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WATER, SANITATION, AND HYGIENE FINANCE (WASH-FIN)

Reflections on Supporting Investor Readiness for Utility-Scale Sanitation Treatment Technologies

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ACRONYMS

AMCOW	African Ministers' Council on Water
ASPG	African Sanitation Policy Guidelines
BMGF	Bill and Melinda Gates Foundation
CapEx	Capital Expenditure
CDC	Centers for Disease Control (USA)
COVID	Coronavirus
CWIS	City Wide Inclusive Sanitation
EU	European Union
FSM	Fecal Sludge Management
FSTP	Fecal Sludge Treatment Plant
GoS	Government of Senegal
HAM	Hybrid Annuity Model
J-OP	Janicki Omni Processor
LMIC	Low to Middle Income Country
MDB	Multilateral Development Bank
MoH	Ministry of Health (Kenya)
MAWASCO	Malindi Water and Sewerage Company (Kenya)
NAWASCO	Nakuru Water and Sanitation Company (Kenya)
ODF	Open Defecation Free
OP	Omni Processor
OpEx	Operational Expenditure
OSS	On-Site Sanitation
PPP	Public Private Partnership
R&D	Research and Development
RFP	Request for Proposal
SADC	South African Development Countries
SDG	Sustainable Development Goals
SME	Small to Medium-Sized Enterprise
USAID	United States Agency for International Development

VEI	Vitens Evides International
WASH	Water, Sanitation and Hygiene
WASH-FIN	Water, Sanitation and Hygiene Finance
WIPO	World Intellectual Property Organization

EXECUTIVE SUMMARY

This report describes USAID's Water, Sanitation and Hygiene Finance (WASH-FIN) Program's experience providing investor readiness support to companies pioneering utility-scale sanitation treatment technology solutions in urban settings in Senegal, Kenya and India. The Program works globally in target countries to close financing gaps to support universal access to water supply and sanitation services through sustainable and creditworthy business models, increased public funding, and expanded market finance for infrastructure investment. In addition to field-based activities in Cambodia, Kenya, Mozambique, Nepal, the Philippines, Senegal, South Africa, and Zambia, the Program supported a United States (US) sanitation solution provider responding to a market opportunity in India.

The support provided to these technology companies is a small subset of the work undertaken within the six-year global program. Although the Program supported a total of five technology companies, the examples in Senegal, Kenya, and India were selected as they received the most sustained and regular engagement; relevant knowledge generated from the broader Program experience is also included.

The objective of USAID's work in this space under the Program was to support these companies to assess and satisfy the need for investment capital within their business models. Technical assistance focused on financial advisory and market analytics to validate assumptions, and financial modeling to analyze cashflows and scenarios. The team used the analysis in preparing materials for investors and supporting resource mobilization. The assistance was short-term and targeted, and there was little direct engagement with service chain elements beyond treatment unless these were integral to the business model. Senegal was unique as the only country activity designed to support an operator of a technologically advanced treatment solution which was under contract with the public sector. [1] Senegal was also the only instance where the enterprise was an intermediary and did not have proprietary ownership of the technology or innovation.

As sanitation is a public good, the report highlights the crucial role of the public sector in market creation for treatment technologies and services. It takes a critical look at the linkages between the public and private sectors in fostering a coherent and efficient marketplace for appropriate technologies. The focus is on treatment technologies applied at utility-scale[2] versus on-site or household solutions, and the practical experience of providing technical assistance to this limited set of firms. Key challenges and lessons learned are documented, such as a gap identified between knowledge and practice as it relates to segmenting sanitation treatment solutions. For example, sanitation assessment methodologies are often based on need, combine on-site sanitation with off-site, or use only traditional networked infrastructure estimates not easily disaggregated or appropriate to estimate the addressable market size for a specific technology or application, or within a specific jurisdiction. These estimates can distort business models and financial projections that underpin capital investment and cashflow estimates. This is indicative of a corresponding need for entrepreneurs and practitioners to refine approaches and funding strategies for bringing innovative, yet unproven utility-scale technologies and solutions to market. The report concludes by contextualizing Program learnings within the existing evidence base and offering perspectives on the way forward.

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1 USAID WASH-FIN (2020) Country Brief Series: Scaling Up Finance to Expand Urban Sanitation Access in Senegal

2 "Utility-scale" refers to solutions that treat human waste at a level of efficacy and scale such that it can reliably serve the needs of a community of users, but is too complex or costly to be undertaken by an individual household.

The key takeaways from this experience include:

- Funding opportunities exist for novel sanitation treatment technologies, but such innovations require a mix of grants and repayable finance appropriately sequenced from public and private sources;
- Proving these treatment technologies is time- and resource-intensive, and financial models to support commercialization must anticipate externalities, such as dynamic policies and regulations and cashflow drivers stemming from other service chain elements;
- There is need to create market demand for sanitation as a public good through government awareness and engagement in policies, standards, funding, and procurement of new technologies;
- To this end, there is a corresponding need to incentivize governments to create an effective enabling environment for innovative treatment technologies that can leverage private capital.

The authors do not take a position on the merits of any single technological solution, but assert that, without a sufficient public sector market for these technologies, innovations will remain difficult to commercialize and slow to achieve economies of scale and financial viability. This will reduce opportunities to meet Sustainable Development Goal (SDG) 6.2 for sanitation. The goal of this report is therefore to help entrepreneurs and developers of utility-scale treatment technology, government policy makers, and advisors, funders, financiers, and other stakeholders to better understand the challenges and opportunities for scaling up these innovative and complex technologies, thereby contributing to addressing the sanitation challenge and specifically, safe treatment of fecal matter that is affordable and efficient.

1.0 BACKGROUND AND CONTEXT

Sanitation is essential for public health, education, and livelihoods. However, public investment in infrastructure and services has not kept pace with urbanization; the World Bank estimates that only 43 percent of the world's urban dwellers benefit from safely managed services[3] while a mere 18 percent of human waste from domestic on-site sanitation facilities is treated.[4] This underinvestment has stalled socio-economic development; in 2012, the World Bank estimated annual economic losses of US$5.5 billion from poor sanitation in 18 African countries, equivalent to between one and 2.5 percent of GDP.[5] Annual global economic costs from inadequate sanitation, manifesting through higher health costs and lost productivity and wages, were estimated at US$223 billion in 2015.[6] As the infrastructure gap and urban populations have continued to grow, these figures, while dated, remain relevant as a benchmark.

1.1 SAFELY MANAGED SANITATION FOR ALL REQUIRES INCLUSION OF NEW, DECENTRALIZED TREATMENT TECHNOLOGY

Providing traditional networked sewerage systems is impractical and costly, especially for underserved urban populations in Low to Middle Income Countries (LMIC), many of whom reside in informal settlements. In these economies, sanitation remains largely informal and highly fragmented across the service chain (Figure 1) and the type, coverage, quality, and reliability of service varies widely. To overcome this challenge, development partners, solution providers and increasingly by government officials are encouraging new decentralized or non-networked treatment solutions. These solutions are part of the "clean technology" sector and include not only advanced treatment solutions such as the thermal technologies discussed herein, but also nature-based solutions which are beyond the scope of the report. While increasingly seen as a viable way forward, the more technologically advanced solutions are capital intensive, and often have unique characteristics that are unfamiliar to sanitation sector decision makers.

Although national policies increasingly reference decentralized sanitation solutions, these policies are often disconnected from prevailing sector practices, which are typically aligned with large sewerage systems. As a result, sector institutions lack specialized capabilities and incentives to assess these nascent technologies to make accurate cost and viability comparisons, establish cost reflective tariffs, etc. Further, even if institutions were appropriately incentivized and capacitated, sector expenditure is already low, and traditional funding is slow and insufficient. On the other hand, private sources of capital are largely unfamiliar with the sector and averse to investing in an underdeveloped market with high uncertainty of public sector counterparty risks. As a result, opportunities for viable market creation and private capital mobilization for these technologies are severely constrained.

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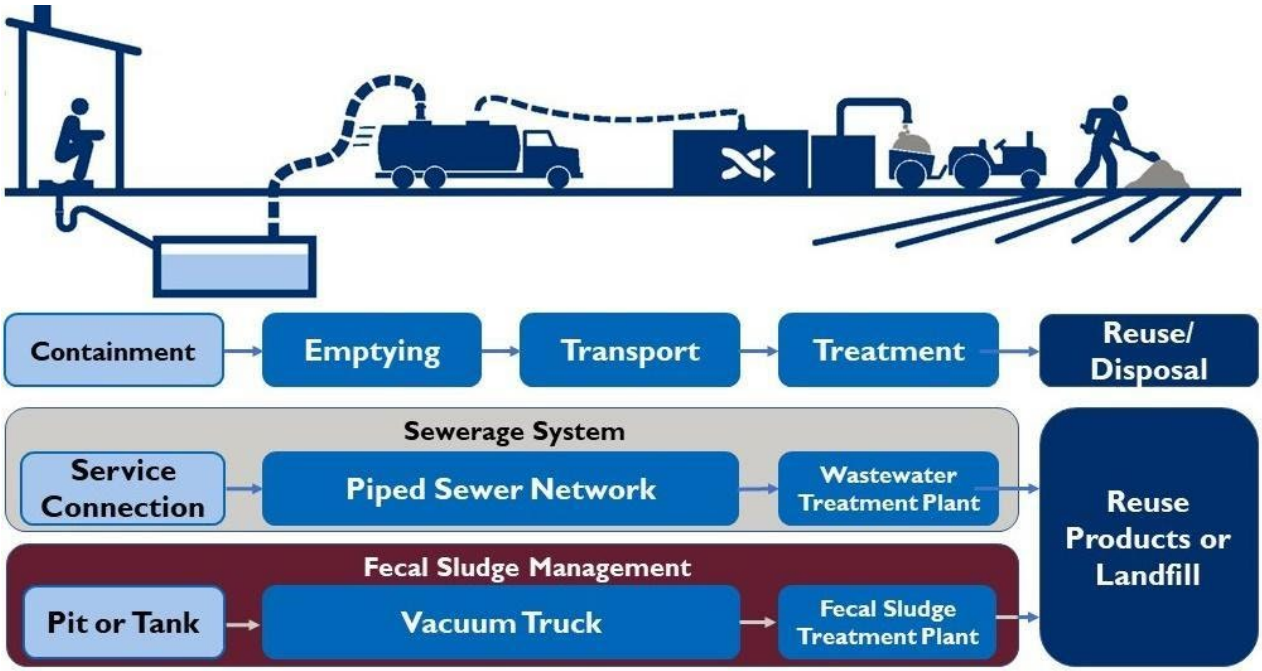
[3] World Bank. (2020). A new chapter in the Citywide Inclusive Sanitation story: the World Bank launches its CWIS web hub; Accessed in November 2021 at https://blogs.worldbank.org/water/cwis-new-web-hub

[4] Journal of Water, Sanitation and Hygiene for Development (2020) Review of frameworks and tools for urban strategic sanitation planning: considering technology innovations and sustainability

[5] World Bank. (2012). Economic Impacts of Poor Sanitation in Africa

[6] Lixil, WaterAid Japan, Oxford Economics (2016) The true cost of poor sanitation

Figure 1: Sanitation Service Chain



Source: Adapted from Bill & Melinda Gates Foundation Water, Sanitation & Hygiene Strategy Overview 2012 and USAID Water and Development Technical Brief 5, Urban Sanitation Services 2021.

1.2 SUPPLY AND DEMAND MISMATCH IN LMICS

At present the public sector in most developing countries has not created sufficient demand (despite the large sanitation needs) to support these treatment technologies. As a result, innovation is not being pulled in from the demand side, but rather is pushed from technologists and entrepreneurs and their supporters on the supply side. This is indicative of an inherent challenge in innovation of insufficient financial resources to move from research and development (R&D) to a commercially viable business model that covers the costs to develop and commercialize the solution. The funding must be adequate to sustain the innovation through the so-called innovation "valley of death" (Figure 2).[7]

Interest in these technologies is growing, however as the technology and markets are nascent, most initiatives are still in the R&D or pilot stage, with some beginning to explore commercial potential. Absent reasonable performance benchmarks or a critical mass of proven prior installations, both governments and investors perceive the solutions as risky. This is a significant obstacle in LMIC economies where the legacy expenditure gap in infrastructure and services means there is no existing market to 'disrupt' (i.e. a new entrant capturing market share that displaces an incumbent product or service[8]), and bring lower costs or efficiency making payback scenarios less certain and investment riskier. This effectively reduces the market entry options for utility-scale solutions to greenfield installations which are more complex and costly.

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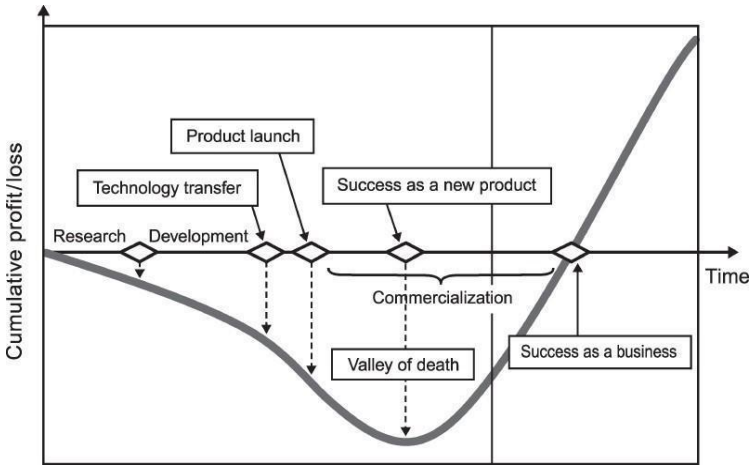
7 World Bank (2015) Water Blog "Innovating through the 'valley of death"

8 Sources: World Bank (2019) Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet; https://www.investopedia.com/terms/d/disruptive-technology; https://strategyforexecs.com/disruption-framework/

Figure 2: Innovation "Valley of Death[9]"



Overcoming these demand side challenges for sanitation treatment in LMICs will likely require intervention from the main funders of large-scale urban infrastructure – national governments, multilateral development banks (MDBs) and bilateral development partners – to elevate the importance of universal coverage and standards, and advocate for enforcement. In more industrialized economies, enforcement of environmental laws has led to regulations and standards that have compelled governments to provide appropriate funding for sanitation which became the foundation of market creation for private innovation.[10]

1.3 UNPROVEN MARKET POTENTIAL; UNRELIABLE MARKET ANALYTICS

The market value of utility-scale treatment has yet to be established. Estimates of sanitation market size are broad and rarely segmented across the service chain or spectrum of demand from rural to urban, features and benefits, or affordability and price. Assessments often estimate gaps in spending to meet equitable social needs such as the SDGs, and while the differentials are indicative of *need*, they do not define a viable commercial *market*. Many estimates aggregate the value of household investments in products or services to contain and capture human waste with the value of larger infrastructural investments in conveyance and treatment. Others calculate the cost differential on a per customer basis for example, comparing a connection to a traditional centralized sewerage system to an on-site or decentralized solution.[11]

In addition, some estimates extend further to include value from resource recovery through circular economy activities that extract sanitation by-products and convert or process them for agricultural and other commercial uses (see Figure 3). In many ways the markets for these products are also nascent, and recent research has revealed uneven results with circular economy models, albeit for lower tech solutions.[12]

Table 1 below shows a range of estimates of the market value for safely managed sanitation technologies and services[13]. Any one of these estimates would indicate a significant market opportunity exists, but

[9] World Bank (2015) Water Blog "Innovating through the 'valley of death'"

[10] See: US Congressional Research Service (2016) Clean Water Act: A Summary of the Law, and Institute for European Environmental Policy (2012) Manual of European Environmental Policy, Directive concerning urban wastewater treatment.

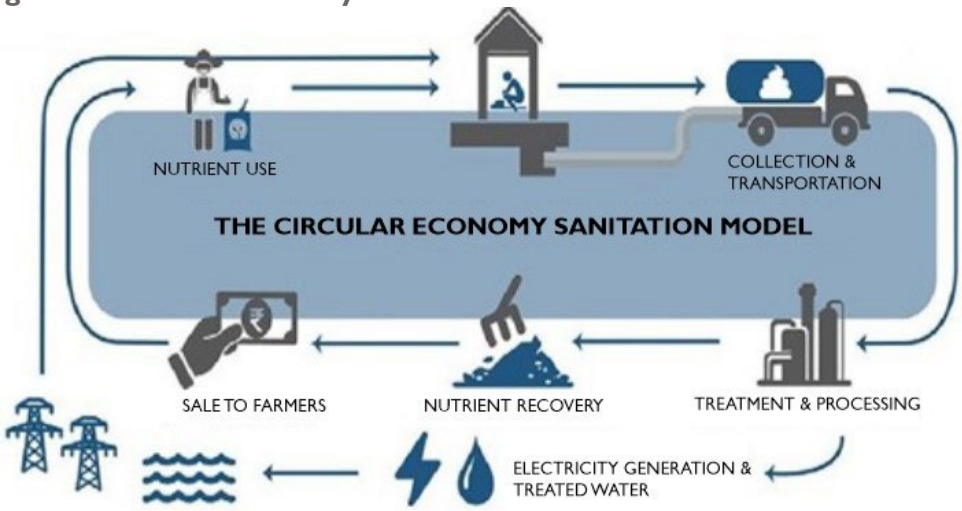
[11] IWA Publishing, Journal of Water, Sanitation and Hygiene for Development (2018) 8 (2): 176–195 (2018) "The cost of urban sanitation solutions: a literature review"

[12] Science of the Total Environment (2020) Evaluating the Circular Economy for Sanitation: Findings from a Multi-Case Approach

[13] For the purposes of this document "safely managed" is defined according to World Bank (2016); The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene as "…an improved facility that is

they are disparate and largely theoretical, and therefore risk distorting expectations of actual market opportunities for solution developers and early-stage funders. These assessments often exclude important context required to understand if there is actual government and/or user expenditure occurring in the market, and the extent of segmentation across the service chain.

Figure 3: Circular Economy Sanitation Model



Adapted from: Science of the Total Environment (2020) Evaluating the Circular Economy for Sanitation: Findings from a Multi-Case Approach

A more accurate characterization of sanitation market value would include consideration of affordability of services and who is responsible for investment and delivery across the service chain.[14] The use of any third-party market assessments therefore requires a rigorous evaluation of the methodology and data that underpins the assessment, as well as a thorough ground truthing to specific local contexts.

TABLE 1: EXAMPLES OF MARKET VALUE ESTIMATES FOR SAFELY MANAGED SANITATION TECHNOLOGIES

Source	Description	Value
Authors' estimate based on World Bank (2016); The Costs of Meeting the 2030 SDG Targets on Drinking Water, Sanitation, and Hygiene and, World Bank (2019); Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet.	Cost for unserved access and to maintain existing services in urban areas until 2030 (exclusive of toilets and latrines).	US$ 93 billion
Boston Consulting Group (2018) "Tech Disruption Comes to Global Sanitation."; and Bill and Melinda Gates Foundation (2020) "Water, Sanitation & Hygiene Strategy Overview."	Cost of toilets and treatment technology in developing Africa and Asian countries, including India in 2018.	US$ 4 to 6 billion

not shared with other households and where excreta are safely disposed of in situ or treated off-site". If these criteria are not met, then the sanitation facility is considered "basic" rather than "safely managed."

[14] World Resources Institute Ross Center (2019) Working Paper: Untreated and Unsafe: Solving the Urban Sanitation Crisis in the Global South

Source	Description	Value
World Bank Water and Sanitation Program (2011) "Economic Impacts of Inadequate Sanitation in India," and Toilet Board Coalition (2017) "The Sanitation Economy in India; Market Estimates and Insights."	Sanitation economy estimates, India only in 2020	US$ 15 billion
IDB, Water for People, One Drop Foundation, IRCWash, WaterAid (2016) "Fostering Water and Sanitation Markets in Latin America and the Caribbean: how the public sector can support the private sector to bridge coverage gaps and improve service quality for low-income populations."	Potential private sector revenue from sanitation in Latin America	US$ 4 to 18 billion
Authors' estimate, based on Sanitation Technology Platform (2017) "Janicki Omni Processor (J-OP) Global Market Roadmap."	Global market for Janicki Omni Processor treatment technology in 2017	USD 2.2 billion

** Examples are all annual, global figures unless stated otherwise.*

1.4 OPPORTUNITIES LIMITED BY THE ENABLING ENVIRONMENT

Urban areas in LMICs currently rely on a variety of affordable, yet informal Fecal Sludge Management (FSM) practices to contain and remove human waste from the home. Private service providers play an important role in constructing and emptying containments, but these providers are largely unregulated, and treatment non-existent. Where treatment is occurring, it is mainly lower tech i.e., stabilization ponds, sludge drying beds and constructed wetlands, with limited mechanization.[15]

To expand commercial application of clean tech innovations in developing countries, the World Bank proposed five broad and interdependent enabling areas:[16] 1) Legal and regulatory framework; 2) Technology development; 3) Market development; 4) Entrepreneurship and business acceleration; and 5) Innovation finance. Attention to all five areas is critical, however most are outside of traditional WASH sector capabilities and roles. Governments, development partners, and WASH institutions, must take up these actions in order to spur innovation in sanitation technologies. While it is largely the private sector developing innovative solutions, the public sector is the only entity positioned to mitigate key risks of public service delivery, coordinate policy design and implementation, structure markets, support policy continuity across national and sub-national institutions, and provide a platform for commercial finance and private sector participation.

The absence of specific and enforced treatment regulations, standards, and a well-defined market compounds the prevailing weak WASH enabling environment in LMICs. These factors mask the true costs of safely managed sanitation and thereby diminish the operational and financial viability of treatment solutions. In the near term, the absence of regulation and standards could create a first mover advantage of sorts for lower tech/low-cost treatment solutions. While these may not be as efficient as advanced technological solutions, over time they will inevitably improve and could create barriers to entry for more complex and expensive high-tech solutions that can otherwise meet the standard and be viable. As the examples in this paper show, developers of more advanced solutions that

[15] For examples see: SNV and ISF (2021) Treatment technologies in practice: On-the-ground experiences of faecal sludge and wastewater treatment, and Borda, WEDC (2009) Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries

[16] World Bank, InfoDev. (2014) "Building Competitive Green Industries: the climate and clean technology opportunity for developing countries."

foster goodwill and trust with national and local government entities can help facilitate development of an appropriate enabling environment sooner and garner first mover advantages in a structured market.

1.5 SOURCING AND SEQUENCING OF FUNDING AND FINANCE

In the absence of a defined and viable market, grant funding for early-stage technology development, validation, and piloting are essential for proof of concept. Such funds have been flowing to utility-scale treatment solutions through various targeted initiatives (e.g., Bill & Melinda Gates Foundation's [BMGF] Reinvent the Toilet Challenge) and general initiatives (e.g., USAID Development Innovation Ventures) to serve outcomes ranging from testing a technology or process, to achieving a targeted service delivery outcome. Program experience indicates that solutions require follow-on funding and support to fully validate commercial viability at a minimum efficient scale for investor readiness.

In this context of private sector innovation, at the market entry stage, the main source of capital should ostensibly be risk capital – private finance seeking potential for adequate returns. However, these sources are scarce in developing countries and external risk capital from angel or venture capitalists is not well aligned with public sector investments and their unique risks.[17] While development partners could help to incentivize this alignment and leverage the investment in early-stage grants, this requires sustained coordination and space for complex transformational, market based approaches.[18,19] Grants and concessionary finance, when misapplied, can inadvertently neglect or crowd out commercial and domestic public finance opportunities. This is an immense coordination and sequencing challenge within a sector that is largely underperforming.

Because treatment is a public service, the enabling environment must not only provide clear rules and signals for entrepreneurs and investors, but also reliable funding from the primary customers – i.e., the public sector – through approved budgets. Public agencies also require the know-how, capacity, incentives, and technical standards to procure pioneering solutions within a reasonable timeframe across multiple cities. As most of these technologies are nascent, they tend to be rather disconnected from public institutions, leaving decision makers unaware, resulting in these solutions not being appropriately considered in government budgets.

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[17] Nanda, Ramana, Harvard Business School (2020) "Financing Tough Tech Innovation", Chapter 5 in The Global Innovation Index 2020: Who Will Finance Innovation? (Cornell University, INSEAD, and WIPO, 2020).

[18] Organization for Economic Cooperation and Development (2019) "Making Blended Finance Work for Water and Sanitation: unblocking commercial finance for SDG 6." OECD Publishing, Paris, France.

[19] USAID Water Sanitation, Hygiene Finance (2018). "Financing Facility Landscape Assessment Report". WASH-FIN Working Paper No. 1.

2.0 INVESTOR READINESS AND RESOURCE MOBILIZATION EXPERIENCE

What is the practical experience of such scale up attempts and in particular, how are the operators faring in their efforts to raise capital for such scale up? This section provides a summary of USAID's WASH-FIN Program experience supporting private entrepreneurs to promote and finance innovative utility-scale sanitation treatment technologies in Senegal, Kenya, and India, including key challenges encountered and efforts to address them.

Each country context is distinct in terms of institutions, degree of government leadership in establishing an enabling environment for market creation. Senegal has a comparatively advanced enabling environment for utility-scale sanitation technologies, including a proven private sector service delivery model implemented through a well capacitated national agency. In Kenya, sanitation is a County function and formal service delivery occurs primarily through corporatized public water utilities and the private sector. In India, although sanitation is a State responsibility, services are provided by municipalities and the private sector with central and State government funding. The unifying characteristic across the three is that urban areas have low levels of safely managed service coverage – especially in rapidly growing, low-income peri-urban areas – as well as insufficient funding, weak regulation, and upwards of 60 percent of human waste estimated to flow into the environment untreated.[20]

In each country, the Program worked with a developer of new sanitation treatment technologies attempting to bring their solution to market in partnership with government. Prior to WASH-FIN support, funding by foundations or development partners supported technology pilots. Although the technologies are similar in that they use sophisticated thermal-based processes to treat fecal sludge and recover resources, the market entry approach and business models vary, as does the degree to which they rely on intermediaries, government, and development partner programs for technical and financial support. The sanitation solutions in Senegal and India were imported, while in Kenya the solution was developed in-country. While all hold promise, like any new venture, these companies are generally self-funded with limited operational track records, revenue, and credit history.[21] Each is at a different level of investor readiness to transition from prototypes and pilots, to commercial operation at scale. All struggle with the common problem of trying to enter a nascent market for a public good with limited funding. While each has achieved admirable technical and operational milestones, none of these solutions has yet crossed the "valley of death" to commercial viability (see Figure 2).

The Program worked to leverage the prior grant funding with strategies to mobilize return-seeking investment, government investment, grants, and technical support. Technical assistance included identifying sources of funds on the input side, and markets for products in the case of resource recovery on the output side. The focus was to create financial models to capture the CapEx/OpEx of the technology development and operation to date and anticipated cashflows from the targeted market opportunity. When appropriate, the Program also supported investor outreach utilizing these same financial models. Below is a summary of the Program's experience in each country, with references to related resources.

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[20] World Bank. (2020). A new chapter in the Citywide Inclusive Sanitation story: the World Bank launches its CWIS web hub; Accessed in November 2021 at https://blogs.worldbank.org/water/cwis-new-web-hub

[21] Social Finance Limited (undated). Scaling-up Sanitation Enterprises: the role of outcomes-based funding.

2.1 SENEGAL—LOCAL ADOPTION OF SEDRON'S JANICKI OMNI PROCESSOR

WASH-FIN Approach	Outcome
Refined financial model with updated revenue streams, actual costs, and capital needs for operation and expanded technology application.	Comprehensive financial model incorporating operating and market analysis, enhanced corporate capacity; government procurement prospects evolving and will ultimately impact private capital potential.

Key takeaway: Bringing technologically advanced and capital intensive sanitation treatment innovations to market requires significant and sustained support

In 1996, the Government of Senegal (GoS) committed to bold reforms to attract private operators to manage urban water supply.[22] This model has since been expanded to rural water supply, and in 2013 to urban sanitation with the delegation to the private sector of the management, operation and maintenance of four Fecal Sludge Treatment Plants (FSTPs) in Dakar. With support from the World Bank and other development partners, the GoS organized water supply and sanitation into sub-sectors, with clear institutional arrangements for service delivery and coordination, and commitment to private sector service provision through contracts. Key to these achievements has been the government's leadership in establishing markets for goods and services in these subsectors.

Within this set up, the National Sanitation Agency of Senegal (ONAS, Office National de l'Assainissement du Sénégal) issues contracts for private sector provision of urban Fecal Sludge Management (FSM), including treatment plant operation and management of sewerage networks. One of the private sector firms contracted by ONAS is DELVIC, a Senegalese Small to Medium-Sized Enterprise (SME) founded in 2013 and the first private African company specializing in FSM and currently operating ten FSTPs in Senegal. In 2015, DELVIC was presented with an opportunity to become a strategic partner to conduct a technical pilot of a prototype Janicki Omni Processor or "J-OP" treatment technology manufactured by U.S. based Sedron Technologies.[23] The J-OP processes biosolids from fecal sludge, solids, and other waste streams into three products: water, electricity and ash.[24] Grant funding from BMGF (which owns the intellectual property for the J-OP), and other development partners (see below) supported the installation of the prototype in Dakar. As part of the technical pilot, and under contract from ONAS, DELVIC has been operating the prototype and working in partnership with Sedron, BMGF, and ONAS to assess technical performance as a basis for optimizing technical and operational upgrades for a commercial scale version of the equipment.

WASH-FIN became active in Senegal in 2017 and USAID identified an opportunity to provide technical assistance to DELVIC. The support was broader than the J-OP and covered capacity building and technical assistance to strengthen DELVIC's financial management, creditworthiness, development of bankable projects, and ability to identify, and confidently communicate with investors to raise capital. For the J-OP specific workstreams, the Program expanded support to include refining DELVIC's strategic business planning process, and conducting marketing studies on J-OP waste inputs and by-product outputs. The business planning and related market studies informed the development of a

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[22] USAID (2017). Africa, WASH, and the Millennium Development Goals: a local systems case study of how Senegal achieved MDG Target 7c. Water for Africa through Leadership and Institutional Support (WALIS) Project.

[23] OP is a generic name for a combined set of physical (thermal), and chemical processes to treat fecal sludge and produce by-products such as electricity and distilled water. Several are being supported by BMGF globally. For J-OP see: https://www.sedron.com/janicki-omni-processor/overview/ (Accessed August 2020; Janicki Bioenergy was rebranded as Sedron Technologies in 2018).

[24] Sanitation Technology Platform (2019). Preparing for Commercial Field Testing of the Janicki Omni Processor: lessons learned by DELVIC Sanitation Initiatives in Dakar, Senegal. RTI International.

comprehensive financial model for J-OP operation and capital planning. The technical assistance also revealed gaps in DELVIC's operating strategy including team capacity in marketing, product/market fit, and quality of by-products. To fill these gaps, DELVIC mobilized grant resources from the Vitol Foundation and the Stone Family Foundation to hire a marketing expert to complement DELVIC's strong technical and management capacity. DELVIC also accessed a USAID Development Innovations Ventures grant for additional related support.[25]

In addition to providing important operational and market related data, the pilot allowed DELVIC to monitor and improve various upstream processes in its FSTP operations.[26] The pilot also revealed the full costs required to set up and operate a new and sophisticated technology. This included costs related to environmental regulations and permits for an industrial technology unfamiliar to sanitation operators. It was unclear, for example, whether to classify the technology as a boiler, or an incinerator. DELVIC helped to resolve this challenge it prolonged the permitting process and preparations for the pilot.[27]

As the pilot prototype unit was technically different from the planned commercial scale J-OP, the team worked with DELVIC and BMGF to use operating data from the prototype as proxy input data for financial models and scenario analysis. The team developed several iterations of the financial model and trained DELVIC in the use of these tools to foster self-reliance. Through this modeling exercise, DELVIC received advisory support on various product line and market entry strategies. However, the end result was that based on the data available from the pilot unit operation, and factoring in the anticipated changes in the commercial scale unit, neither debt nor equity was seen as a viable source of capital for DELVIC to purchase the J-OP at the (2017) estimated cost of between US$1.4 to 3 million per unit.[28] Nevertheless, analysis for DELVIC's business plan showed a higher net present value (NPV) for FSTPs equipped with a J-OP vs. without[29]. The financial model will require further refinement to build off the pilot using data from technology updates and improvements.

In working as a neutral advisor that engaged with government and financiers, WASH-FIN was able to deliver strategic analytical inputs and assist DELVIC in developing a robust business plan and financial model specific to the J-OP. DELVIC also received staff training on how to make updates to the model. Preliminary testing of the commercial scale unit installed in 2021 is underway with changes expected to impact not only capital cost, but also the technical operations and resulting cashflows. For this next stage, ONAS will own the commercial scale J-OP and DELVIC is exploring operating the J-OP under a profit-sharing arrangement with ONAS.[30]

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25 USAID WASH-FIN (2021) Scaling Sanitation Treatment Technologies: Lessons Learnt from Supporting DELVIC Sanitation Initiatives SA

26 Sanitation Technology Platform (2019). Preparing for Commercial Field Testing of the Janicki Omni Processor: lessons learned by DELVIC Sanitation Initiatives in Dakar, Senegal. RTI International.

27 Ibid.

28 Sanitation Technology Platform (2017) "J-OP Global Market Roadmap."

29 Consultation with ONAS (April 2022)

30 USAID WASH-FIN (2021) Scaling Sanitation Treatment Technologies: Lessons Learnt from Supporting DELVIC Sanitation Initiatives SA

2.2 KENYA—SANIVATION TRANSFORMATION OF FECAL SLUDGE TO FUEL

WASH-FIN Approach	Outcome
Financial modeling to expand resource mobilization, strengthen investor readiness.	Improved internal financial processes and practices. Financing leveraged from equity and grants.

Key takeaway: Early stage grants and partnering with local governments on proof of concept can lead to mobilization of private capital for public service provision.

In 2016, the Kenya Ministry of Health (MoH) recognized the need for a paradigm shift in meeting the country's sanitation and hygiene goals within the new, decentralized system of governance which devolves service provision to the county level. In response, MoH prepared the Kenya Environmental Sanitation and Hygiene Strategic Framework, which emphasized increased public and private sector investment in pursuit of "a clean, healthy and economically prosperous Kenya free from sanitation and hygiene related diseases."[31] The Framework had a more traditional approach to sanitation with a focus on sewerage systems with centralized wastewater treatment, and market-based products for households. It also included resource recovery, and decentralized treatment technologies were encouraged to utilize "less energy-intensive technologies such as wetland construction, oxidation ditches, extended aeration and stabilization ponds".[32]

In 2018, the sanitation function was transferred to the Ministry of Water, Sanitation and Irrigation, which has a defined sub-sector for "Sewer and Non-Sewer Sanitation Services," including planning, financing, and developing decentralized infrastructure and services for proper sludge management and wastewater disposal. During this time, upwards of 95 percent of human waste entered the environment untreated or inadequately treated in Kenya, contributing to a high burden of childhood morbidity and mortality from diarrheal diseases.[33]

Kenyan company Sanivation began operations in 2013 having received initial support from the US Centers for Disease Control (CDC) for a small-scale pilot of its innovative system for solar treatment of fecal waste in a refugee camp.[34] The knowledge gained was leveraged in a partnership with Nakuru County government and other stakeholders in tackling multiple elements of the sanitation service chain. This included development of a Sanivation-operated container based sanitation service in the town of Naivasha and a method for processing the treated waste with agricultural by-products and creating charcoal briquettes for a cooking fuel. During this time, the CDC and USAID contributed additional funding for R&D of a scaled-up version to process larger volumes of sludge and fuel products called "super logs" for industrial use. The town of Naivasha entered into an agreement with Sanivation for the company to build a large-scale facility adjacent to its wastewater treatment plant.[35]

As Sanivation was starting out, a parallel waste processing project funded by the European Union (EU), SNV, Vitens Evides International (VEI), and others for Nakuru city also emerged in 2013. This initiative set out to utilize sludge from County-owned Nakuru Water and Sanitation Company's (NAWASCO) sewerage treatment plant to produce briquettes. The factory began production in 2017 and leading to

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[31] Republic of Kenya, Ministry of Health (2016). Kenya Environmental Sanitation and Hygiene Strategic Framework, 2016-2020.

[32] Ibid

[33] USAID (2019). Turning Waste Into Power https://www.globalwaters.org/GWS-Stories/turning-waste-power

[34] For details see: https://wash.unhcr.org/organisation/sanivation/ (accessed August 2021)

[35] Sanivation.com and USAID (2019). Turning Waste Into Power https://www.globalwaters.org/GWS-Stories/turning-waste-power

incorporation as a subsidiary of NAWASCO in 2018.[36] While distinct from Sanivation's start-up, this initiative uses similar technology and demonstrates parallel local government and development partner interest in utilizing new innovations for treatment in Kenya.

In addition to developing the technical solution, Sanivation is an operator generating revenue from households for its container-based sanitation service and the sale of briquettes, and super logs. The processing of human and other waste into fuel contributes to conserving Kenya's forests and financially empowers households involved in the sale of briquettes.[37] Sanivation has worked to enter the market by developing a novel thermal technological solution to treat fecal sludge, while also generating demand for its fuel products. As the operation evolved, it was necessary to apply learnings and refine the operational and marketing aspects, which required additional funds. Sanivation worked with the Program to seek private capital to fund improvements and exploit new opportunities. The technical assistance included financial modeling and advisory, underpinned by refined market analysis for end products, and developing communications materials to support investor outreach. The interventions helped to demonstrate that Sanivation is a viable entity worthy of investment, which led to relationships with new financial partners and US$3.7 million in resources mobilized to date, including grants, equity, and debt. Sanivation is using the funds to scale up production at the Naivasha Waste Processing Plant and for expansion to other Kenyan towns.

Through its partnership with Nakuru County and support from the Kenya regulator, Sanivation is exploring leveraging additional resources, including the possibility of utilizing the regulatory provision for NAWASCO to collect a Sewerage Levy as payment for service delivery. Sanivation's in-country presence, and its approach to partner with local government, and adjust its technology, offerings, and business model to the local context are considered to key drivers of results and ability to mobilize early-stage private capital. This positioned them well not only to receive targeted technical assistance from the Program, but also for opportunities to serve Naivasha and other communities.

2.3 INDIA—FINANCING BIOMASS CONTROLS' BIOGENIC REFINERY INSTALLATIONS

WASH-FIN Approach	Outcome
Financial modeling and capital planning, investor readiness, and transaction advisory support.	Streamlined financial model; line of credit accessed from WaterEquity based on revenue anticipated from market opportunities in the form of public tenders.

Key takeaway: A strong government led enabling environment and public funding can support a favorable climate to leverage private sector participation.

India is experiencing a water and sanitation crisis, as some 70 percent of urban waste water discharged into rivers, lakes, and ponds, is untreated, and 65 percent of households are outside the coverage of a public sewerage network.[38,39] The enabling environment is comparatively strong, with the 2017 National Policy on Fecal Sludge and Septage Management identifying a need to invest in the FSM service chain,

[36] SNV and ISF (2021) Treatment technologies in practice: On-the-ground experiences of faecal sludge and wastewater treatment, Case Study No.4

[37] USAID WASH-FIN (2020) Country Brief Series: Expanding Finance for Water Service Providers in Kenya

[38] CEPT University Center for Water and Sanitation (C-WAS)

[39] National Policy on Fecal Sludge and Septage Management (FSSM), AMRUT, MOUD, 2017

including private sector participation.[40,41] Sanitation is a State level function, and states subsequently prepared FSM policies and plans. Several states adapted an innovative Public Private Partnership (PPP) structure from the road sector called the Hybrid Annuity Model (HAM). The HAM combines upfront public investment for a portion of the capital cost and an annuity payment for operating costs during the concession period.[42] States have issued tenders for over 100 municipalities to attract private sector innovation to address India's urban sanitation crisis. Notably, the tenders defined the technical and service level standards but were agnostic as to specifying any specific technology or approach.

This development was timely for U.S based technology provider, Biomass Controls PBC, which had already piloted its technology in India. Biomass Controls uses a thermal process to convert high moisture organic waste, including human excreta, into pathogen-free, nutrient-rich "biochar," a carbon product used as a soil amendment that can sequester carbon. The technology received U.S. government and investor support for R&D and pilots. BMGF supported pilots for three systems in India covering CapEx and first year of OpEx for field testing.[43] Operational since 2017, the pilot systems now serve 50,000 people per day, up from an initial 15,000; partners are planning for commercial transfer of the equipment to local government in 2022.[44]

The pilots provided exposure to the Indian market and as Biomass Controls prepared to participate in the PPP tenders and raise funds from investors in 2019, there was a need for more refined financial modeling and capital planning support to understand the opportunities, the financing required to scale, and the options to source it.

At this stage, WASH-FIN supported Biomass Controls with developing corporate finance strategies and capital planning as a basis to objectively assess PPP and other opportunities in India. This support was instrumental in Biomass Controls accessing a US$1million line of credit from WaterEquity, an asset manager committed to providing affordable capital for WASH investments. WaterEquity was providing finance to other firms in the space and was familiar with the HAM structure and tenders in India. While political transitions through elections in certain states delayed the process, it eventually advanced, and access to this line of credit provided Biomass Controls with the resources to participate as a sub-contractor in one city in India and fund other business development efforts in Asia. The financial modeling showed that a combined long-term lease and maintenance service model was more viable than a capital investment model, with an added benefit of ensuring the system is maintained to standard, including the emerging ISO 31800 sanitation standard which has been included in recent treatment tenders in India.[45] Biomass Controls has also recently signed licensed manufacturing agreements in India and South Africa which offer prospects for further expansion. During the COVID 19 pandemic, Biomass Controls' remote monitoring and data collection capabilities proved to be an effective means to provide evidence-based reports for its installed units.

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40 National Policy on Fecal Sludge and Septage Management (FSSM), AMRUT, MOUD, 2017

41 USAID, State of Urban Water and Sanitation in India, TERI, 2017

42 CEPT University Center for Water and Sanitation (2018) Hybrid Annuity Model (HAM) for Sanitation

43 Dalberg (2018). India: market insights for the omni processor. Sanitation Technology Platform (STeP). Page 80, and Biomass Controls consultation (December, 2021)

44 Biomass Controls consultation (December, 2021)

45 https://sanitation.ansi.org/Standard/ISOPC318 (Accessed December 2021), and Consultation with Biomass Controls (December 2021).

3.0 REFLECTIONS ON IMPLEMENTATION

With 60 to 70 percent of human waste globally entering the environment *untreated*, there is a massive need for investment in sanitation treatment infrastructure and services[46]. New technologies have great potential to serve unconnected households and complement expensive sewerage systems. However, experience has revealed a gap in terms of understanding the needs and maturity of the market and establishing responsive business models and arranging finance to reach commercial viability and growth stage. In this section, we reflect on our experience as it relates to the formation and operation of markets and initiatives for utility-scale urban sanitation treatment services and their readiness for investment capital. The authors acknowledge that three examples are a very small sample and that there are many existing technologies and new innovations at various stages of development in this space.

3.1 TECHNICALLY SOUND SOLUTIONS OFTEN REQUIRE SIGNIFICANT TIME TO IDENTIFY, ACCESS, AND SERVE A VIABLE MARKET

The experience indicates that for sophisticated utility-scale sanitation treatment technologies, even when technologies are able to break out of the lab and obtain funding, there is still a long journey to through the so-called valley of death to commercial viability. The technologies supported did not have the challenge of displacing an existing technology or solution, but they do face the challenge of convincing a critical mass of buyers that their technology offers a set of features and benefits at a price point appropriate to the value proposition as seen by market actors. The sanitation enterprises supported by the Program clearly see a market need – billions of people lacking safe and affordable sanitation services. What is missing for utility-scale treatment technologies to date is effective market demand created by the primary customers: government. None of the cases supported by WASH-FIN have achieved commercial viability, though they continue to work towards this goal. For Sanivation, although the pilot phase has shown that the technology works well and is largely acceptable to the people of Naivasha, moving beyond the original factory has taken considerable time and is an ongoing strategic conversation. For DELVIC, the decision by the government of Senegal to have ONAS be the owner of the updated J-OP, is indicative of the time required to reach commercial viability.

For these technologies to advance to a viable scale of application, they require a supportive market environment to fit into, including regulatory and policy structures, sufficient and reliable funding, and a value proposition that generates and sustains revenue to cover costs and attract required investment capital. For example, Sanivation's efforts to advocate for innovative 'waste to value' technologies in Kenya led to an opportunity to contribute technical support to Malindi Water and Sewerage Company (MAWASCO) on deployment of such technologies within a City-Wide Inclusive Sanitation (CWIS) approach. The local government's leadership in pursuing this solution, with support and funding available from the World Bank resulted in approximately US$ 7 million allocated for treatment plants as part of the CWIS initiative. [47] This is a good example of an in-country presence providing an opportunity to not only build on prior achievements and demonstrate the value of innovations to decision makers, but also the importance of a detailed understanding of and alignment to the conditions and challenges of the local context, which can vary significantly across and even within countries.

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[46] World Bank. (2020). A new chapter in the Citywide Inclusive Sanitation story: the World Bank launches its CWIS web hub; Accessed in November 2021 at https://blogs.worldbank.org/water/cwis-new-web-hub

[47] About US$7 million in proceeds from a World Bank loan was re-allocated to support the waste-to-value project in Malindi. (Sanivation consultation and https://sanivation.com/malindi (2021)

Of the various sanitation solutions supported by the Program, the most promising deploy simpler and lower cost technology in terms of CapEx and OpEx, and balance this with revenues collected from both service provision and the sale of treatment by-products, through resource recovery. The extent to which the solutions' entry strategy and business model fit the enabling environment, can attract public funding, and meet affordability criteria, further enhances their prospects. Those that don't will require more time and working capital in the commercialization stage (Figure 2); lower cost and simple/less risky technologies will have an advantage.

3.2 FINANCIAL MODELS MUST BE DEMAND-BASED AND INCLUSIVE OF ALL COSTS AT OPERATIONAL SCALE

To be viable, the all-inclusive costs of any technological solution must reflect all the peripheral improvements needed at the installation sites to accommodate the innovative technology as well as those required to access inputs and deliver outputs. For example, the J-OP operated by DELVIC for the initial pilot prior to WASH-FIN support was itself a costly investment. In addition to the technology, the installation would need to cover other costs such as compliance with environmental regulations and permitting. DELVIC also learned that the fecal sludge and other inputs for the J-OP operation required more advanced and reliable processes than what is typical for simpler sludge processing. This resulted in a shift in thinking to consider sludge as a feedstock or a fuel similar to an industrial process and led to optimization improvements from DELVIC to ensure sufficient sludge and other inputs were available to maintain the for J-OP operation.[48]

Therefore, when preparing pro-forma financial models, entrepreneurs and analysts must consider the prevailing operating environment. Inefficiencies in existing sanitation containment infrastructure and transport systems may require additional investment to optimize throughput and consistency at the level required to reliably produce the feedstock for the more advanced treatment technologies. Operators need to ensure unwanted contaminants are removed and depending on the technology, supplemental additional feedstock from agriculture or municipal solid waste may be required. They must also account for costs related acquisition, logistics, and storage of inputs, at a volume many times that of fecal sludge. For example, the Sanivation factory requires mixing dried sludge with agricultural waste to produce fuel briquettes which analysts factored into financial models. Similarly, in anticipation of the updated J-OP, DELVIC received an assessment of the availability and cost of municipal solid waste to be mixed with dewatered fecal sludge.

For a reuse product, the costs to acquire and process feedstock, and for required packaging, marketing, and distribution to service these markets must be included.[49] If these costs cannot be covered by revenue at a competitive price, they will need to be covered on the public good side of removing human waste from the environment or as a basis for another reliable source of revenue.

The WASH-FIN experience therefore re-emphasizes the fact that resource recovery models need to fully appreciate the CapEx and OpEx investment required to deliver the products consistently and reliably in accordance with the demands of a commercial market for products, not only the sanitation or treatment service. For more sophisticated capital-intensive utility-scale treatment technologies, this introduces additional layers of uncertainty into business models as the byproducts must compete with incumbents in quality and availability. When models consider the full costs, it may impact the value proposition, or otherwise require more CapEx, better terms, additional working capital, or public

[48] Sanitation Technology Platform (2019). Preparing for Commercial Field Testing of the Janicki Omni Processor: lessons learned by DELVIC Sanitation Initiatives in Dakar, Senegal. RTI International.

[49] Ibid.

support. This calls for conducting a rigorous evaluation of the methodology and data that underpins a market assessment, as well as a thorough ground truthing of third-party data to the specific local context (which the commercial field test can support).

Over time, operators like DELVIC will be better able to understand cashflows and how to improve operations for follow-on investments or replication. This learning will be beneficial for the commercial field test of the updated J-OP, which will further inform on technical and market factors.

3.3 AVAILABLE MARKET ASSESSMENTS ARE INSUFFICIENT TO PREPARE INVESTOR FACING FINANCIAL MODELS

Sanitation is a public good with vast potential for public and private sector innovations to deliver a reliable public service. However, the team found that available assessments often did not adequately quantify actual demand or the "addressable market" for segments of the service chain targeted, nor did they provide a basis from which to establish this with confidence, such as factoring in existing practice and competing solutions in the market and switching costs. While analysts can come up with an estimate of the market value derived from the general "need" for sanitation based on estimated costs of assets required to deliver services at a certain scale/scope, these estimates will not necessarily account for the full lifecycle costs required to operate and maintain viable service delivery. Analysts found that the use of assessments of market size that were not based on actual or likely future customer spending, primarily from the public sector, diminished stated value propositions and investment proposals.

In supporting DELVIC, Sanivation, and Biomass Controls, the team interrogated existing financial models and supporting data, and challenged owners to refine assumptions around estimates for the overall and addressable markets, the costs to access these markets and the potential for revenue. The models relied on available data from pilots, operations, or market analysis for both the input side of the process, as well as the by-product outputs in the case of DELVIC and Sanivation. For Biomass Controls, the support involved financial analysis to compare a contract arrangement for an operator to purchase the technology and related support, vs. a lease and maintenance service model. Resource recovery did not factor into the Biomass model as this would be the role of the operator.

Publicly available assessments based on need or service delivery gaps are useful baseline indicators but are not adequate for developing reliable business use cases and financial models for investment decisions. Breaking down or segmenting market assessments across the service chain or spectrum of demand from rural to urban (in the case of regional or national estimates), desired features and benefits, affordability, and price would help as would inclusion of any intermediaries required to deliver a viable service.[50] Estimates of markets for resource recovery products require more analysis and need to clearly delineate not only the core sanitation service delivery market estimates, but also the resource recovery market value assumptions specific to the solution e.g. water, energy, nutrients, etc. This requires estimates based on actual or likely customer spending as an indicator of demand, segmented by addressable markets across socio-economic and geographic typologies of cities but must be checked against actual practice as public budgets are not always fully expended.

In preparing investor ready financial models, the Program worked with the principals and technical staff to estimate the addressable market and the expenditure and time required to access the market and generate revenue. Where reliable market data for all revenue generating activities is not available, early-stage equity or grant funding should invest in this scope or seek partners to fill this gap as part of piloting and commercial field testing in anticipation of follow-on funding and finance rounds. Financial

[50] IWA Publishing, Journal of Water, Sanitation and Hygiene for Development (2018) 8 (2): 176–195 (2018) "The cost of urban sanitation solutions: a literature review"

models for imported solutions carrying foreign exchange risk must factor this in and consider its impact on cashflow and financial risk – critical when revenue is in local currency.

3.4 EARLY-STAGE GRANT FUNDING CAN BE CATALYTIC, BUT AS A PUBLIC GOOD, PUBLIC EXPENDITURE IS REQUIRED TO CREATE A MARKET

Each of the supported solutions relied on grant funding for early development, piloting, and proof of concept. Program experience shows that grant funding can catalyze additional equity and debt finance. It is noteworthy that in the case of Sanivation, this was not a linear process as the firm continued to access grants after accessing repayable finance. However, we assert that to effectively, and quickly, scale and replicate solutions at a commercially viable scale beyond one-off installations, governments must come in with sustained and reliable expenditure to procure these solutions. It would be beneficial to pair early-stage R&D funding with strategic technical assistance, enabling environment reforms, and incentives that support product launch and attract private capital during commercialization (Figure 2). Development partners can support this and encourage the goal of transitioning to government ownership and budgets. Investing in defining and tracking success of pilot installations and raising awareness can help unlock public funding, as exemplified in the Malindi Kenya example noted earlier.

DELVIC and the J-OP entry into Senegal offers an example of the importance of technology being commercially field tested before pursuing market finance. In this case, the technology owners had invested grant funds in the technical pilot to the point where DELVIC as an operator was interested in exploring commercial investment to be ready for scale up. However, as the team explored investor appetite it became clear that the commercial unit required more robust testing and operation, and more refined cashflows, for investors to commit funds. In retrospect, while the financial analysis and modeling of the pilot operation was useful in terms of gaining knowledge, understanding markets, improving processes, and building internal capacity at DELVIC, if a technology or the use case is going to change significantly, it is advisable to consider waiting until the updated data is in to evaluate readiness for investors. The extent to which firms can demonstrate to investors that public funds are budgeted, and tenders issued for their particular solution is another factor to consider. For example, Biomass Controls could cite several published public tender opportunities in India in its successful financing application.

Market entry strategy is another consideration that impacts sequencing and sourcing funding. As globally oriented solutions, Biomass and J-OP (in partnership with DELVIC), made initial assumptions and market entry decisions based on product development, prior pilots, and information from partners, including government. In contrast, Sanivation, with its in-country presence and a deliberate focus on specific counties in Kenya, developed its technical solution iteratively within the local context and used this experience to adjust the product/service fit and assess the market dynamics in parallel.

When taking the decision to fund R&D through grants, it is advisable that funders and firms plan for the commercialization phase to fully account for the requirements of market entry,[51] thereby mitigating risk and having a clear vision. Technology uptake is likely to be slow and iterative especially in LMICs. While initial seed funding through grants is important, firms will require additional capital to sustain a broader market entry process and commercial viability. To support this, governments and development partners should invest in the enabling environment to foster innovation to ensure more become viable. In addition to technical assistance, governments could provide grant support to providers and training to design procurements that encourage innovation and experimentation, and fund technology standards development and certification. The social nature of sanitation and its public service character suggest that solutions will require credit enhancements and structures to reduce the risk for private capital; it is

[51] InfoDev (2014) "Building Competitive Green Industries: the climate and clean technology opportunity for developing countries." World Bank, InfoDev.

worth noting that unlike other sectors that are expected to transition to pure commercial finance, blended finance in this space is expected to be a permanent reality.[52] As with water supply and other urban services, local currency finance is preferential to avoid expensive foreign exchange risk.

WASH-FIN initially focused narrowly on supporting mobilization of market finance for going concerns responding to specific or emerging market opportunities. From that initial position, the nascent stage of the technology underpinning these business models and the market entry challenges faced were underappreciated. Despite this, Biomass Controls and Sanivation were able to mobilize repayable finance due to their respective prior investment and results, and the advanced nature of the market opportunities identified. However, DELVIC, as an intermediary looking to purchase a technology that was still evolving and with an uncertain revenue stream and cashflow was not ready for commercial or impact capital for this application, notwithstanding the considerable progress made. The latest plan to operate the updated unit under contract is more in line with DELVICs traditional business; if this application requires working capital it is more likely to be bankable.

3.5 SUPPORT SHOULD BE BALANCED TO REACH PROMISING FIRST MOVERS AND ALLOW SPACE FOR A VARIETY OF SOLUTIONS

In Senegal, the government's interest in experimenting with new technology and the focused and coordinated support of BMGF and other partners was instrumental to implementing the J-OP technical pilot and preparing for the commercial use case with the updated unit. In contrast, in India, government initiated a process by which states put out tenders across multiple municipalities that were technology agnostic (provided they met the terms of the tender) and offered the opportunity for the domestic and international market to respond with competing technologies and solutions. This is a good approach for the Indian context where thousands of sub-national municipalities are responsible for service provision across states with policy and funding support channeled from the federal government through taxes and transfers. It allows for broader risk taking and demonstration of not only technology, but also resource mobilization and institutional arrangements. In national service delivery contexts such as Senegal, policy makers should similarly seek appropriate means to ensure there is an ecosystem of possible solutions that achieve government service standards and objectives. Indeed, ONAS is actively seeking to improve treatment efficiency in Senegal having initiated a project to rehabilitate and modernize FSTPs in Dakar and expand the range of solutions through testing of mechanization and disseminating results.[53]

The time factor is also important; the longer it takes to demonstrate and institutionalize decentralized, high-tech solutions, the prevailing simpler, lower cost solutions may become locked in. Purely from the perspective of a technologically advanced and more expensive solution provider, the concern is that this would raise the bar further even when the advanced one otherwise offers potentially higher value-add. While there may appear to be little risk to focus and attention on individual solutions, there could be opportunity costs to this approach to the extent it diminishes opportunities for local innovation.

On the solution provider side, focusing too much on a single market and entry strategy may not be the most efficient allocation of resources to commercialize the technology broadly; there could be other market opportunities better aligned to reach commercial viability more rapidly. The J-OP and Biomass Controls both have a limited presence in other countries through licensing and joint venture arrangements. Sanivation has yet to bring either its technology or integrated solution outside of Kenya. Kenya also has two other technologically advanced and integrated treatment solutions operating, and

[52] Convergence (2021) Outcome Document; Working Group on Blended Finance for Water Infrastructure Maintenance and Fecal Sludge Management

[53] ONAS Consultation (April 2022)

emerging potential in Malindi. However there has yet to emerge a national level impetus – with funding, incentives, and reforms to replicate and scale these solutions across its 47 county jurisdictions.

3.6 IMPROVING THE ENABLING ENVIRONMENT REQUIRES CHANGES IN INCENTIVES

Mismatched and distorted incentives that sustain the status quo is the key development challenge in bringing new technological treatment innovations to LMICs. Governments are risk averse and typically do not invest in unproven technologies, especially in highly visible social sectors and at sub-national level. Fear of failure in resource constrained departments is high and decision makers may prioritize more familiar, traditional technologies and systems. In practical terms, this means that the knowledge and capabilities of decision makers still favors expensive sewered systems and centralized treatment plants. Although some studies indicate sewers will still have a role, and be able to compete with other systems,[54] the physical realities of dense, informally settled urban areas in LMICs makes networked solutions impractical and inefficient. Coupled with budgets that are far below the CapEx cost to meet minimum needs, low willingness of households to pay for services, and limited financing options, it is difficult to conceive of achieving the SDGs based on these systems. Governments and development partners have acknowledged as much, and policies on FSM and emerging planning frameworks such as City-Wide Inclusive Sanitation[55] offer a potential pathway forward.

To mitigate investment risk and demonstrate value to commercial financiers, the sector requires a supportive, reliable, and rational enabling environment to encourage adoption of new technologies and private sector investment. In all sectors, and in particular a social sector, this is the role of government. Areas of opportunity for government or development partner support include:

- Enabling environment reforms to define and enforce regulations and standards, especially to protect the environment and public health, but also quality of service and cost recovery tariffs.
- Institutional strengthening, including improved enforcement and compliance to standards, performance benchmarking, and procurement and public financial management.
- Supporting market-based solutions by facilitating access to finance, disseminating information, or providing business support services.[56]
- Advocating and providing funding to link or include sanitation treatment technologies in national industrial development, innovation promotion and SME development and finance programs.
- Supporting coordination across sectors to leverage synergies and exploit opportunities; strong candidates are urban solid waste management, agriculture, and renewable energy.
- Targeting capital or operating subsidies to influence investment by financial actors or funding activities that benefit the community as a whole (e.g., wastewater treatment).

[54] World Resources Institute Ross Center (2019) Working Paper: Untreated and Unsafe: Solving the Urban Sanitation Crisis in the Global South

[55] USAID (2020), Technical Brief 5; Urban Sanitation Services

[56] Trémolet, Sophie (2013). Sanitation Economics: understanding why sanitation markets fail and how they can improve. Waterlines Vol. 32, No. 4

- Funding interventions such as grants to support R&D, credit enhancements such as partial credit guarantees, favorable tax or import policies, contract terms that front load payments as a form of finance[57], or targeted capital or operational subsidies.

In India, government initiatives, with support from BMGF, World Bank, USAID and others, have provided a favorable enabling environment underpinned by a well-articulated national policy that sets a common vision, defines roles and responsibilities, synchronizes programs, and mandates equity.[58] Pioneering state governments have adapted an innovative PPP structure that leverages national and state funds with private participation across multiple municipalities.[59] The approach is technology agnostic with scale that offers solution providers an opportunity to compete, learn, and innovate while serving the market thus created. Of the three countries, the enabling environment in India was best-suited for adoption of sanitation innovations across the service chain with strong potential for creation of a viable ecosystem of public service-oriented solutions.

In Kenya, decentralization is evolving and relationships and responsibilities between county and national government and sector institutions require enhanced policies, capacity, tools, and resources to enable more efficient and effective devolved WASH service delivery. In a dynamic enabling environment, markets are more unpredictable and technology introduction faces particular, local challenges. In this context, Sanivation's in-country presence, its position as both the owner and user of the technology, combined with a partnership with one of Kenya's 47 counties resulted in a business model that responded to local needs and evolved to leverage grant funding to attract equity, and debt finance. Although the technical solution is perhaps the most proven, replicating this model in Kenya and expanding to other counties will require public support either directly through budgetary expenditure channeled through tenders, or indirectly through technical assistance and training for county officials, application of new levies or a combination of these and other means. Sanivation's established goodwill with national and local decision makers, combined with its proven ability to access capital to invest in execution of plans, bodes well for expansion in Kenya. Market creation actions in the public space (such as in Malindi) would build on this, as well as the achievements of Sanergy, another innovative sanitation service provider utilizing thermal treatment technology in Nairobi.[60]

Senegal has a well-developed institutional framework for urban FSM services and the government has embraced private sector participation and is actively working to improve and expand this model.

3.7 TECHNICAL ASSISTANCE MUST BE DELIBERATE AND WELL COORDINATED

WASH-FIN technical assistance focused on strengthening financial management, business planning, and creditworthiness of the treatment technology and service providers. This support helped innovators to advance their offerings and access the capital required to respond to opportunities in countries with favorable enabling environments. The experience has shown that early-stage grant funding can lay the foundation for a treatment solution, FSM enterprise, or project to grow to a stage where it is ready to

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[57] Nanda, Ramana, Harvard Business School (2020) "Financing Tough Tech Innovation", Chapter 5 in The Global Innovation Index 2020: Who Will Finance Innovation? (Cornell University, INSEAD, and WIPO, 2020).

[58] Government of India, Ministry of Urban Development (2017). National Policy on Faecal Sludge and Septage Management.

[59] Convergence (2021) Outcome Document; Working Group on Blended Finance for Water Infrastructure Maintenance and Fecal Sludge Management

[60] See: https://www.sanergy.com/

take on equity and/or debt.[61] However, to leverage this early-stage grant funding, solutions often require further targeted efforts to refine financial analysis and market analytics to satisfy investors. For Sanivation and Biomass Controls, this technical assistance proved catalytic in accessing repayable finance.

Funding and time constraints define the practical limits of technical assistance. The Senegal activity was the only WASH-FIN activity that included working in this space from inception to support DELVIC. The Kenya activity added Sanivation with a narrowly defined scope and there was no Program presence in India and therefore all work was remote and on-demand. They were all relatively light touch approaches to deliver specialized and targeted technical assistance. While that generally worked well, the impact was limited to these three firms and as noted, the direct assistance generally did not extend into other service chain elements. A more comprehensive approach working with national and sub-national governments on reforms to overcome the enabling environment constraints, and on the demand side with the public and private sector across the service chain would open up potential for broader impact and replication.

Similarly, time and space for deeper local development partner coordination was not always practical, so there were limited opportunities to learn and seek synergies. On the supply (finance) side, practitioners could take a similar comprehensive approach to use technical assistance to leverage all sources of capital more efficiently across the service chain and optimize and incentivize each link to form a stronger whole. Integrating this assistance within CWIS and other frameworks would likely create efficiencies of scale and scope, with potential for market creation and resource mobilization over multiple cities. Across both demand and supply, more comprehensive and highly segmented market and institutional assessments across the service chain and geographically would be beneficial.

[61] Convergence (2021) Outcome Document; Working Group on Blended Finance for Water Infrastructure Maintenance and Fecal Sludge Management

4.0 LOOKING FORWARD

In each of these countries, barring a pronounced change in the enabling environment and increase in funding flows, the potential market for utility-scale technological treatment will remain constrained by the inefficiencies of the prevailing market that favors expensive and impractical grey infrastructure on the high-end, or tolerates unregulated solutions on the low end. In a market so underserved at present, with significantly misaligned incentives, it is unlikely that the demand side will pull in sophisticated treatment technologies to achieve scale quickly; most markets will require slower, resource intensive push approaches. Over time, it is likely that a spectrum of solutions will emerge and complement one another, and each will have a place in accordance with the country's enabling environment, the solution business model, and the local (urban) economic base that results in the ability to pay. However, developers of technology will have to pay sufficient attention to the critical institutional and governance aspects to ensure strong product-market fit and be sufficiently resourced for a push approach. Even in countries already making progress, policy makers and practitioners must do more to institutionalize and fund market creation on the demand side.

There are encouraging indicators that the public sector is beginning to incorporate these technologies as part of the sanitation solution. In addition to India, several countries have taken initiatives to mainstream non-sewered sanitation solutions. Kenya has recently launched new national urban sanitation guidelines based on AMCOW's African *Sanitation* Policy Guidelines (ASPG),[62] which outline the challenges and frame the actions and roles for diverse stakeholders. Institutions in Kenya and Bangladesh are giving space for inclusion of technologies to manage and treat fecal sludge "with lower carbon footprint and lower land footprint."[63,64] Bangladesh recently launched a Support Cell for Citywide Inclusive Sanitation and FSM to ensure safely managed sanitation for all by 2030.[65] In South Africa, the Water Research Commission (WRC) has established centers for innovation in WASH, including sanitation technologies. This includes the South African Sanitation Technology Enterprise Programme (SASTEP), a national innovation platform developed in partnership with BMGF to fast-track the adoption of innovative sanitation technologies. The program's vision: "Upon conclusion of SASTEP, a rejuvenated South African sanitation industry should have emerged that not only creates jobs and contributes to GDP but also is a global leader in the application of alternative sanitation technologies that provides everyone in South Africa with access to dignified sanitation that minimizes pollution, beneficiates wastes, and promotes health, safety and water security."[66]

These and other WRC initiatives seek to accelerate market entry of WASH technology innovations, applied R&D, and transfer technology from domestic universities. Biomass Controls is delivering its solution as part of SASTEP and has licensed a local manufacturer that will be producing systems for the 16 South African Development Countries (SADC).

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62 African Ministers' Council on Water [AMCOW] (2021). African Sanitation Policy Guidelines (ASPG). See: https://amcow-online.org/initiatives/african-sanitation-policy-guidelines-aspg which offers a link to access support for countries to develop policies.

63 Athi Water Works Development Agency (2018). Strategic Plan 2018-2022.

64 Government of the People's Republic of Bangladesh (undated). Procurement of Plant: scope of supply of plant and services. Bidding Document for EAP/DPHE/W 19

65 The Financial Express (Nov. 2020) "DPHE sets up support cell to ensure sanitation"

66 See: http://www.wrc.org.za/ (Accessed Dec 2021)

To give utility-scale sanitation treatment innovations a fighting chance to achieve commercial viability requires strong and consistent government policy, standards, and enforced regulation - in short, an effective enabling environment. These serve as benchmarks and guideposts for early development and deployment of innovations, and eventually underpin commercial expansion.[67] Sanitation is a public good and the public sector must ultimately play a significant role in creating the market for reliable, resilient, and sustainable long-term service delivery.[68] A government led market provides a signal for entrepreneurs to apply their solutions and is evidence for mobilizing private capital to invest in new solutions. The more governments support these solutions, the more viable the market is likely to be; encouraging innovation has been effective in other sectors and the examples show potential for sanitation. Absent these enablers, and sufficient and reliable public funding, viable markets for utility-scale treatment solutions in LMIC urban areas are unlikely to develop in line with the SDGs or be efficient.

[67] World Bank InfoDev (2014) Building Competitive Green Industries: the climate and clean technology opportunity for developing countries.

[68] Organization for Economic Cooperation and Development (2019) "Making Blended Finance Work for Water and Sanitation: unblocking commercial finance for SDG 6." OECD Publishing, Paris, France.

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