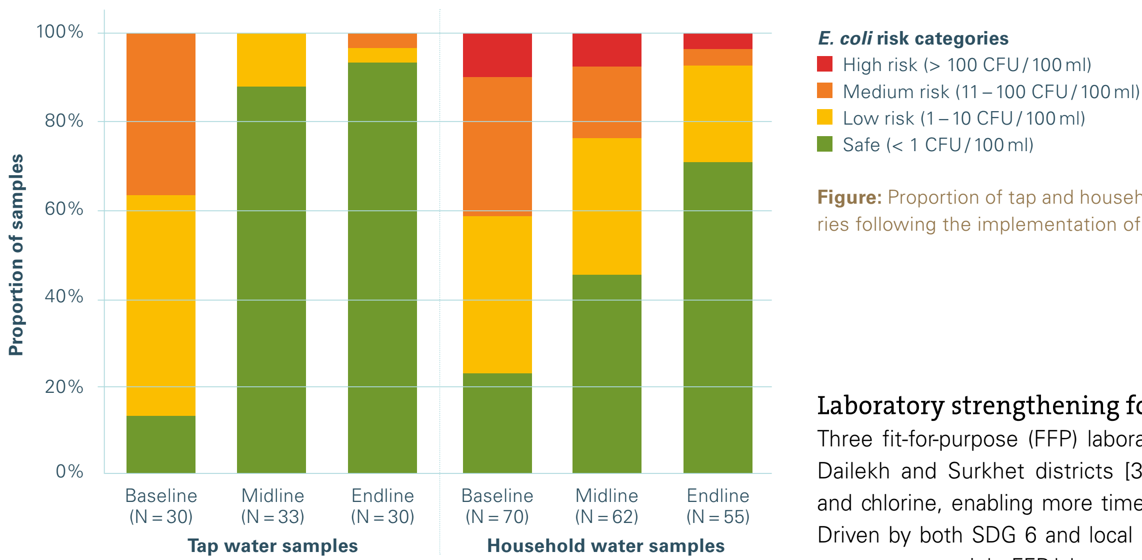


Figure: Proportion of tap and household water samples in WHO risk categories following the implementation of passive chlorination [2].

Introduction

There has been a decade-long collaboration between Helvetas Nepal and Sandec under the REACH programme, led by the University of Oxford, to strengthen rural water quality monitoring and management. To showcase the progress made, a knowledge-sharing workshop was held in Kathmandu in January 2025 with government representatives, implementing agencies, non-governmental organisations, political leaders, and water system operators, to reflect on achievements and discuss the way forward.

Understanding the challenge

In 2015, the programme began with a comprehensive assessment of microbial water quality in rural piped water schemes of western Nepal. Early findings were concerning: 93 % of tap samples and 83 % of household-stored water were contaminated with *Escherichia coli (E. coli)*, indicating faecal contamination risks [1]. These results emphasised the need for a risk management approach to identify contamination sources and inform mitigation actions.

Risk-based interventions to improve water quality

A Water Safety Plan (WSP) approach was adopted to identify contamination risks and implement targeted interventions across five schemes in Dailekh district, including source protection, water quality testing field laboratories, household hygiene promotion, and community training. While these measures significantly reduced *E. coli* contamination to 50 % at taps and 47 % in household-stored water, they did not guarantee safe water at the point of use [1]. To strengthen microbial safety, system-level passive chlorination was introduced in six piped schemes in 2019. In one year, the proportion of samples contaminated with *E. coli* decreased from 87 % to 7 % at taps, and from 77 % to 29 % in household-stored water [2]. This demonstrated the effectiveness of a multi-barrier approach that includes residual chlorine in stored water to provide ongoing disinfection.

Laboratory strengthening for sustainable operation

Three fit-for-purpose (FFP) laboratories were established in 2018 in Dailekh and Surkhet districts [3] to monitor *E. coli*, pH, turbidity, and chlorine, enabling more timely responses to water safety risks. Driven by both SDG 6 and local demand for improved water quality management, eight FFP labs were later established across Karnali and Sudurpaschim provinces between 2018 and 2022. Further expansion of FFP labs is ongoing.

Future of the collaboration

The results of this partnership demonstrate that sustained and continued improvements in safe rural drinking water are achievable through a risk-based approach, regular monitoring, affordable technologies, and local ownership. Our work supports scale-up and uptake by other implementing agencies and long-term improvements in water safety. Learnings from Nepal, REACH sites in Kenya with FundiFix, and in Bangladesh with SafePani have also supported the development of tools and guidance for rural water quality laboratory setups. The collaboration between Helvetas Nepal and Sandec continues under the WABES Integrate project, which is evaluating different chlorination technologies across varying levels of centralisation to guide optimal treatment strategy selection (See p. 40 for the article about this chlorination study). •

References

[1] Tosi Robinson, D., et al., 'Assessing the impact of a risk-based intervention on piped water quality in rural communities: The case of mid-western Nepal', *IJERPH*, 15/8, (2018), 1616.
[2] Crider, Y. S., et al., 'Evaluation of system-level, passive chlorination in gravity-fed piped water systems in rural Nepal', *ES&T*, 56/19, (2022), 13985 – 13995.
[3] *Fit-for-purpose labs for monitoring and managing rural water supplies* (Oxford, REACH, 2023).

[1] Eawag / Sandec, Switzerland
[2] Helvetas Nepal
[3] University of Oxford, UK
[4] Helvetas Swiss Intercooperation, Switzerland
Contact: marisa.boller@eawag.ch

Clara NextGen: Improving Electrochlorination Accuracy and Reliability

A collaboration between Eawag, CSEM, and CLARA Water AG aims to improve the chlorine dosing in untreated water. The technology developed will improve access to safe water. Nicolas Seemann-Ricard[1], Donato Patrissi[2], Roger Limacher[3], Jihyun Lee[3], Noa Schmid[3], Marisa Boller[1], Stefano Cattaneo[3], Sara Marks[1]

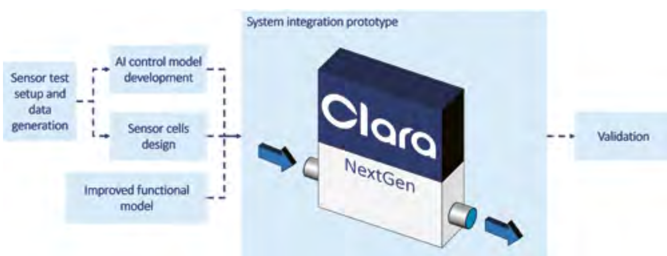


Figure: Main work packages of the Clara NextGen project.

Seid Kifle

Photo: Operator refilling Clara V2 with brine solution.

Introduction

Achieving Sustainable Development Goal 6 – universal access to safe and affordable drinking water – requires scalable, reliable, and locally adaptable water treatment technologies. The Clara online electrochlorinator (Photo) is a promising solution. Unlike passive chlorinators that rely on chlorine tablet supply chains and have difficulty dealing with water quality and flow variations [1], Clara generates the chlorine solution *in situ* using table salt and solar energy. This solution is then dosed using pumps based on water flow in a distribution pipe.

Over 20 Clara systems have been installed across Ethiopia, Madagascar, and Kenya. These self-contained devices have been shown to significantly reduce *E. coli* contamination in distribution networks [2]. However, CLARA Water's experience in commercialising these devices revealed opportunities for improving user experience and the consistency of free residual chlorine levels at consumption points.

The Innosuisse-funded Clara NextGen project is a 2-year partnership between CLARA Water AG, CSEM, and Eawag to create the next-generation Clara device (Figure). This project focuses on developing: **1)** adaptive dosing based on real-time water quality sensing, **2)** a revamped hydraulic system to reduce manual operation and maintenance, and **3)** improved remote communication for retrieving quality data and key process parameters.

Research & Development activities

A custom inline water chlorination test bench at Eawag will be used to simulate chlorination dynamics for groundwater and surface water sources. An array of direct (free residual chlorine) and lower-cost proxy sensors (oxidation-reduction potential, pH, temperature, and conductivity) placed up- and downstream of the chlorination point will collect data on water quality, chlorine demand, and chlorine decay across various water compositions.

CSEM's artificial intelligence (AI) specialists will use these data to develop a model capable of estimating the optimal chlorine dose based on the proxy-measurements enabling a target free residual chlorine level at the outlet of the Clara device and, consequently, at the end of the distribution system. In parallel, CSEM will also lead the redesign of the hydraulic and chlorine dosing system. The main objectives are to automate brine generation, reduce points of failure, and decrease the frequency of manual operator intervention from several times a day to once a week.

The second phase of the project (2026–27) will focus on combining the sensor array, AI modelling, and revamped system design to build a prototype. This system will be installed in Ethiopia to validate and finetune chlorine control. Here, the focus will also be on developing the back-end data management and graphic user interfaces.

Outlook

The Clara NextGen project represents an important step toward making water disinfection even more reliable, autonomous, and scalable. Ultimately, Clara NextGen's goal is to deliver a fully integrated, low-maintenance solution that can bring safe drinking water to more communities worldwide. •

References

[1] Lindmark M. et al., 'Passive In-Line Chlorination for Drinking Water Disinfection: A Critical Review', *Environ. Sci. Technol.*, 56/13, (2022), 9164–9181.

[2] Hänni J., 'Assessment of in-line chlorination and its effect on child health in rural Ethiopia' Master's Thesis, EPFL, (2024).

[1] Eawag/Sandec, Switzerland
[2] Clara Water AG, Switzerland
[3] CSEM, Switzerland
External funding: Innosuisse project number 121.676 IP-EE
Contact: nicolas.seemann-ricard@eawag.ch

Influence of Seasonality on WASH Insecurity in Healthcare Facilities

Assessing insecurities of water, sanitation, hygiene, and solid waste services in health care facilities across seasonal changes revealed that traditional access metrics do not fully reflect user experiences, and seasonal variability influences water quality and user perceptions. Olivia A. Ahebwa[1], Charles B. Niwagaba[1], Alex Y. Katukiza[1], Marisa Boller[2], Davis Majara[1], Sara Marks[2]

Olivia Ahebwa

Photo: Healthcare facility in Kakooge town.

Introduction

Access to water, sanitation, and hygiene (WASH), and solid waste management (SWM) is essential for infection prevention and control in healthcare settings; yet, many facilities in low- and middle-income countries struggle with sustaining these services, compromising patient safety and public health [1,2]. Water scarcity threatens access to essential services and poor SWM practices contribute to environmental hazards, disease transmission, and antimicrobial resistance. Many healthcare facilities worldwide lack basic water services and proper hand hygiene at the point of care [3]. While the Joint Monitoring Programme (JMP) evaluates WASH service access, it does not systematically account for user experiences, i.e. reliability and affordability. Yet, WASH insecurity is increasingly linked to declining service quality. Despite growing attention on WASH insecurity in healthcare settings, the role of seasonal variability – particularly how it shapes access, quality, and user experiences – remains underexplored in current research and policy frameworks.

Objective and methodology

The study used a mixed method approach to evaluate user experiences across seasons in 10 private and government health centres in Wobulenzi and Kakooge, Uganda (Photo), supporting the development of the INWISE (Institutional WASH Insecurity Experiences) scale. The goal is to generate evidence-based recommendations to enhance service sustainability, infection control, and patient safety. Between August 2024 and February 2025, the research team conducted structured surveys with 383 participants (130 medical and non-medical staff, and 253 recently discharged patients), direct observations based on JMP WASH service ladders, and water quality testing (pH, turbidity, residual chlorine, *E. coli*, and total coliforms) during both the dry and rainy seasons. Cognitive interviews refined survey data collection instruments, and statistical analyses (Spearman's correlation and multivariate logistic regression) were conducted.

Preliminary results – water

Most healthcare facilities used similar drinking water sources across seasons, with only two switching from rainwater in the rainy season to piped water or water supplied by truck in the dry season. *E. coli* levels were higher during the rainy season due to the contamination of rainwater and dispensers.

Comparing water quality with user experiences during the rainy season showed the following correlations. Better water quality was associated with fewer users reporting being affected in their activities by water issues ($\rho = -0.20$, $p = 0.001$), and with greater satisfaction with the drinking water available ($\rho = 0.15$, $p = 0.015$). However, during the dry season, better water quality was negatively associated with users' reported satisfaction and perceived water availability ($\rho = -0.14$, $p = 0.027$; $\rho = -0.13$, $p = 0.048$, respectively). This suggests that water quality alone may not improve users' experiences when quantity or access is limited. Better experiences are likely due to the combination of clean water and greater availability. Although the strength of the correlations was weak, these findings contribute to a growing evidence base on the role seasonality has on water users' felt experiences. The differing correlations between water quality and satisfaction with water availability during the dry and rainy seasons suggest that better water quality or higher JMP service levels alone do not necessarily translate to better user experiences. It also highlights the important role seasonality and water availability play in shaping user perceptions.

Conclusion

This preliminary analysis focused on the water-related measures and underscores the importance of both water availability and quality in healthcare settings, particularly during the dry season. The findings suggest that inadequate water supply services compromise patient and staff well-being, and point to the need for comprehensive water management strategies. These should address physical infrastructure and user perception and experience, as well as high contamination during the rainy season, to ensure consistent water access year-round, and support resilient healthcare environments in small towns. The impact of seasons on sanitation, hygiene, and SWM will be assessed in the next steps. •

References

[1] Embrey M. et al., 'Integration of IPC/WASH critical conditions into quality of care and quality improvement tools and processes: Bangladesh case study', *Antimicrob Resist Infect Control.* 13/1, (2024).

[2] WHO, *Water, Sanitation and Hygiene in Health Care Facilities* (World Health Organization, Published online 2015).

[3] WHO and UNICEF, *Wash in Health Care Facilities: Global Baseline Report 2019* (World Health Organization and the United Nations Children's Fund, 2019).

[1] Makerere University, Uganda
[2] Eawag/Sandec, Switzerland
Contact: marisa.boller@eawag.ch


PADAD

Water Safety Management

About 1.8 billion people use a source of water that is unsafe, and large disparities in access to water exist between rural and urban areas and among different regions worldwide. Sandec's Water Safety Management (WSM) research is developing and evaluating appropriate solutions to enhance water management, support the reliable access to water, and strengthen the consumption of safe drinking water in vulnerable households. Research activities focus on:

- Laboratory and field-level performance evaluation of innovative methods for drinking water treatment and safe storage in low-income areas.
- Assessment of effective and sustainable safe water interventions, strategies, and programmes.
- Impact evaluations of improved access to safe drinking water.
- Assessment of water management and climate resilience of WASH.

Photo: Training interviewers in The Gambia on how to conduct on-site water quality tests.

Photo by Regula Meierhofer.

Water Quality and Child Health Status in The Gambia Central River Region

In The Gambia, unsafe water and poor sanitation pose a significant health threat to children under the age of five years. This study investigated the factors associated with the health and nutritional status of these children.

Loïc Fache[1], Emma Ossola[1], Regula Meierhofer[1]

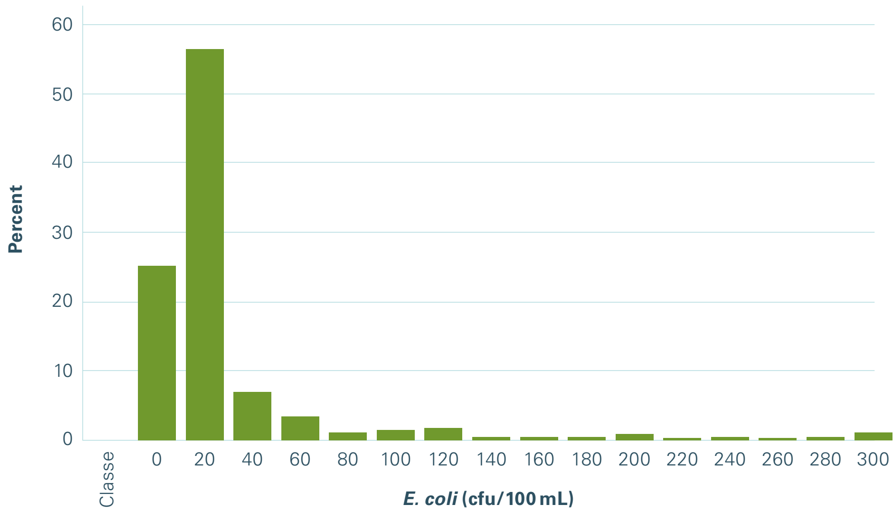


Figure: Counts of *E. Coli* CFU / 100 ml in drinking water containers at household level.

Introduction

According to UNICEF's indicators for The Gambia, the prevalence of diarrhoea among children under five was 23.7 % in 2018 [1]. And diarrhoea is the third leading cause of child mortality in the study region [2]. Children's repeated exposure to diarrhoea can lead to chronic malnutrition, inhibiting children from growing and healthy development [3]. This cross-sectional study aimed at understanding the WASH conditions in central Gambia and their link to water quality and child health.

Methods

A cross-sectional survey was conducted in 13 zones of the Central River Region of Gambia in July 2024. The communities selected for the study had to be as similar as possible in terms of: socio-economic conditions, population numbers, the number of alternative water sources, and the presence of other WASH programmes. Households with at least one child under five years of age were surveyed and interviews were done in a total of 601 households.

Water quality was assessed by measuring *E. coli* and coliforms at water distribution and consumption points using on site membrane filtration of 100 ml water samples and subsequent incubation on Nissui compact dry plates to measure colony forming units (cfu). Free residual chlorine (FRC) and pH were measured, using a pool tester with DPD Nr.01 and phenol red tablets, respectively.

Socio-demographics, water handling, hygiene practices, and child health data were collected via structured interviews, observations of WASH practices and clinical signs of malnutrition, and height, weight, and middle upper arm circumference (MUAC) measurements of the children. IBM SPSS 28 was used to calculate frequency statistics and univariate logistic regressions to assess the association of risk factors with child health outcomes. Child stunting, wasting, and thinness were assessed by calculating the Height-for-Age Z Score (HAZ), Weight-for-Age Z Score (WAZ), and weight-for-height (WHZ) scores, using WHO's AnthroPlus software.

Results

Socio-Demographics

Most respondents were female (97 %), while the household heads were predominantly male (97 %), and most households gained their income from farming (89 %). Education levels were low, with 90 % of the interviewees being unable to read or write. The households had average monthly expenses of 7346 GMD (about $ 100), and in 99.5 % of the cases, the respondents owned their own home. The median land ownership was three hectares, with an interquartile range of two to four hectares.

Water supply and safety

Most households (86 %) relied on standpipes for water. 71 % of them were public, while 15 % were private. The water came from solar-powered boreholes (Photo). Interruptions of the water supply for more than one week were reported by 57.7 % of the households. 38 % of the respondents reported that their water was chlorinated at least once during the past two years; however, no chlorine was found in the water during the time of data collection. Households did not treat their water 72 % of the time, and those that did only used cloth filtration.

Water was transported from the point of distribution to the point of consumption in jerrycans by 93 % of the respondents. For water storage, 57 % of the households used the same containers, while 39 % used clay pots as storage containers. Both storage and transport containers were cleaned frequently with soap or ash: 46 % of the transport containers daily and 31 % every second day, and 32 % of the storage containers daily and 41 % every second day.

Water quality
Water quality analysis at the point of consumption revealed that 23.3 % of the samples complied with WHO guidelines for drinking water quality. They contained 0 *E. coli* CFU / 100ml. However, 42.6 % of the samples were in the low-risk category (1 – 10 *E. coli* CFU / 100 ml) and 27.1 % in the medium- to high-risk categories (Figure).

Hygiene and household observations
During the observations, interviewers rated the cleanliness of water transport and storage containers, and 98.5 % of the containers were clean. Their observations showed that there were several indicators that highlighted challenging conditions in terms of household hygiene. 93 % of the households had a handwashing station, but 30 % lacked water and 77 % lacked soap. About 86 % of the households had a pit latrine in their yard and 66.2 % of the toilets were rated as clean. Animal faeces were observed in 60 % of the yards and inside 16 % of the homes.

Child nutrition and health
Stunting was observed in 36 % of the children, among these 16 % were severely stunted. The mean Height-for-Age Z-score was -1.4. About 43 % of the children were underweight or severely underweight. Poor diet, limited to rice or millet with occasional vegetables, was observed in many households. The interviewees reported a high incidence of infectious diseases in the last two weeks before their interview, including fever (54.4 %), cough (43.8 %), and diarrhoea (27.2 %).

The Table lists the factors identified as significantly associated with stunting using univariate logistic regression. An odds ratio (OR) superior to 1 indicates a positive association (i.e. the higher the ratio, the more stunting was observed).

Conclusion
The study highlighted a high prevalence of infectious diseases and malnutrition in the study area. The factors associated with stunting were related to household hygiene and girls had an almost three times higher odds ratio of being stunted. These findings highlight the need for improvements in WASH infrastructure and hygiene practices, particularly in the management of animal faeces, handwashing, and appropriate storage of drinking water. In addition, the findings show that more care should be provided to baby girls. •

References
[1] Unicef, 'MICS', [web page] (2024) <https://mics.unicef.org>, accessed 15 May 2025.
[2] Momodou, J., 'Health & Demographic Surveillance System Profile: Farafenni Health and Demographic Surveillance System in The Gambia', *International Journal of Epidemiology*, 44/3, (2015), 837 – 847.
[3] Berkman DS, et al., 'Effects of stunting, diarrhoeal disease, and parasitic infection during infancy on cognition in late childhood: a follow-up study', *Lancet*, 359 (2002), 564 – 571.

Variables		Sig	OR	95 %	CI
Frequency of cleaning the transport container	<1x / week	0.01	7.59	1.75	33.03
	1x / week	0.32	1.26	0.80	2.00
	2^{nd} day	0.03	1.54	1.05	2.28
Child sex (1 = female 0 = male)		<.001	2.85	2.01	4.05
Food added during the first 6 months (1 = yes 0 = no)		0.05	1.41	1.00	2.00
Storage container placed 30 cm above the ground (1 = yes 0 = no)		<.001	2.25	1.44	3.49
Drum with water in toilet available (1 = yes 0 = no)		0.04	0.69	0.49	0.98
No handwashing material available		0.01	1.57	1.12	2.19
Animal faeces visible inside the house (1 = yes 0 = no)		0.04	2.29	1.05	4.99

Table: Univariate logistic regression models of stunting (HAZ-score) and the significantly associated variables.

Emma Ossola

Photo: Women queuing for water at a solar borehole.

[1] Eawag / Sandec, Switzerland

Assessing the Viability of Water Governance in the Watershed of Tocantins, Brazil

The Water Flow Diagram and the Viable System Model were used to assess systemic water governance challenges. Deficiencies and weaknesses in monitoring, coordination, and law enforcement, and unequal distribution of water, uncontrolled abstraction, and water losses were found. R. Meierhofer[1], L. Fache[1], F.N.S. Souza[2], N.C.R. Bergiante[3], F. G. Silva[2], M.C.N. Belderrain[4], D. Spuhler[5], M. Schwaninger[6], J.M. Alves[2]

System 1 (S1)	Contains the primary operational unit of the overall system.
System 2 (S2)	Provides coordination and facilitates communication.
System 3 (S3)	Represents executive management, establishes rules, allocates resources, is responsible for monitoring and auditing and interacts with higher level systems.
System 3* (S3*)	Is an extension of System 3 and provides independent monitoring, adding an extra layer of auditing and control.
System 4 (S4)	Monitors the external environment and is responsible for strategic development and the conception of adaptions for the system to remain viable.
System 5 (S5)	Constitutes the normative management responsible for policy decisions

Table: The five interconnected subsystems of the Viable System Model.

Introduction

Water supply and water quality management in the watershed of Palmas, the capital of Tocantins, covering an area of 17,760 km^2, have been detrimentally affected by changes in precipitation patterns, including irregular and heavy precipitation events and extended periods of drought. These climate change related developments challenge the viability of the current water governance systems that need to balance the availability of resources, the need to satisfy different demands for the water, and opposing interests. By analysing the governance of water services in the region's watershed, our project aimed at identifying challenges and potential areas of improvement.

Methodology

To assess the viability of water governance, we combined the Water Flow Diagram (WFD) and the Viable System Model (VSM) and assessed the outcome with a broad range of stakeholders using a participatory approach. The WFD visualises water balances and flows in the dry and the rainy seasons, presenting volumes used for different utilisation processes, treatment, and contamination risks [1]. Data for the diagram were extracted from official reports and retrieved from models constructed using the Soil and Water Assessment Tool (SWAT+).

The VSM is a model to analyse the systemic complexity of management and governance structures, the regulation of their operations and the system's viability and adaptability in changing environments. It is structured into five interconnected subsystems, as presented in the Table [2].

Data were collected by reviewing documents, regulations and conducting qualitative interviews with representatives of different organisations. Two participative co-creation workshops were conducted with stakeholders from the federal and the state government, non-governmental organisations (NGOs), civil society organisations, including indigenous groups, the municipal authorities, and the water utility. Their aim was to review and discuss the WFD and the VSM diagnostics of the water governance system.

Results

The Water Flow Diagram

The WFD diagram highlights that during the dry periods, large volumes of water (116 Mio m^2) were abstracted for the irrigation of only 2.7 % of the agricultural area and that 25 % of the water was lost during transmission via pipes (Figure). In the urban water supply system, losses in the piped water systems amounted to 30–39%. Water losses above 30 % in urban distribution systems indicate that the systems are highly inefficient and problematic. Such losses often reflect poor system management or aging infrastructure, which result in economic and resource inefficiencies [3].

The run-off of pesticides from intensive agriculture, sewage from livestock production and partially inadequate sanitation in rural areas were identified as contamination risks. The adequacy of drinking water and waste water treatment in remote communities remained unclear. Not visualised in the diagram are the abstraction of groundwater and industrial water use as they were not regulated or monitored.

The Viable System Model – Diagnosis of water governance

Assessment of the subsystems in the VSM revealed that at the operational level (S1), there was an absence of a functioning local management unit in charge of balancing water utilisation with resource availability. This impaired the flow of information to the executive management (S3) of challenges "on the ground", such as uncontrolled abstraction, high water losses, and reports on water contaminating practices. At the same time, the implementation of normative and strategic measures established at the higher level of governance, including the collection of water fees, needed improvement. The function of local management was assumed by an intermediate consortium that was constrained by a weak decision-making autonomy, fragmented access to resources, and the lack of infrastructure and technical capacities.

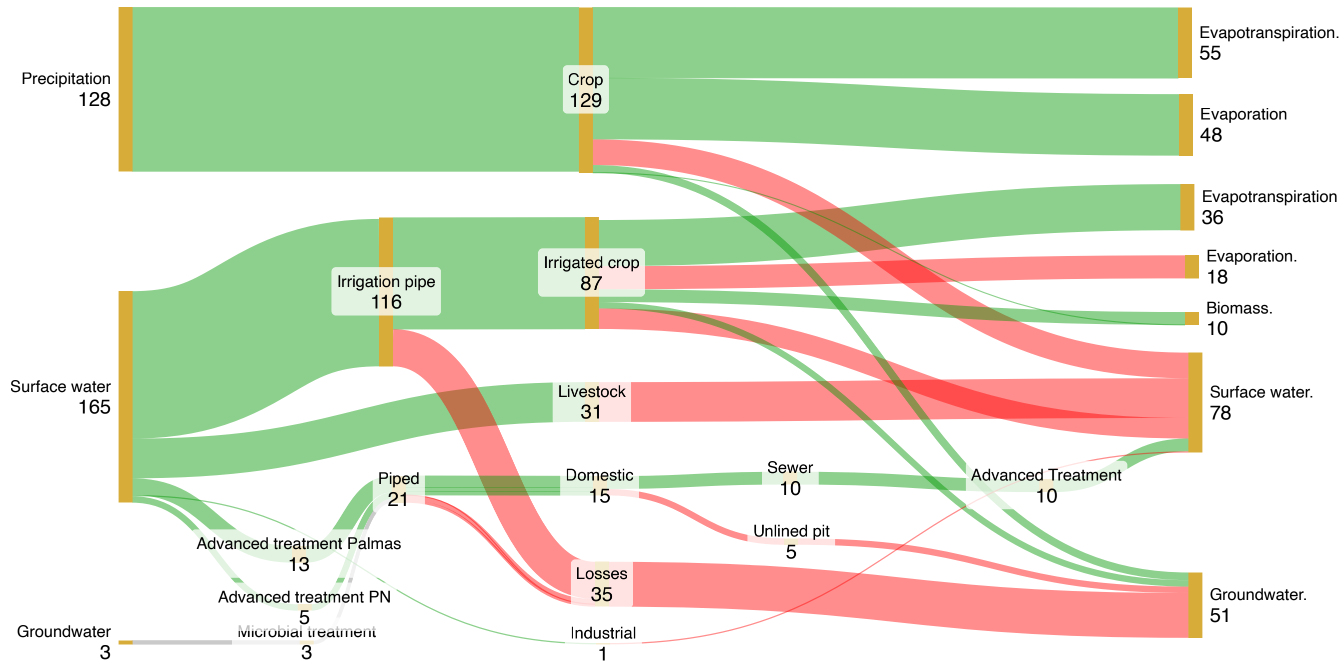


Figure: Water Flow Diagram for an average dry season (six months) based on data from 1993–2023. Water flows in Mio m^3.

Weak monitoring mechanisms on hydrometeorology and missing access to data platforms were identified as important weaknesses of the coordinative function (S2). As a consequence of the inadequate information systems, the exchange between organisations at different levels of management (Naturatins, Semarh, ATS, BRK, ANA) was affected.

The Palmas Lake River Basin Committee (CBHLP) is responsible for the executive management (S3) of the water services in the watershed of Lake of Palmas. It is composed of representatives from government agencies, water users (i.e. agriculture, industry, and municipalities), NGOs and community-based organisations, including indigenous groups. Currently, although the committee fulfils the regulatory requirements, its lack of doing consensus-building among the stakeholders hinders smooth cooperation between them. Naturatins has the role of supervising and auditing compliance with water service regulations (S3*). However, because of their responsibility to supervise a broad range of environmental licensing across the state of Tocantins, Naturatin's has limited capacity to do this task effectively.

The Tocantins State Department of Environment and Water Resources (Semarh) has the responsibility for strategic management and organisational development (S4) in the watershed of Lake of Palmas. Targets defined by Semarh have to be approved by the State Water Resource Council (CERH), which is the supreme political decision-making body of water service management in the state of Tocantins (S5). During our participatory observations, it was noted that the plans and accountability reports presented by Semarh were often validated by the CERH without thorough review or discussion. The absence of a critical debate can result in plans that do not reflect local realities and needs, and may lead to a mismatch of the alignment of operational activities with long-term strategies.

Conclusion

The combined application of the WFD and the VSM during a participatory analytical process proved to be effective in identifying challenges and potential mitigation measures in the governance of water service management in the Lake of Palmas river basin. The participatory diagnostic process identified a large gap between the regulated allocation of water utilisation and uncontrolled abstraction. This imbalance increased due to prolonged periods of drought, indicating that the institutional capacity of operations is below the threshold required to respond effectively to the environment's complexity.

An algedonic channel that transports alarms was lacking. This is problematic as potential threats, such as water scarcity, over-utilisation, and pollution, are not being recognised in advance, impairing the development of preventative or adaptive measures. Therefore, implementing effective monitoring and information exchange systems are recommended to improve coordination among regulatory agencies, support compliance with the legal requirements, as well as implementation, supervision and strategic planning, and to enhance the long-term viability of water service governance in the watershed of Lake of Palmas. •

References

[1] Bouman L. et al., 'The water flow diagram', *Frontiers in Water*, 6, (2024).

[2] Alves, J. et al., 'From the black box to the fish farming development policy project: A diagnosis from the viable system model', *Syst Res Behav Sci*, 38, (2020), 1–14.

[3] Alegre H. et al., *Performance Indicators for Water Supply Services* (IWA Manual of Best Practice, 2017, 3rd Edition).

[1] Eawag/Sandec, Switzerland

[2] University of Tocantins, Center for Development and Environmental Performance Assessment, Brazil

[3] Fluminense Federal University, Production Engineering Department, Brazil

[4] Aeronautics Institute of Technology, Management and Decision Support, Brazil

[5] Eastern Switzerland University of Applied Sciences, Institute for Environmental and Process Engineering, Switzerland

[6] University of St. Gallen, Institute of Management & Strategy, Switzerland

Education and Training

Sandec aims at reducing the global WASH capacity gap. It does this by offering a wide range of education and training initiatives. These cover face-to-face, blended and online formats, as well as fellowships. Five of our main focus areas are:

- Offering free online education at scale with the MOOC series "Sanitation, Water and Solid Waste for Development".
- Conducting research on digital learning in the WASH sector.
- Teaching Master's courses on Sanitary Engineering at EPFL Lausanne and ETH Zürich.
- Hosting Master's and PhD students and visiting scientists from low- and middle-income countries who receive Eawag Partnership Programme Fellowships.
- Fostering capacity development collaborations with partner institutions in Africa, Asia and Latin America.

Photo: Dr. Solomon Yared from Jigjiga University of Ethiopia met with Mr. Abubakar Batte from Makerere University of Uganda in Jigjiga to share their collaborative experiences and engagement in Water, Sanitation, and Hygiene (WASH) initiatives, particularly through their partnership with Eawag-Sandec.

Photo by Jigjiga University.

Co-creation of WASH and Solid Waste Management Capacities in Uganda

The partnership between the town councils of Kakooge and Wobulenzi, Makerere University, and Eawag-Sandec led to context-specific results. The developed co-creation approach has the potential to be successfully applied in other contexts. Abubakar Batte[1], Charles B Niwagaba[1], Laura Nelly Velásquez[2], Fabian Suter[2]

Abubakar Batte

Photo 1: Data collection during a GIS-session for technical staff of Kakooge town council led by Abubakar Batte from Makerere University.

Introduction

An integrated baseline assessment (IBA) of WASH and solid waste management (SWM) conducted in July and August 2023 revealed that both Kakooge and Wobulenzi, Uganda, face several WASH and SWM challenges. These include irregular waste collection, unlined sanitation infrastructure, and contaminated drinking water [1]. This resulted in the town councils of both towns, and participants from Makerere University and Eawag-Sandec, joining forces to develop and test a co-creation approach to increase the WASH and SWM capacities of the towns. The process of co-creation was selected due to its potential to clearly identify context-specific needs, build trust between the partners, facilitate social learning, and drive community transformation, as well as its adaptability to similar contexts [2,3].

Methodology

The capacity development collaboration started with a co-creation workshop during the Uganda Water and Environmental Week in March 2024. Twenty participants from both towns assessed the context-specific needs in the towns and identified two priorities: (1) a Geographic Information System (GIS) training for technical staff and (2) a WASH and SWM refresher training for town council members and Village Health Teams (VHT's). To kick-off the design process, the workshop participants jointly agreed on cornerstones of the selected priorities, i.e. content, format, and language.

The GIS-training was designed and led by from Makerere University and offered independently to members of both town councils over a period of four months (Photo 1). Video-based learning, using modules of the Massive Open Online Course 'Introduction to GIS Mapping' from the University of Toronto [4], was combined with hands-on sessions at the town councils. To ensure that the training was affordable, a free of charge software, QGIS, was used to train participants in data collection, visualisation, and analysis.

The WASH and SWM refresher training was co-designed and facilitated by participants from Makerere University and Eawag-Sandec. A three-day workshop was planned for 16 town council members and VHT representatives from both towns. During this time, participants first learned new knowledge and skills through practical exercises and, thereafter, taught their peers what they learned. The participants also designed exercises to transfer the knowledge and skills learned to members of their own communities (Photo 3). The 'learning buddy system' was a key feature of the training. Each participant was paired with someone from the other town to encourage reflection, brainstorming, and experience-sharing.

Practical exercises included collecting and testing water samples, simulating pollution scenarios at dumpsites, and implementing improvements, such as segregating, fencing, covering, and compacting waste. Short theoretical inputs, for example, on waste treatment technologies complemented the training. The final part consisted of teams from both towns making specific commitments to plan and implement WASH and SWM improvement activities in the coming months.

A half-day follow-up workshop was conducted separately in each town one month later to conclude the co-creation cycle. The activities that had already been fully initiated and implemented were discussed. Activity planning for the coming months was also done.

Results

One result of the co-creation approach was the start of a series of WASH and SWM improvement activities by team members in both towns. While some of them are already completed (e.g. WASH community sensitisation campaign, a benchmarking visit to the landfill in Gulu city, etc.), others are currently ongoing, such as water quality monitoring and mapping of unnamed roads in Kakooge. Further activities are planned for the near future (e.g. acquisition of water testing kits and developing town-wide waste collection services). The 'learning buddy system' strengthened connections between

Fabian Suter

Photo 2: Exchange about best WASH and SWM practices in Wobulenzi during the Practical WASH and SWM training.

Abubakar Batte

Photo 3: Prototyping exercise during the Practical WASH and SWM training.

the technical and political staff of both towns and facilitated the sharing of challenges, solutions, and ideas relevant to their contexts beyond the training. When asked about the key barriers to fully implement all of the planned activities, members of both towns mentioned limited financial resources and the lack of specific WASH and SWM capacities, such as the equipment and infrastructure to do water quality analysis and to upgrade dumpsites. Identifying practical solutions to overcome these barriers is part of the WABES Integrate project that runs until December 2026. Identifying practical solutions to overcome these barriers is part of the WABES Integrate project that runs until December 2026 (See pp. 32–33).

Conclusion

The process and results of the co-creation approach underline that community engagement alone does not automatically yield broad-based participation. Meaningful community participation can be deliberately cultivated through structured and intentional participatory approaches. Without such intentionality, efforts to engage communities risk falling short of their goals [5]. While the results in Kakooge and Wobulenzi are context-specific, the co-creation approach has the potential to be successfully applied in other contexts. A major strength of this approach is that it eliminates the need for a handing-over phase as local stakeholders are co-leaders of the process from the beginning. •

References

[1] Narayan A. et al., 'Integrated Baseline Assessment of Water, Sanitation and Solid Waste Management', *Sandec News*, 25, (2024), 34–35.

[2] Wainaina G., 'Co-creation: The missing ingredient in WASH solutions', *AVOW – Africa's Voice on Water*, Autumn 2024. p.36.

[3] Jacobi, J. et al., 'Transdisciplinary co-creation increases the utilization of knowledge from sustainable development research', *Environmental Science and Policy*, 129, (2022), 107–115.

[4] Online course series 'GIS, Mapping, and Spatial Analysis Specialization' by Toronto University on Coursera https://www.coursera.org/specializations/gis-mapping-spatial-analysis#courses.

[5] Tsekleves, E. et al., 'Community engagement in water, sanitation and hygiene in sub-Saharan Africa: Does it WASH?', *Journal of Water, Sanitation and Hygiene for Development*, 12/2, (2022), 143–156.

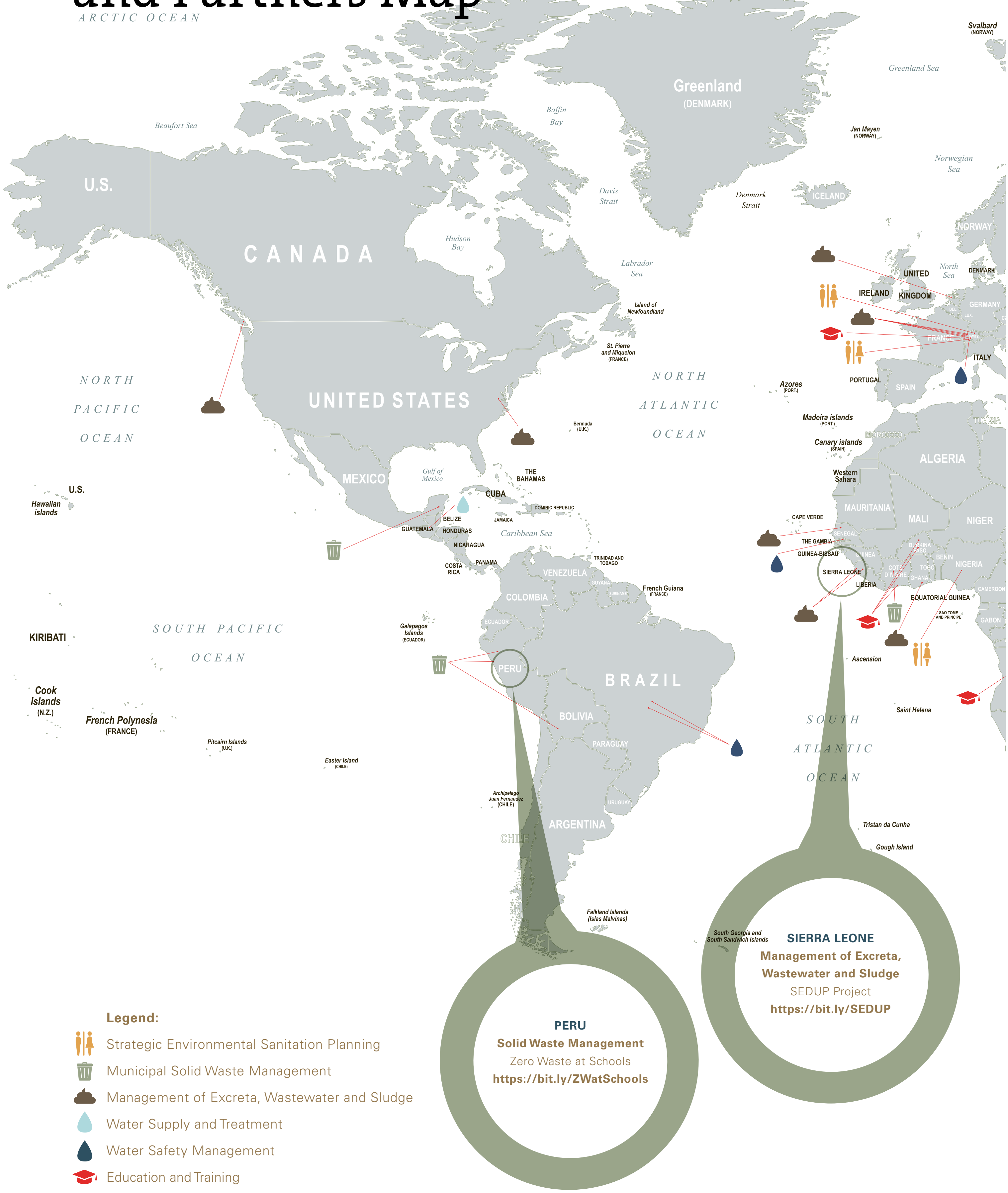
[1] Makerere University, Uganda

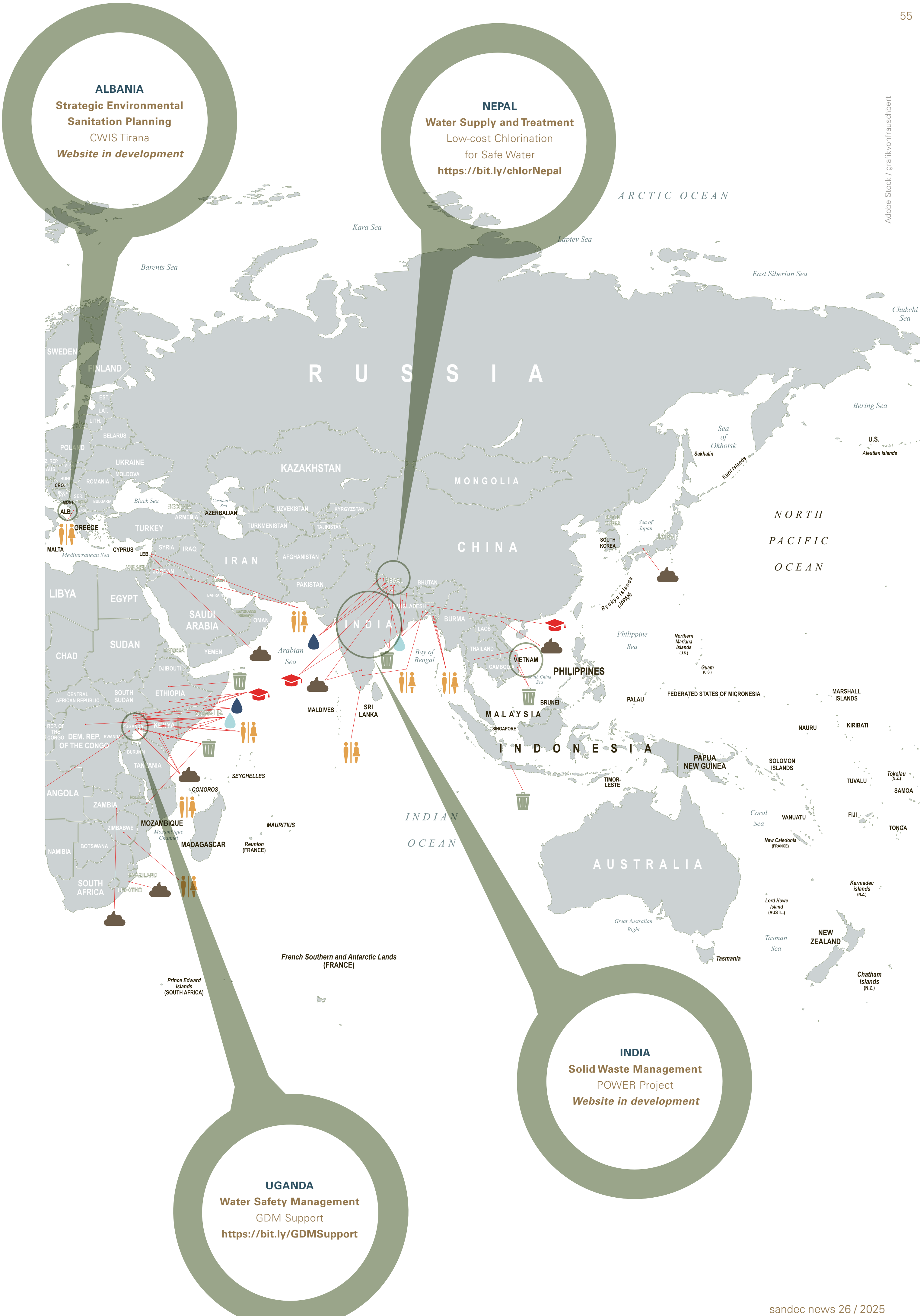
[2] Eawag / Sandec, Switzerland

For more information about capacity development initiatives of the WASH Learning Lab:
https://www.eawag.ch/en/department/sandec/digital-learning/collaboration/

Contact at Makerere University: abubakarbatte@gmail.com
Contact at Eawag: fabian.suter@eawag.ch

Global Research Projects and Partners Map




ALBANIA
Strategic Environmental Sanitation Planning
CWIS Tirana
Website in development
NEPAL
Water Supply and Treatment
Low-cost Chlorination
for Safe Water
https://bit.ly/chlorNepal
INDIA
Solid Waste Management
POWER Project
Website in development
UGANDA
Water Safety Management
GDM Support
https://bit.ly/GDMSupport
ARCTIC OCEAN
Kara Sea
Laptev Sea
Barents Sea
East Siberian Sea
Chukchi Sea
RUSSIA
Bering Sea
Sea of Okhotsk
Sakhalin
Kuril Islands
U.S.
Aleutian islands
KAZAKHSTAN
MONGOLIA
CHINA
NORTH PACIFIC OCEAN
SWEDEN
FINLAND
EST.
LAT.
LITH.
BELARUS
POLAND
UKRAINE
MOLDOVA
ROMANIA
CRO.
SER.
BULGARIA
MONT.
ALB.
GREECE
MALTA
Mediterranean Sea
CYPRUS
LEB.
TURKEY
Black Sea
GEORGIA
ARMENIA
AZERBAIJAN
Caspian Sea
UZBEKISTAN
KYRGYZSTAN
TURKMENISTAN
TAJIKISTAN
SYRIA
IRAQ
IRAN
AFGHANISTAN
PAKISTAN
NEPAL
BHUTAN
BANGLADESH
INDIA
SOUTH KOREA
Sea of Japan
JAPAN
Ryukyu Islands (JAPAN)
BURMA
LAOS
THAILAND
CAMBODIA
VIETNAM
PHILIPPINES
Philippine Sea
Northern Mariana islands (U.S.)
Guam (U.S.)
PALAU
FEDERATED STATES OF MICRONESIA
MARSHALL ISLANDS
BRUNEI
MALAYSIA
SINGAPORE
INDONESIA
NAURU
KIRIBATI
PAPUA NEW GUINEA
SOLOMON ISLANDS
TUVALU
Tokelau (N.Z.)
SAMOA
TIMOR-LESTE
LIBYA
EGYPT
SAUDI ARABIA
OMAN
YEMEN
Arabian Sea
Bay of Bengal
SUDAN
CHAD
ERITREA
DJIBOUTI
ETHIOPIA
SOUTH SUDAN
CENTRAL AFRICAN REPUBLIC
REP. OF THE CONGO
DEM. REP. OF THE CONGO
RWANDA
UGANDA
KENYA
BURUNDI
TANZANIA
SOMALIA
MALDIVES
SRI LANKA
SEYCHELLES
COMOROS
ANGOLA
ZAMBIA
MALAWI
MOZAMBIQUE
Mozambique Channel
ZIMBABWE
MADAGASCAR
MAURITIUS
Reunion (FRANCE)
NAMIBIA
BOTSWANA
SWAZILAND
LESOTHO
SOUTH AFRICA
INDIAN OCEAN
Coral Sea
VANUATU
FIJI
TONGA
New Caledonia (FRANCE)
AUSTRALIA
Kermadec islands (N.Z.)
Lord Howe Island (AUSTL.)
Great Australian Bight
Tasman Sea
Tasmania
NEW ZEALAND
Chatham islands (N.Z.)
French Southern and Antarctic Lands (FRANCE)
Prince Edward islands (SOUTH AFRICA)

Dr. Nida Maqbool

Paul Donahue

Photo: Nida Maqbool and Linda Strande in the laboratory at Eawag.

Dr. Nida Maqbool is from Islamabad, Pakistan, and is an Assistant Professor at the National University of Sciences and Technology and working as a Faecal Sludge Management expert.

What did you study and where did you do your university degrees?

I did my Bachelor's degree in Agricultural Engineering at the University of Agriculture, Pakistan, and my Master's degree in Environmental Engineering at the National University of Sciences and Technology (NUST), Pakistan. I later completed my PhD under joint supervision from NUST and Eawag, focusing on the levels of stabilisation during the storage of wastewater in non-sewered sanitation systems, such as pit latrines and septic tanks, and how this stabilisation impacts greenhouse gas emissions and the performance of downstream treatment technologies.

How did you find out about Eawag-Sandec and what is your relation to Eawag-Sandec?

I first came across Eawag-Sandec's work in 2019 through its Massive Open Online Course (MOOC) on Faecal Sludge Management taught by Dr. Linda Strande. This sparked my interest in the field of non-sewered sanitation and inspired me to pursue faecal sludge treatment as the focus of my PhD research. In 2021, I reached out to Dr. Strande to explore opportunities for collaboration, which eventually led me to get in the capacity building initiatives of Eawag and ETH Zurich (Eawag Partnership Program and ETH4D Fellowship). This engagement formed the foundation for a joint PhD project between NUST and Eawag-Sandec.

What work did you do at Eawag-Sandec?

At Eawag-Sandec, I worked with the MEWS research group under the supervision of Dr. Linda Strande. I evaluated the biomethane potential (BMP) of faecal sludge and the potential for co-digestion with food waste. The findings suggested that anaerobic digestion is more suitable for short-term storage systems, such as container-based sanitation (CBS) or humanitarian settings. And the research outcomes were published in a peer-reviewed journal.

How has Eawag-Sandec been beneficial to your career?

Working with Eawag-Sandec helped me build a solid foundation in field-based research, project design, and scientific communication. The exposure to interdisciplinary teams and innovative approaches significantly strengthened my ability to design and implement Faecal Sludge Management (FSM) projects in developing country contexts.

What are you presently doing?

I am currently an Assistant Professor at NUST and working as an FSM expert. My work involves research, teaching, and leading field-based sanitation projects. I am also open to collaborating with non-governmental organisations (NGOs) and international non-governmental organisations (INGOs) on developing feasibility assessments, treatment plant designs, performance evaluations, and business models for scalable and sustainable FSM solutions.

Is there anything I have not asked that you feel is important to talk about?

Yes, I'd like to add that Eawag-Sandec's open-access resources and commitment to capacity building in low- and middle-income countries have been extremely valuable not only for individuals like me, but also for institutional strengthening in the sanitation sector. •

Contact: nidamaqbool@iese.nust.edu.pk

New Group Leader – Dr. George Wainaina

Organise to Adapt: Supporting Resilience in Water and Sanitation Organisations

Paul Donahue

Photo: George Wainaina will lead the new Organisational Dynamics and Climate Adaptation (O&C) research group at Sandec.

Water, sanitation, and solid waste organisations face the constant challenge of sustaining and expanding services despite disruptions, such as extreme weather events and funding shortages. These utilities and agencies rely on partnerships with funders, regulators, NGOs, and Small and Medium-sized Enterprises (SMEs). To succeed, they need capabilities not just for daily operations and long-term strategy, but also for dynamic functions that enhance both operations and strategy.

These dynamic capabilities function to enhance seeking resources, such as funding, knowledge, and innovations, to leverage threats and opportunities within and outside organisations. The dynamic capabilities are vital to sense, seize, and utilise resources effectively, enabling organisational transformation to ensure uninterrupted services. Unfortunately, many organisations lack these capabilities to varying degrees.

My research group will investigate the dynamic capabilities that water, sanitation, and solid waste organisations need to adapt strategies and leverage new interventions in response to risks, threats, and opportunities, including climate issues. Interventions include infrastructure (e.g. blue-green infrastructure), strategies and concepts (e.g. Citywide Inclusive Sanitation – CWIS), and policies (e.g. ringfenced levies), all crucial for service delivery.

Focusing on organisations is key because every new intervention requires adapting organisational approaches, and vice versa. This often means building capabilities organisations currently lack. This research area has not received enough attention, as sector focus has been largely on governance, household scale, infrastructures and innovations. An organisational perspective can provide insights into better management, leading to improved services for all, and enhanced abilities to advocate for regulations, anticipate threats, and transfer and embed technologies or mobilise funding.

We will explore synergies that bridge research gaps through knowledge brokerage. This will involve working with sector organisations in co-shaping research questions, contributing to studies, and receiving and assessing relevant feedback. To get involved, please reach out to me at: george.wainaina@eawag.ch •

New Group Leader – Dr. Karin Gallandat

Paul Donahue

Photo: Karin Gallandat will lead the new Public Health, Infrastructure and Climate (PHIC) research group at Sandec.

What is your academic and research background?

I studied environmental engineering at EPFL and completed doctoral studies in environmental health at Tufts University (USA). My PhD work combined laboratory and field evaluations of disinfection interventions implemented in response to Ebola virus disease and cholera outbreaks. Upon graduation, I joined the London School of Hygiene and Tropical Medicine, where I further specialised in global health research on water, sanitation, and hygiene in humanitarian settings.

Do you have other professional experiences?

As an undergraduate student, I had a side job as a proofreader for newspapers and, during my Master's, I worked part-time for an engineering company where I developed hydraulic models of municipal water supply networks in Switzerland. For the past three and a half years, I was an infrastructure financing program manager in the Economic Cooperation and Development division of the Swiss State Secretariat for Economic Affairs (SECO).

What will your research group focus on?

We will develop operational research on the challenges of improving water supply and sanitation infrastructure in low-resource and humanitarian settings. Ultimately, I hope our work will support the delivery of safe, climate-resilient services that effectively prevent infectious diseases and improve public health outcomes among vulnerable populations. Achieving this will require close collaboration with development and humanitarian agencies. One of the key reasons why I was drawn to Sandec is its strong tradition of producing high-quality, practice-oriented research.

What do you see as the biggest challenges for your research group?

Conducting operational research linked to infrastructure programmes requires continuous, long-term engagement with partners. Pragmatism and flexibility will be key to balance implementation and research needs. Another challenge is integrating climate adaptation aspects into our work, as this is a rapidly evolving research field. Last but not least, working in complex emergencies comes with a number of logistical, safety and ethical risks. Establishing strong collaborations with local organisations and universities at research sites will be critical to mitigate these.

What are your interests outside of research?

Music is central: I have been playing the piano since I was seven, love going to the opera and concerts of all kinds, and I started swing dancing two years ago, which is a lot of fun! I also enjoy being in nature and went on a 10-day hike across the Apennine Mountains in Italy last month. •

WASH Learnings from COP29

Researchers from Eawag together with representatives from the ETH Domain and other institutions participated at the COP29 in Baku, Azerbaijan, as part of the Swiss Delegation. Here are some reflections on the importance of the science-policy interface in the WASH and Climate sectors.

The United Nations Framework Convention on Climate Change (UNFCCC) meets annually to review the implementation of the Convention at the Conference of Parties, also known as the Climate COP. COP29 took place in Baku, Azerbaijan, in November 2024, and was dubbed the "Finance COP" due to its primary focus on setting a new collectively quantified goal on climate finance (NCQG) for developing countries based on the Paris Agreement.

Although the topic of water, sanitation, and hygiene (WASH) has historically been underrepresented in the COPs, in recent years, due to increasing research on the mitigation potential and adaptation needs of WASH, the topic has been gaining prominence in the conference pavilions and negotiation tables. However, in Baku, there was frequent acknowledgement that there is not enough empirical evidence to guide climate resilient WASH policies.

As we plan for the post-SDG 2030 agenda, climate resilient WASH and its accompanying indicators are likely to become highly relevant. Teams from WHO and UNICEF are working together with researchers and practitioners globally to provide the scientific evidence that would elevate the significance of the WASH and climate connections. Efforts are underway at Sandec to assist such work and support the development of climate resilient WASH policies and practice. •

Abishek S Narayan/Tural Aliyev

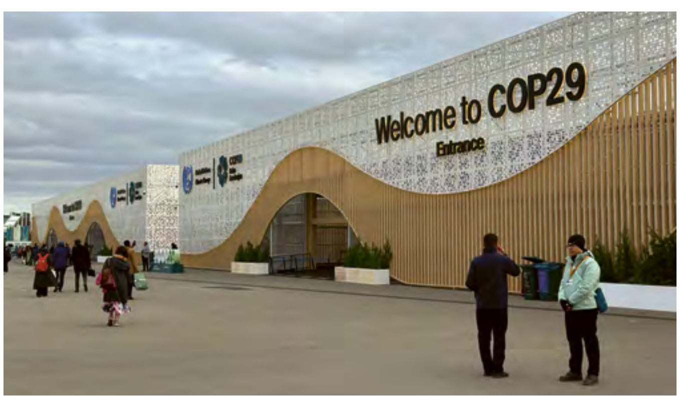


Photo 1: COP29 took place at the Baku stadium and hosted over 80,000 people.

Abishek S Narayan/Tural Aliyev

Photo 2: Abishek Narayan took part in a roundtable discussion on the links between safely managed sanitation and resilience to climate change.

Abishek S Narayan/Tural Aliyev

Photo 3: Swiss researchers, including Eawag ESS's Tural Aliyev, presented their research on urban governance and climate resilience.

Abishek S Narayan/Tural Aliyev

Photo 4: The negotiation process was intense and often extended into many nights of the two week event.

The Sandec Team

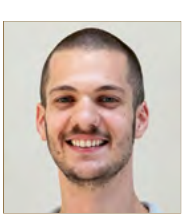
From left to right – Front row: Michael Vogel, Ladislava Shirokov, Paul Donahue, Nicolas Seemann-Ricard, Dorian Tosi Robinson, Natalia Montoya, Daniela Peguero, Laura Velasquez
2nd row: Maja Schøn, Sara Marks, Alan Said Hernandez Vazquez, Abishek Narayan, Philippe Reymond, Linda Strande, Karin Gallandat, Kayla Coppens, Loïc Fache, Regula Meierhofer, Fabian Suter, Ednah Kemboi, Nienke Andriessen, Marisa Boller, Chris Zurbrügg, Sara Ubbiali, Johanna Brendow, Caterina Dalla Torre, George Wainaina
Missing in photo: Vasco Schelbert, Laura Baquedano, Christoph Lüthi, Kelsey Shaw, Seju Kang, Jasmine Segginger

New Faces at Sandec

Esther Greenwood has a PhD from ETH Zürich and an MSc from Lund University. She did her Doctoral and Master's research in Eawag's Pathogens and Human Health Group (UMIK), evaluating child health impacts of drinking water services and addressed critical data gaps on SDG 6 in low- and middle-income countries. She is now a Postdoctoral Researcher in the Public Health, Infrastructure and Climate group.

Jess MacArthur has a PhD from UT Sydney and an MSc from University of Oxford. Most recently, she worked with Save the Children as a Research and Learning Advisor for the USAID funded PRO-WASH award and has over a decade of experience in working in Sub-Saharan Africa, South Asia, and Southeast Asia. She is now the Knowledge Broker in the Organisations and Climate Group.

Julian Fritzsche returns to Sandec after completing an internship, part-time work, and a Master's thesis with the department. With a background in WASH and solid waste management for development, he is particularly interested in circular economy approaches, nature-based solutions, and working in diverse cultural contexts. He now joins the Management of Excreta, Wastewater and Sludge group as a Scientific Project Manager.

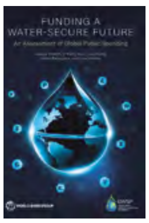


Nicolas Seemann-Ricard holds an MSc from ETH Zürich and a BEng from Lancaster University, UK. His previous work and research experience includes designing low-cost biogas remote monitoring devices and large-scale solar power plant engineering. He is now a Project Officer in the Water Supply and Treatment group, developing the next generation of the Clara electrochlorinator.

Seju Kang holds an MS from Seoul National University and a PhD from Virginia Tech. In 2023, he began postdoctoral research in the Department of Environmental Microbiology (Umik) and in Sandec's Mangement of Excreta, Wastewater and Sludge, supported by the Eawag Postdoctoral Fellowship. His research focuses on wastewater-based (or environmental) surveillance of infectious diseases in different sanitation contexts.

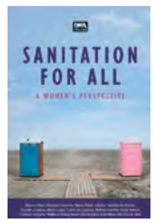
On the Bookshelf

Apart from the publications cited in the previous articles, we would like to recommend the following new books and key readings in the areas of our research.



Funding A Water-Secure Future

This study is a first-ever attempt to gain a 360 panoramic view of spending in the entire global water sector to better understand the financing and funding gaps in relation to sector goals, and guide thinking on alternative ways to close them. The report offers practical steps that countries can take to spend better so that they can spend more on water.
By: The World Bank, 2024, 378 pages
https://bit.ly/FundingAWaterSecureFuture



Sanitation For All: A Women's Perspective

This book offers a critical look at the challenges and solutions needed to achieve Sanitation for All, including for vulnerable people, refugees, asylum seekers, stateless, or internally displaced persons, and especially women. It presents sanitation policy and decision-making from the perspective of women, providing conclusions to the prevailing debates.
By: BEJ Cisneros, et al.
IWA Publishing, 2024, 190 pages
ISBN: 9781789064049

Solid Waste Management: Challenges and Recent Solutions

This book provides a holistic picture of waste and its management techniques, with all the recent advancements and necessary projections for the future. It emphasises the practices, problems, and management of a broad variety of industrial solid waste and facilitates a major understanding of the utilisation of sustainable tools to combat all types of problems.
By: Rajeev Pratap Singh, et al.
CRC Press, 2024, 334 pages
ISBN: 9781032534183

Compendium of Solid Waste Management in Humanitarian Contexts

The Compendium is a comprehensive compilation of the most relevant and sector-reviewed solid waste management (SWM) technologies, planning aspects, and cross-cutting issues. The main focus is on the management of domestic and municipal solid waste in humanitarian contexts. It is primarily a capacity strengthening tool that supports SWM planning, implementation, and decision-making.
By: German Wash Network, 2025, 184 pages
https://bit.ly/Compendium-SWMHumanitarianContexts
ISBN: 978-3-906484-81-5

On the YouTube Channel

We would like to recommend this new video produced by Eawag / Sandec that deals with issues in our areas of research.

Spotlight On Planning For Zero-Waste At Schools: A Toolkit
One of our 'Spotlight on WASH Publications' videos, it highlights the Zero Waste At Schools Toolkit, which teaches students how to look at waste no longer as trash, but as a resource. The video introduces the Zero Waste approach, for example, how to set up a recycling unit or transform kitchen waste to compost. It helps schools and students improve their waste management and prepare for a more sustainable future.

Produced by: Eawag / Sandec
Filmed by: Laura Baquedano, Eawag / Sandec
Edited: Laura Baquedano, Eawag / Sandec, 2025, 1:28

Watch Adeline Mertenat introducing the publication "Planning for Zero-Waste at Schools – A Toolkit".

Publication Information

Sandec
Department of Sanitation, Water and Solid Waste for Development

Publisher: Eawag, 8600 Dübendorf, Switzerland, Phone: +41 58 765 52 86
caterina.dallatorre@eawag.ch, www.eawag.ch, www.sandec.ch

Editors: Paul Donahue and Linda Strande, Eawag

Content Production Manager: Eawag Communication Department

Publication: Sandec News is published once a year and is free of charge.
It is available as a printed copy or it can be downloaded as a pdf file from our homepage, at www.sandec.ch

Layout and figures: Katja Schubert, grafikvonfrauschubert feat. Eawag

Photos: All photos are from Sandec if not mentioned otherwise.

Printer: Effingermedien AG, www.effingermedien.ch

Circulation: 2,300 copies printed on BalancePure BA white, 100% Recycling-Phase

New subscribers: Please contact caterina.dallatorre@eawag.ch

ISSN 1420-5572

Eawag: Swiss Federal Institute of Aquatic Science and Technology

Cover Photo: Compost from a mix of organic and faecal waste being weighed at a pilot facility in a low-income neighbourhood in Kampala, Uganda. The facility is run by GiveLove.org.

Cover Photo by Abishek Narayan.

Eawag
Überlandstrasse 133
8600 Dübendorf
Telefon +41 58 765 55 11
info@eawag.ch
eawag.ch