

# THE CIRCULAR SANITATION ECONOMY

New Pathways to Commercial and Societal Benefits  
*Faster at Scale*

A THOUGHT PIECE FROM THE TOILET BOARD COALITION  
NOVEMBER 2017



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WATER  
RESEARCH  
COMMISSION



Confederation of Indian Industry

In Partnership with: QSA Partners

## ABOUT THE TOILET BOARD COALITION

Founded in 2014, the TBC is a unique business-led partnership with the ambition to address the global sanitation crisis by accelerating the Sanitation Economy.

The TBC is enabling private sector engagement; connecting large and small companies; and ensuring close collaboration between private, public and non-profit sectors with the common goal to achieve Sustainable Development Goal 6 (SDG6), universal access to sanitation.

The TBC runs the Toilet Accelerator, the world's 1st accelerator programme dedicated to sanitation entrepreneurs in low-income markets.

The members of the Toilet Board Coalition believe that accelerating the Sanitation Economy will deliver significant impact to business and society.

## ABOUT THE TOILET ACCELERATOR

In 2016, the TBC launched the "Toilet Accelerator" to amplify support to innovative sanitation business models operating in low-income markets. The Toilet Accelerator works with promising sanitation businesses for a duration of 12 months through a small business-large business mentorship programme model.

In 2016 and 2017 the TBC has worked with ten inspiring sanitation businesses operating across Africa, India and Southeast Asia. This study focuses on our findings during our work with four Circular Sanitation business models in Africa in 2017.

## ABOUT THIS PAPER

### OBJECTIVE

To demonstrate the commercial viability of the Circular Sanitation Economy, by backcasting from the future, to envisage the new business models operating at city scale, and to explore two key questions:

- Will current Circular Economy Sanitation business models be profitable at scale, and will public subsidy still be required?
- What are the key elements of the commercial case – the key arguments needed at the inflexion points where scale-up decisions are made?

**This paper has been produced in collaboration with QSA Partners and the Circular Sanitation Economy companies of our 2017 Accelerator Cohort: The BioCycle, Safi Sana, Sanergy and Sanivation.**



QSA Partners were contracted by the TBC to undertake the financial modelling of the Circular Sanitation Economy business models, based on the 2017 Cohort and other data. More detail on QSA can be found at <http://www.qsapartners.co.uk>

## OUR APPROACH

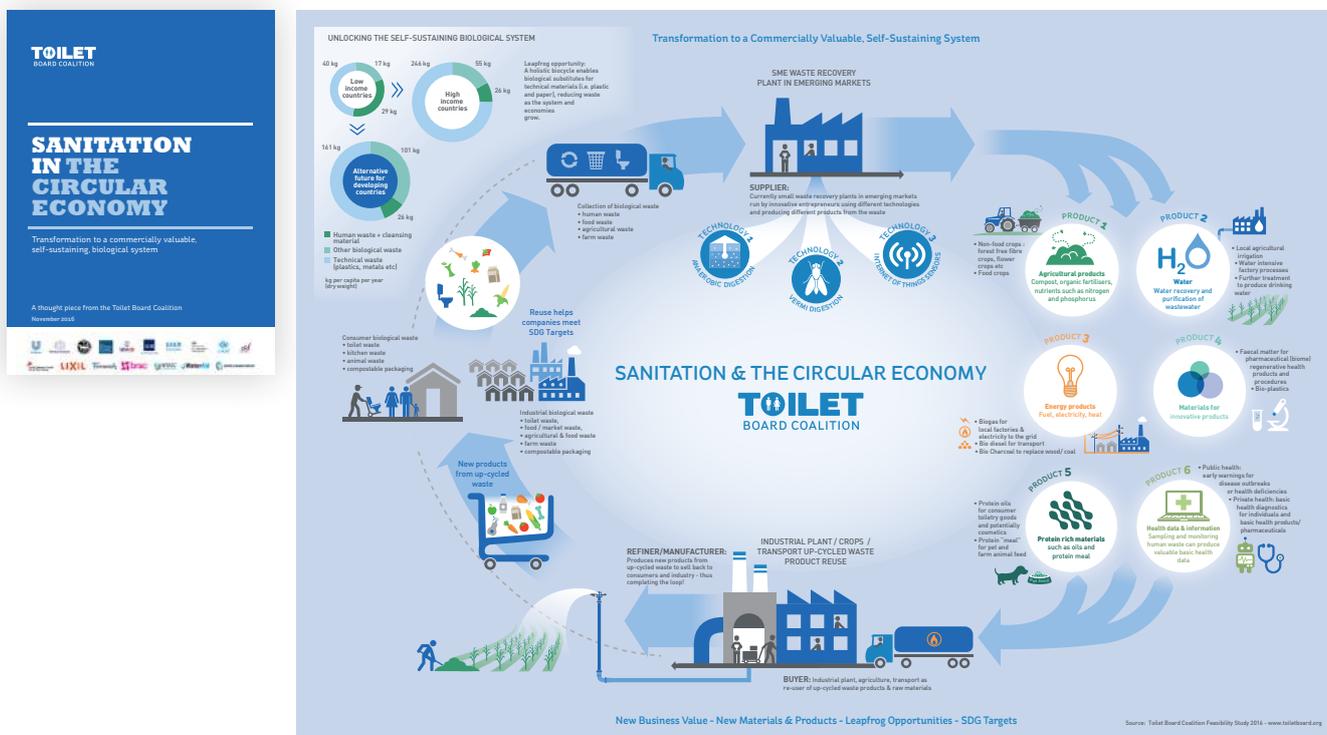
### 2016 - SANITATION IN THE CIRCULAR ECONOMY: Transformation to a Commercial Valuable, Self-Sustaining, Biological System

In 2016 the Toilet Board Coalition launched an inquiry to explore the business opportunity for Sanitation in the Circular Economy. Three key opportunities for business were identified:

1. Realise value from products derived from “Toilet Resources” (the TBC’s preferred term for human waste)
2. Build a holistic biological waste / resource system, not only for sanitation
3. Use Circular Economy models to provide toilets / infrastructure

Read the full report here: [http://www.toiletboard.org/media/17-Sanitation\\_in\\_the\\_Circular\\_Economy.pdf](http://www.toiletboard.org/media/17-Sanitation_in_the_Circular_Economy.pdf)

Figure 1 - TBC Sanitation in the Circular Economy, Report and Infographic, 2016



### 2017 - THE CIRCULAR SANITATION ECONOMY: New Pathways to Commercial and Societal Benefits Faster at Scale (This Report)

The most frequent feedback question from the 2016 report was: Does this work as a commercial reality? Therefore our 2017 enquiry has focused on finding evidence for commercial viability. To address this, two studies were commissioned by the TBC:

- Sister report - TBC with Tata Strategic Management Group – “The Sanitation Economy in India: Market Estimates & Insights.” Toilet Board Coalition. November, 2017.
- This report - TBC with QSA Partners - commercial case (Africa + wider data)

The two studies were designed to “meet” in considering a hypothetical city of 3 million people. This does not imply a single SME fully serving a city, let alone producing a single re-use product – the reality would be a hybrid of solutions. 3 million is just a notional scale factor representing “city size” – roughly comparable to our city partner Pune. The modelling has extrapolated from the companies’ own forecasts, to scale up to a hypothetical city of 3 million people, without adding further assumptions of scale or experience benefits in doing so. It is premature to evaluate the more nuanced effects of scale and competition this would bring.

Figure 2 - Hierarchy of Economic Analysis of Sanitation and the Circular Economy



1. World Bank (2013) Infographic “What’s a Toilet Worth”
2. Lixil Corporation, with Oxford Economics (2016) The True Cost of Poor Sanitation
3. Ellen MacArthur Foundation (2015) Towards a Circular Economy: Business Rationale for an Accelerated Transition

The approach was developed in consultation with the 2017 TBC Toilet Accelerator Cohort, to ensure relevance of approach, and use of real numbers, backed up by wider sources.

The findings are based on analysis of commercial data from the Toilet Board Coalition 2017 Toilet Accelerator Cohort and others. Therefore high levels of confidentiality are required to protect commercial information, so this report publishes the insights, not the data. Further notes on the modelling methodology are in Appendix 1.

We thank our many contributors (see acknowledgements) – the findings do not necessarily reflect their views.

It is important to remember that the Circular Sanitation Economy is in its infancy. There are few companies operating, and they are in few places, at small scale, some using new technologies, and all facing many barriers.

We concluded it is too early for “proof” of the Circular Sanitation Economy’s profitability or investability. Attempting this might even undermine credibility and confidence, and discourage investment and/or other funders. The requirement at this stage is to win the commercial arguments needed to make progress, so that the sector can prove itself at scale.

**Therefore our chosen focus is:**

**What are the key arguments for the Circular Sanitation Economy, at the inflexion points where key decisions will be made?**

**This report attempts to answer these questions as The Commercial Cases.**

Table 1 - Circular Sanitation Economy - The Commercial Cases

	<b>NEW BUSINESS MODELS</b> aiming for each to be profitable at city-scale	<b>NEW DEALS</b> aiming for the commitments that will draw in investment and participation	
<b>What are the inflexion points?</b>	<b>Case 1 - Winning Customers</b> For re-use products and services, based on a range of technologies, sold at a competitive price	<b>Case 2 - Winning Contracts</b> Large companies and cities contracting with entrepreneurs to create the nucleus of the new ecosystem	<b>Case 3 - Shifting the Context</b> Changing the mindset of key stakeholders towards a new sanitation business model
<b>What outcomes are needed?</b>	Large organisations buying materials and energy from sanitation entrepreneurs	Both municipalities and large companies giving contracts to sanitation entrepreneurs, which are beneficial in themselves and also prove the model at scale	Governments, municipalities, and utilities recognising the merits of the Circular Sanitation Economy system, and shifting strategies, subsidies, and regulation to support it

## FOREWORD

Circular Economy principles are becoming a business imperative for the future. Evidence over the past decade has shown that by applying a Circular Economy lens, businesses can reduce costs and generate new revenue streams. We argue this to be true also for the emergent sanitation sector and more broadly what we at the Toilet Board Coalition call the rise of the Sanitation Economy.

In response, we as business leaders and members of the Toilet Board Coalition, are keen to signal to our stakeholders our willingness to formulate and support innovative business solutions that firmly bring sanitation into the Circular Economy and in doing so enable us to leverage significant benefits for our businesses and for society. When applied to sanitation, the Circular Economy unlocks a rich cycle of biological, and renewable, resources that can be used and reused continuously. This represents a new reservoir of resources, currently being lost and often causing harm to society, which if captured could amount to 3.8 trillion<sup>1</sup> litres of biological material globally each year.

The compelling evidence and statements from the companies and stakeholders who have contributed to this report, along with the data presented, make it clear that the Circular Sanitation Economy could significantly speed up the pace of change and the scale needed to achieve Sustainable Development Goal 6: Universal access to adequate and equitable sanitation and hygiene. The safe management of Toilet Resources is critical to creating sustainable and resilient sanitation systems for all.

Moreover, the new technologies and business models emerging - as discussed in The Commercial Cases section of this report - present real promise for profitability at scale, replicability, faster and at lower cost than traditional sanitation systems.

It is our aim that this report provides new evidence to the global sanitation and business communities that there is significant opportunity, now, to evolve our thinking about waste management to a focus on the mining of vast resources and potential products that lie within our toilets, everyday, by the entire population.

We hope that our fellow business leaders become as inspired as we are about the toolbox of business opportunities outlined in this report, and will join us in accelerating the Circular Sanitation Economy.



*Charlie Beevor*

**Global Vice-President**

Household Cleaning Brands  
Unilever  
& Toilet Board Coalition Chairman



*Pete Dulcamara*

**Vice President**

Corporate Research & Engineering  
Kimberly-Clark Corporation  
TBC Circular Economy Chair  
TBC Partnership Council Member



*Cheryl Hicks*

**Executive Director**

Toilet Board Coalition

<sup>1</sup> Based on 500 litres urine and faeces excreted per person per year. Quantity may vary depending on volume and components of food intake. H. Zeeuw and Pay Drechsel ed. RAUF Foundation & International Water Management Institute (IWMI) (2015). Cities and Agriculture: Developing Resilient Urban Food Systems. Earthscan by Routledge. New York.

## IN SUPPORT OF THE REPORT - QUOTES

*Charlie Beevor*

Global Vice-President  
Household Cleaning  
Brands, Unilever, TBC  
Chair

“

The vision of the Circular Sanitation Economy opens up the prospect of delivering universal access to sanitation and toilets, in new ways. This vision radically broadens the range of companies, investors and business sectors that would have an interest to address the sanitation crisis. As business leaders of the Toilet Board Coalition we call on our global business peers to include sanitation in your Circular Economy strategies, and in doing so, unlock vast benefits for our businesses and society.

*Pete Dulcamara*

Vice President -  
Corporate Research &  
Engineering, Kimberly-  
Clark Corporation, TBC  
Circular Economy Chair,  
TBC Partnership Council  
Member

“

In nature, one species waste is another species food. The Circular Sanitation Economy can do the same for industry by offering new materials, products, business models, commercial channels, and alternate sources of energy and water. The benefit to big and small companies alike, is the potential for cost savings by reducing, recycling, and reusing materials, energy, and water. In addition, companies can develop increased sales and customer loyalty by using local ecosystems and materials, increased strategic partnerships with key suppliers, and possibly easier access to capital in partnership with municipalities. Lastly, companies participating in the Circular Sanitation Economy, as part of their CSR efforts, can enhance their reputation, brand equity, and employee attraction and engagement. Essentially, the Circular Sanitation Economy is a new business model for industry, using the principles of nature to shift from scarcity to abundance while empowering local communities to solve the global sanitation crisis.

*Pascale Guiffant*

Former Deputy Vice  
President, Sustainable  
Development &  
Reputation, Suez &  
& TBC Independent  
Director

“

The sanitation crisis we have been facing for years really needs a broad mobilisation of actors. We know that if we only rely on implementing new sewer systems, many people will still have to wait a long time for sanitation. Sanitation entrepreneurs are bringing innovation and new solutions that will help in accelerating the development of access to sanitation. They are also bringing a Circular Economy vision with innovation, technology and new business models. Operators will gain from contracting with them and helping their solutions to scale up.

*Martin de la Harpe*

Head of Sustainability,  
Flamingo

“

Given the projected growth in world population over the next decades big opportunities exist in agriculture in returning nutrients to soil using Circular Economy approaches which combine sustainability with high productivity. Flamingo Horticulture is continuing to gain expertise in this area, and is collaborating with Sanitation in Kenya.

*Ms Seema Arora*

Deputy Director  
General; Confederation  
of Indian Industry (CII) &  
TBC Partnership Council

“

Universal sanitation coverage and access is the need of the hour. Transformation from the linear approach to a circular approach to the Sanitation Economy is imperative for business development. We hope that this publication enables various stakeholders, including industry, toilet innovators and sanipreneurs to build new and scalable business opportunities in sanitation.

*Jon Lane*

Former Head of  
the WSSCC, TBC  
Independent Director

“

We failed to achieve the MDG target for sanitation. The SDG target is more onerous especially since it – rightly, in my view – includes the concept of safely-managed sanitation. A Circular Economy approach will be a vital component of all successful sanitation services by the year 2030, so we must understand and implement it now in order to achieve the SDG target.

*Perry Rivera*

Managing Director, Ayala,  
COO, Manila Water, TBC  
Independent Director

“

I commend the TBC and its research team for framing the Circular Sanitation Economy. I hope that the new, emerging and leading-edge business-led model will disrupt the market, create exciting opportunities, address the sanitation crisis and make the world a better place for all.

*Jon Shepard*

Director, Enterprise  
Growth Services  
Ernst & Young LLP

“

The concept of modelling a sanitation system around a 3m-person city makes this tangible at a big enough scale for real impact. This is the first report like this I've seen that sets out a roadmap for the various actors/stakeholders to follow.

*Brian Arbogast*

Director of Water,  
Sanitation, and Hygiene  
Programme, Bill &  
Melinda Gates Foundation

“

We welcome the Toilet Board Coalition's analysis of many exciting trends in non-sewered sanitation in this report. In particular, I appreciate the TBC's realistic application of the Circular Economy concept, avoiding naive assumptions that self-funding systems can be immediately created but recognizing that new approaches that are more cost-effective than sewer systems and wastewater treatment plants deserve more attention, starting today, from municipalities, utility operators, and all other sanitation stakeholders.

*Sylvain Usher*

Executive Director,  
African Water Association  
(AFWA)

“

The Toilet Board Coalition's work with entrepreneurs in Africa, who are developing new and innovative models to address sanitation, waste management and treatment, is very welcome. The new evidence outlined in this report, for the viability of these Circular Sanitation Economy cases in Africa, provides an important tool for our AFWA members, seeking solutions, across the continent. We are pleased to support this important work and to continue to partner with the TBC to accelerate these models in Africa in the near future.

*Jin Montesano*

Chief Public Affairs  
Officer, Lixil  
Corporation, TBC  
Steering Committee

“

The sanitation crisis is enormous in its magnitude. As a result, we need to be creative and smart in our solutions, as traditional flush toilets and sewer infrastructure is not universal. As a toilet manufacturer, we believe that the technology and resources to tackle this issue already exist. Together with sanitation entrepreneurs and other actors in the field, we need to harness our capabilities and provide high quality innovative and sustainable solutions that will build confidence in these new sanitation models among users and municipalities. Doing so will help bring the Circular Sanitation Economy to life.

*Stefan Reuter*

Managing Director,  
Borda

“

We were very pleased to contribute to the report and welcome its conclusions. We see in India a desperate need to prove and scale up a range of more decentralised and locally-appropriate systems, while keeping in view the interconnectedness and interdependence of various ecosystems to avoid negative un-intended consequences. We need to move away from piece-meal actions and embrace holistic thinking and solutions to solve problems for municipalities and their citizens. We are delighted to be working with the TBC on its Pune project, to design, deliver and demonstrate effective and economical working models, and an excellent opportunity to develop the Circular Sanitation Economy further.

*Chris Williams*

Executive Director,  
Water Supply and  
Sanitation Collaborative  
Council (WSSCC)

“

Thinking holistically about sanitation and hygiene is vital if we are to achieve SDG Target 6.2. TBC's report reminds us of the benefits of that safely managed waste (or, 'Toilet Resources'), including waste water, faecal sludge, and safe use of stabilised sludge for the purposes of bio-gas and agriculture production. The report also reinforces the need for supply-side approaches, including small-scale entrepreneurs operating at various stages of the supply chain of sanitation and hygiene services and products.

*Lisa Morden*

Senior Director, Global  
Sustainability, Kimberly-  
Clark Corporation

“

Recognising that any “waste” material has inherent value and that its use can create supply chain, environmental and social advantages is a key differentiator for the Toilet Board Coalition as they tackle issues of lack of access to sanitation. Applying the principles of the Circular Economy not only enables progress in this area, but carries with it other sustainability benefits related to water, carbon and waste as well. In addition, tackling the underlying systems issues associated with the value network, rather than the symptoms we see with a linear view, helps to ensure that the solutions are practical and sustainable through time. Because of this powerful model, we are working to bring more of our partners to the table to support the important and innovative work being tackled by TBC.

*Portia Persley*

Office of Water (E3/W),  
Bureau for Economic  
Growth, Education and  
Environment  
U.S. Agency for  
International Development  
(USAID) & TBC Steering  
Committee

“

The sanitation market is uniquely positioned to trail-blaze as a segment of the economy that walk the walk. The future of the Circular Sanitation Economy is one of closed loop systems that earn revenue while having a positive health and environmental impact. As the number of people with access to sanitation facilities and amount of waste generated increases, so too does the potential revenue from waste products. Now that's a win-win.

## ACKNOWLEDGEMENTS

### Project Team

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*Tejes Pradeep* (Research)  
*Cheryl Hicks* (Editor)

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*Sophie Tremolet*

### Key Sources

Toilet Accelerator 2017 Cohort and mentors  
[The BioCycle](#) - *Marc Lewis*  
[Safi Sana](#) - *Aart van den Beukel*  
[Sanergy](#) - *David Auerbach, Katie Wartman*  
[Sanivation](#) - *Andrew Foote, Catherine Berner*  
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[EY](#) - *Jon Shepard, Clare Stevens*

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<i>Anina Henggeler</i>	<i>Barbara Ward</i>
<i>Jin Montesano</i>	<i>Christian Zurbrügg</i>
<i>Alison Parker</i>	

## DISCLAIMER

The findings are based on analysis of commercial data from the Toilet Board Coalition 2017 Toilet Accelerator Cohort, and others. High levels of confidentiality are required to protect commercial information, so this report publishes the insights, not the data.

The contents of this paper provide a synthesis of our discussions and findings from the study. All information has been subject to the interpretation of the authors, the Toilet Board Coalition Secretariat, and does not necessarily represent the views of all Toilet Board Coalition members, or those companies and experts who participated in the study.

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## SANITATION IS EVERY BUSINESS'S BUSINESS.

The Sanitation Economy presents vast potential for global economic growth while addressing one of the most urgent grand challenges of our time, achieving universal access to improved sanitation (SDG6).

It monetises toilet provision, products and services, biological resources, data and information to provide benefits across business and society.

**There is an opportunity now for business leaders to adopt THE SANITATION ECONOMY as a new business imperative to ensure sustainable growth into the future.**



## WHAT IS THE SANITATION ECONOMY?

The Sanitation Economy is a robust marketplace of products and services, renewable resource flows, data and information that could transform future cities, communities, and businesses.

**The Sanitation Economy is smart, sustainable, innovative, cost saving and revenue generating.**

The Sanitation Economy links three distinct areas for business and societal benefit:

### THE TOILET ECONOMY

Toilet product and service innovation that provides toilets fit for purpose for all contexts and incomes. This spans centralised and decentralised, sewered and non-sewered, high water tables and low, low-income to high, rural, urban and peri-urban. The designs apply the Circular Economy to minimise waste and GHG, and capture data to feed the Smart Economy.

### THE CIRCULAR SANITATION ECONOMY

Toilet Resources feed into a system which replaces traditional waste management with a Circular Economy approach. This connects the biocycle, recovering nutrients and water, creating value-adding products such as renewable energy, organic fertilisers, proteins, and more, and catering for multiple forms of biological waste.

### THE SMART SANITATION ECONOMY

Digitised sanitation systems that optimise data for operating efficiencies, maintenance, plus consumer use and health information insights - and is a key part of smart cities architecture.

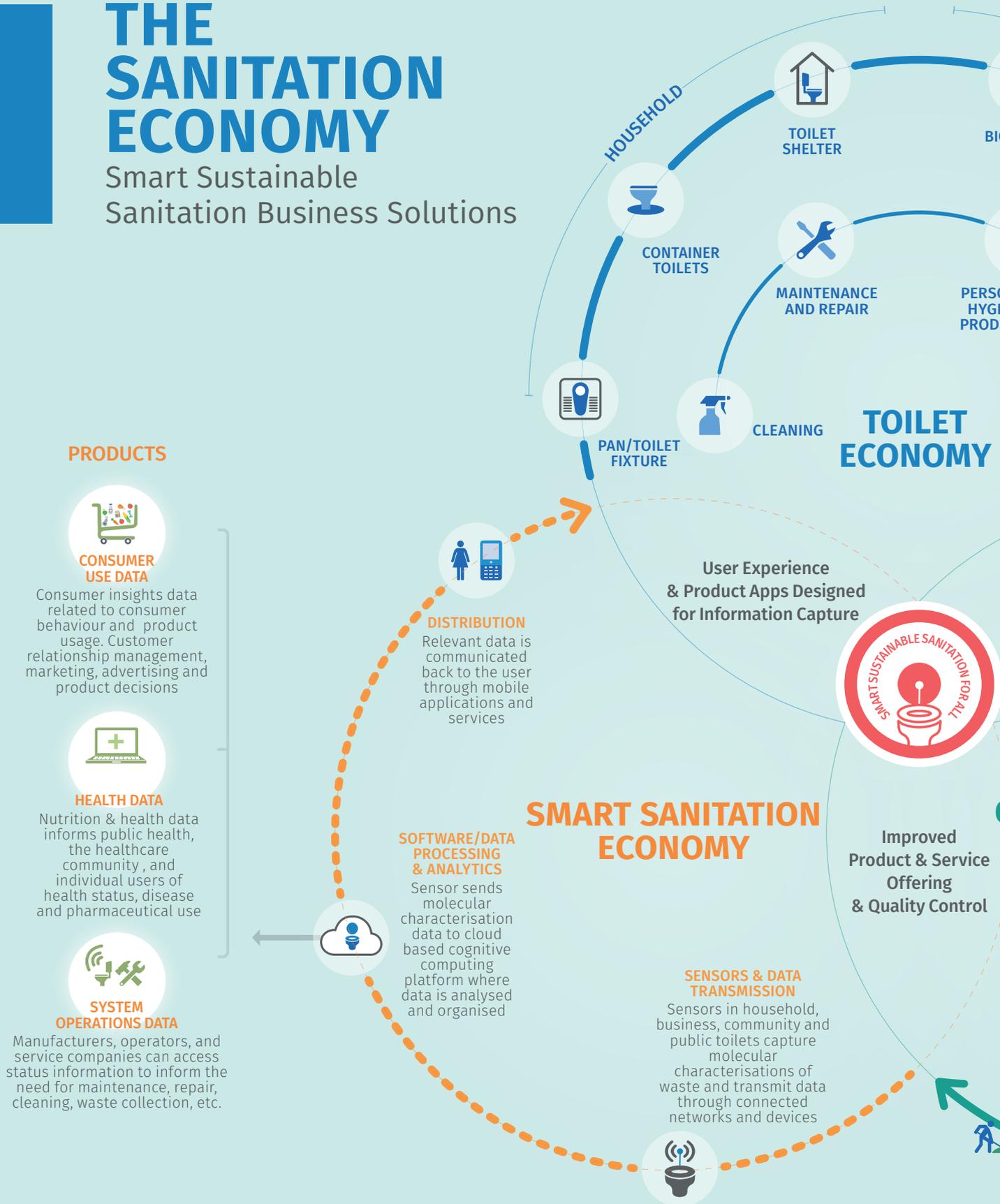
**The economic case for the Sanitation Economy is becoming increasingly clear.** Evidence now exists of working business models, technologies, and demand - momentum is building.

*For more on THE SANITATION ECONOMY - see "INTRODUCING THE SANITATION ECONOMY" Toilet Board Coalition, November 2017*

Figure 3 (Overleaf) - The Sanitation Economy - Infographic

# THE SANITATION ECONOMY

Smart Sustainable Sanitation Business Solutions



## PRODUCTS



### CONSUMER USE DATA

Consumer insights data related to consumer behaviour and product usage. Customer relationship management, marketing, advertising and product decisions



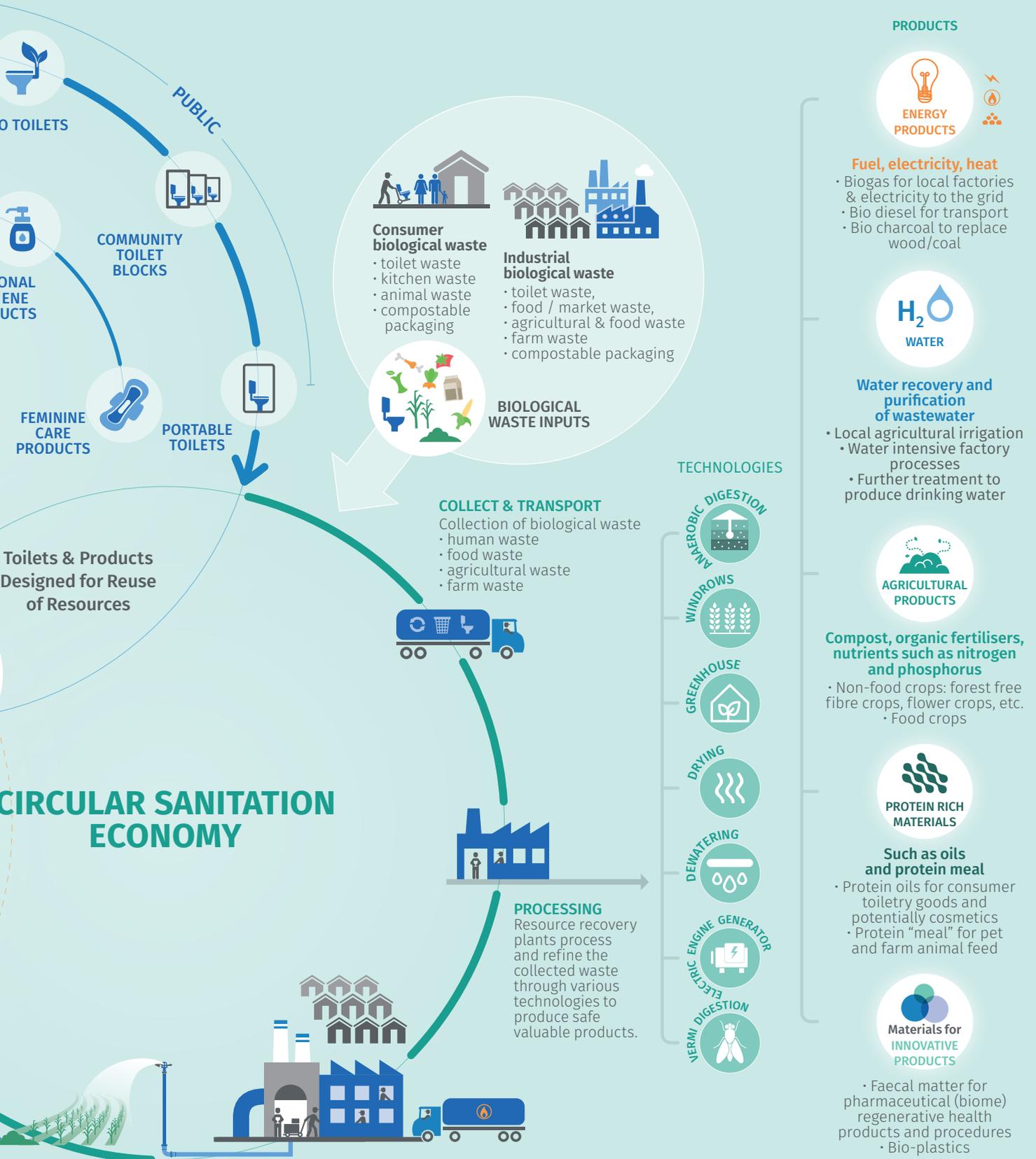
### HEALTH DATA

Nutrition & health data informs public health, the healthcare community, and individual users of health status, disease and pharmaceutical use



### SYSTEM OPERATIONS DATA

Manufacturers, operators, and service companies can access status information to inform the need for maintenance, repair, cleaning, waste collection, etc.

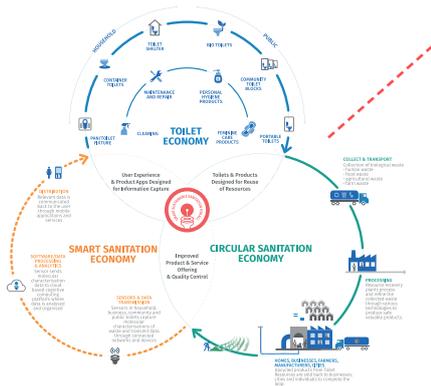


# CIRCULAR SANITATION ECONOMY

Figure 4 Circular Sanitation Economy Infographic

# CIRCULAR SANITATION ECONOMY

A Marketplace of Business Solutions



Toilet Resources feed into a system which replaces traditional waste management with a Circular Economy approach. This connects the biocycle, recovering nutrients and water, creating value-adding products such as renewable energy, organic fertilisers, proteins and more, and catering for multiple forms of biological waste.

Many businesses do not see their exposure to poor sanitation, or the opportunities it could represent, and have lacked a toolbox of business solutions they could adopt. See Table 2 to understand where your business fits into the Circular Sanitation Economy. The benefits and implications for each type of organisation are developed further in the Key Findings Section, Key Finding #3.

**Table 2 - The Circular Sanitation Economy ECOSYSTEM**

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**Sanitation entrepreneurs** are already starting to operate the new model at small scale. They are at the leading edge of innovation, making the new model work on the ground. They have the prospect of a profitable business model, when scaled up.

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**Operators** of sanitation and waste systems, large and small, public and private, can collaborate with the entrepreneurs and build a new ecosystem for sanitation, waste/resources, and energy. Like their counterparts in energy, they become leaders in an inevitable new economy shift towards less centralised systems.

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**Large companies**, across diverse industry sectors, have the prospect of growing markets, new raw materials, and new energy and waste/resource services. They play an important role in providing stepping stones to scale, buying materials and energy, and contracting to build sanitation plants co-located with their operations.

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**Governments and municipalities** can achieve health and environmental improvements which will transform cities and their economies, at far lower cost than by building traditional sewer systems. They legitimise this new model by giving district-scale contracts to sanitation entrepreneurs, with a modest subsidy for toilet provision. Appropriate regulation will be needed, consistent with this new and different model.

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## THE CIRCULAR SANITATION ECONOMY: New Pathways to Commercial and Societal Benefits - *Faster at Scale*

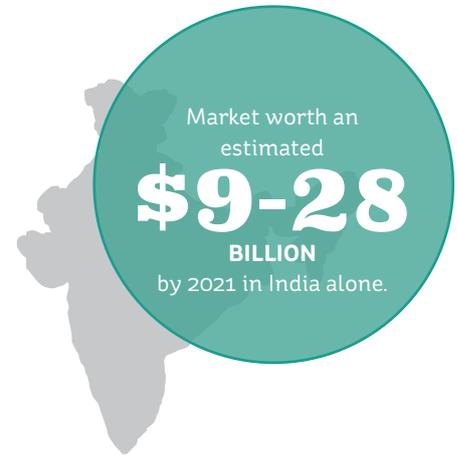
A new business-led sanitation model is emerging: **THE CIRCULAR SANITATION ECONOMY**

Evidence is building that this model will deliver sanitation **faster**, at **scale** – bringing significant benefits to business and society:

- Lower-cost & revenue-generating sanitation delivery
- A flexible, scalable, approach requiring less infrastructure
- Renewable materials and energy, and improved waste disposal
- Private sector & investor engagement

It leverages innovative new business models, disruptive technologies, new collaborations and contracts to shift the context of sanitation systems for the future.

This paper demonstrates the commercial advantages, viability, and potential, and invites commitment to delivering Circular Sanitation faster at scale.



## KEY FINDINGS

Circular Sanitation business models:

### 1

Can be **profitable at scale**, and at lower cost than traditional sanitation systems.

### 2

Work within a rapidly scalable “**new grid**” – a new network of material, energy, and information flows, based on Circular Economy and Smart Cities systems. This is differentiated both from traditional sewer networks, and from fully decentralised “off-grid” sanitation. Its key advantage is a flexible physical and financial structure which facilitates rapid scale-up.

### 3

Open up new opportunities within a new ecosystem comprising **entrepreneurs, utilities/waste operators, large businesses across diverse sectors, and cities/municipalities**. This will draw in new participants, and new investment, to the Sanitation Economy.

### 4

Build a **working biological cycle**, in a form largely absent in both developed and developing countries today. This closes the nutrient loop, improving agricultural productivity in short and long term, and creates a working pathway for all forms of biological waste.

## KEY FINDING #1:

**Circular Sanitation business models can be profitable at scale, and at lower cost than traditional sanitation systems.**

We have modelled commercial data from the Toilet Board Coalition 2017 Toilet Accelerator Cohort and others, all companies operating in low income markets. The modelling has extrapolated from the companies' own forecasts, to scale up to a hypothetical city of 3 million people. This is based on selling competitive products and services derived from Toilet Resources, at market prices.

This covers:

- Compost, in Ghana, Kenya and Haiti
- Electricity, in Ghana
- Solid fuels, in Kenya
- Proteins from contracted sewage treatment in South Africa

Our modelling shows all of the business models capable of being profitable at city-scale, with an Internal Rate of Return of 8%, sufficient to attract commercial investment. There is still the requirement for some municipal subsidies and/or gate fees, but at a lower level than with a sewerred sanitation system.

This is the fundamental conclusion from the study, based on conservative modelling directly derived from the participating companies' own figures. Due to strict confidentiality agreements with the companies who have participated in this study, we cannot publish the detailed numbers behind these conclusions. (Please see appendix 1 for more on the methodology).

Our Sanitation Economy in India Market Estimates & Insights study indicates additional revenues into sanitation, of \$19-60 million, in a notional city of 3 million population. These comprise of four basic types of re-use products (\$13 million), the potential to provide health data (\$6 million), plus (in specific circumstances) the additional possibility of \$41 million of water sales.

Previous analysis of small decentralised and circular sanitation business models, reached different conclusions about prospects for profitability. Our conclusion finds the key to profitability for small sanitation businesses, is the scale itself, as opposed to any issue with the technology or circular business models. Profitability at scale is linked in part to redirected focus of the companies on product sales vs. focus on sanitation and waste management as a service.

### **The way forward - getting to scale.**

For small businesses to grow beyond their local small-scale ecosystems (1-10,000 customers) they need larger ecosystems. Larger ecosystems (10,000-100,000 customers) can be found in large company manufacturing, plantations or mining towns for example. Full scale would mean 1 million+ customers, which would be found at city-scale.

This finding is developed in Commercial Case 1.



## KEY FINDING #2:

**Circular Sanitation business models work within a rapidly scalable “new grid”** – a new network of material, energy, and information flows, based on Circular Economy and Smart Cities systems. This is differentiated both from traditional sewer networks, and from fully decentralised “off-grid” sanitation. Its key advantage, over both, is a flexible physical and financial structure which facilitates rapid scale-up.

It has a lower cost overall (by a factor of at least x2, and in some cases as high as x14), and can generate revenue both from re-use products and from bundling other services together with toilet provision – **an estimated market between \$9-28 billion in India alone.**

Traditional sanitation systems use flush toilets and a grid of sewer pipes, with treatment plants being added to reduce the environmental impact of the outflows. These require an up-front commitment of capital and design (layout and technology) which is very difficult to achieve in fast-growing low income cities. The alternative, off-grid systems implemented at small scale, is more flexible, but has been difficult to scale up because it is inherently fragmented. Despite huge effort in applying these two solutions, the challenge of serving the 2.3 billion people without sanitation remains stubbornly unresolved<sup>2</sup>. A new, more readily scalable, model is needed.

### The “New Grid”

The Circular Sanitation Economy envisages a different approach, combining some elements of the established approaches, while creating a “new grid” of interconnected flows of material, energy, and information, none of them needing infrastructure of the magnitude of sewer systems. This requires limited up-front commitment to design or capital expenditure, and can adapt as cities develop and technology improves.

This is a more radical approach than simply adding waste management systems to established toilets and sewers – even if some of the technologies may be the same. The Circular Sanitation Economy goes much further into development of products, services, and markets, and so requires not only engineering solutions but a much wider range of skills and relationships.

The individual components of this system are proven – in fact few depend on new technology. **The key requirement now is to develop the system to operate at city scale.**

This finding is developed in Commercial Cases 2 and 3.

2 WHO/UNICEF (2017) Joint Monitoring Report

Table 3 - Circular Sanitation Economy - New Grid and New Business Models

PHYSICAL CONFIGURATION	FINANCIAL MODEL
<ul style="list-style-type: none"> <li>• Toilets compatible with resource re-use</li> <li>• Collection systems (generally not sewers, but selectively integrating with sewer systems)</li> <li>• Blending with other biological waste</li> <li>• Treatment processes producing a range of energy and products for sale</li> <li>• Implemented rapidly district by district, adapting to city needs, improving technology, and changing markets</li> <li>• Sensors embedded throughout the sanitation system, optimising operations in the context of a smart city, and potentially informing preventative healthcare</li> </ul>	<ul style="list-style-type: none"> <li>• Overall cost far cheaper than sewer systems by factor x2 - x14</li> <li>• Business net revenues significantly reducing the public cost, both from bundled user services, and from re-use product sales, accessing markets worth an estimated \$9-28 billion by 2021 in India alone</li> <li>• Reduced municipal subsidies / gate fees, complementing small user charges</li> <li>• Operators profitable, with municipal contributions much lower than for sewer systems</li> </ul>



## KEY FINDING #3:

**Circular Sanitation business models open up new opportunities within a new ecosystem comprising entrepreneurs, utilities/waste operators, large businesses across diverse sectors, and cities/ municipalities. This will draw in new participants, and new investment, to the Sanitation Economy.**

The Circular Sanitation Economy ecosystem was already introduced above, with its four participants: sanitation entrepreneurs, large companies, operators, and governments / municipalities. This will draw in new participants, and new investment, to the Sanitation Economy.

Table 2 introduced the four key participant organisation types in the Circular Sanitation Economy – entrepreneurs, large companies, operators, and governments/municipalities – and set out the case for each to be involved. Each realises benefits relevant to their own needs and interests, and, together, the participants deliver sanitation at scale, with its known benefits and risk avoidance. This is simply not happening widely or rapidly enough using traditional systems, and cannot be achieved by the participants acting in isolation. Although such collaboration requires an initial investment of time to set up, it yields a much lower-cost and more flexible solution. It represents the kind of ecosystem typically necessary for a systemic change, bringing together skills not found in any one organisation.

### Table 4 - Benefits for Participant Organisations

#### Benefits for CITIES, MUNICIPALITIES, AND GOVERNMENTS

- Meet improved sanitation access and resilient service delivery to citizens faster at scale
- Faster, lower-cost, and revenue generating deployment of sewage management
- Leapfrog opportunities in new integrated waste management strategies
- New engagement opportunities with private sector partners via new contracts

The Sanitation Economy addresses market and service failures that have held back economies, citizens and governments. The resulting system will be much less expensive than a sewer system, can adapt to the changing pattern of population and other activity, and to emerging technologies which will further improve its efficiency.

The Circular Sanitation Economy has the potential to open up new opportunities for efficient integrated waste management. By creating a pathway for biological waste – food waste, farm and agricultural waste, Toilet Resources and other compostable materials – a city can open the way for much wider use of such materials, and may even start substituting other materials, particularly plastics. Plastic waste is already a major problem and projected to double in scale as economies grow. This can start with initiatives to migrate locally-produced products into compostable materials – shopping bags for example, or locally-produced food packaging. As critical mass builds major manufacturers will then start to substitute their use of plastics, as some are already committing to do.

Realising these benefits requires political will to embrace the Sanitation Economy – both the physical system itself and the ecosystem of organisations needed to deliver it. This will contradict the training and mindset of many people, some of them established experts in traditional sanitation and waste. It will require strong leadership to forge a new path. This leadership will be rewarded with successful implementation, new investment and service provision from the private sector, and ultimately clean, safe and healthy communities for citizens. Ultimately, if not immediately, this will be a vote-winner.

### Benefits for LARGE COMPANIES

- New products and services - for new sanitation systems evolving differently for the future
- New source of raw materials, energy, and waste disposal - solving resource constraints & sustainability issues
- Enhanced business operations - employee health and productivity benefits, minimisation of sanitation risks, and optimisation of operational efficiencies
- Broad reputational benefit stepping up to tangible brand purpose and employee engagement

For many businesses sanitation appears peripheral to their interests, and may even have a “yuk factor” which is an unwelcome association for their brands. Our analysis suggests that a new business viewpoint is emerging which identifies multiple benefits.

Businesses already engaged in sanitation have typically been attracted by one or more of the following – these still apply, and could be considered the obvious benefits:

- Reputational gains from participating in the resolution of the sanitation crisis
- Accessing bigger markets as improved sanitation lifts the economy
- Businesses (large and small) operating directly in sanitation have the opportunity to grow and prosper with more sanitation provision
- Businesses selling products directly related to sanitation can access bigger markets

The Circular Sanitation Economy extends the benefits:

**New products and services:** The Circular Sanitation Economy creates a new ecosystem of businesses operating within communities in growing markets, creating new products and services designed for for new markets and driven by innovative entrepreneurs. Companies participating in these new networks will gain first mover advantage, with new products, services, and marketing and sales channels, and a reputation established with Bottom of the Pyramid (BoP) consumers whose incomes will grow. These opportunities will extend beyond sanitation-related categories, into areas such as preventative healthcare, and financial services. This is becoming a highly creative space, a platform for product testing, and a data-rich system, with new deep consumer insights. Continuing R&D from major companies will further widen the set of value-adding opportunities. And as entrepreneurs innovate and grow in this space, they can become value-creating investment/acquisition targets for larger companies.

**New source of raw materials, energy, and waste disposal.** Applying Circular Economy thinking to sanitation yields a growing range of biological materials and energy products – a list extending far beyond the traditional production of compost. These all have a strong sustainability story – typically a low carbon and water footprint – in addition to the back-story of sanitation provision. Increasingly, other advantages are emerging which will yield performance and/or cost benefits, for example through enhanced soil productivity. The Circular Sanitation Economy also creates an effective disposal route for all biological waste, from business and consumers, something which barely exists even in developed countries, and which could enable wider use of compostable materials in many applications, helping to reduce other waste problems, particularly plastics.

**Enhanced business operations.** Lack of sanitation provision hinders facilities such as factories and plantations. Contaminated water and land can directly impact operations and increase costs. Employees and their families face health problems which impact their productivity, and hold back the development of the local community. Implementing the Sanitation Economy at a business location can solve these problems, making the facility more productive, more attractive to employees, and more sustainable.

**Broad reputational benefit stepping up to tangible brand purpose and employee engagement.** The Sanitation Economy achieves direct human and environmental benefits, and allows business in many sectors to get directly involved. Broader corporate CSR programmes are evolving towards specific development of brand purpose. Employees have increasingly high expectations of their employers' commitment to a triple bottom line, and want opportunities to get personally involved in such work. The Sanitation Economy is an ideal opportunity to step up CSR to this new level of tangible delivery.

### Benefits for OPERATORS

- Faster, lower-cost deployment of sewage management
  - Legitimacy with customers and investors across geographies by working in partnership with entrepreneurs
  - Separation of engineering and operations/maintenance to ensure optimal services for customers
  - Use of technical know how to open new markets and to reach scale
- 

Sanitation systems, based on flush toilets and sewers, are rightly credited with transforming developed world cities, starting in the 19th century. Dramatic falls in infectious disease and odour, as well as a wider clean-up of the city environment, enabled economic growth and was instrumental in creating vibrant modern cities.

However, the persistence of the 2.3 billion number of people without sanitation, despite considerable global effort, indicates that the same approach cannot be replicated across the remainder of the world.

**Faster, lower-cost deployment of sewage management.** Sewered sanitation is an expensive, often inflexible option (lock-in of future infrastructure) with long lead times to be implemented as the universal solution. Moreover traditional design has not taken into account new Circular Sanitation opportunities for reuse and revenue generation. Alternative options are much more radical than just adding waste management to the established systems.

**Legitimacy with customers and investors.** New partnerships, particularly with local entrepreneurs, enable transition by creating new ecosystems of large and small organisations, who can integrate the deep knowhow of the existing operators with the new (and local) thinking of the entrepreneurs. There may be opportunities to separate the engineering skills of operators from local entrepreneurs who can more efficiently perform operations and maintenance functions to ensure uninterrupted and optimal service for customers. In combination, and with appropriate contracts in place, these partnerships can legitimise new systems and products derived from Toilet Resources with customers and investors.

**Extending beyond technical know how to open new markets and to reach scale.** The Circular Sanitation Economy creates a new range of materials, energy, and information-based products and services derived from Toilet Resources and other biological waste streams. This requires not only technical innovation but opening up new markets and communicating the case for these new products to potentially sceptical customers and stakeholders. Here the skills and influence of large companies across multiple sectors come into play as part of the ecosystem.

Un-locking these benefits will require different technical skills and an entrepreneurial business mindset. Deep transition, in culture, skills, and business models will be needed. This is similar to the energy industry's transition from fossil fuels to renewables, which similarly brings a large degree of decentralisation.

Operators joining the Circular Sanitation Economy will maximise advantage as first movers, and have the opportunity to work with the best potential partners – the most talented entrepreneurs, the most innovative and influential large companies, and the most aligned cities.

**Benefits for SANITATION ENTREPRENEURS**

- Open space of market need for innovative, low-cost sewage management and solutions
  - Profit potential and legitimacy via partnerships with large companies and governments will enable growth and draw in investment
  - Purpose driven businesses will attract a range of stakeholders and good employees, as well as enabling some philanthropic funding in the early stages.
  - High potential for exits to larger industrial incumbents
- 

A range of entrepreneurs are needed. Some will directly engage in toilet provision, collection and treatment operations. Others may focus on the development of re-use markets. Others will develop new processing technology, or transport/container systems, which can be widely used across the emerging "new grid." There are opportunities for digital entrepreneurs, developing sensors, preventative healthcare systems, and optimisation tools for the new grid. Some of these will necessarily be based in-field, others may operate more widely, from a base which could be in any country. There will be licensing and franchising opportunities. Altogether this is a diverse opportunity needing a range of skills and interests.

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## KEY FINDING #4:

**Circular Sanitation business models build a working biological cycle**, in a form largely absent in both developed and developing countries today. This closes the nutrient loop, improving agricultural productivity short and long term, and creates a working pathway for all forms of biological waste.

Applying Circular Economy thinking to sanitation creates a working biological cycle, in which nutrients are returned to the biosphere, most often to the soil.

This moves beyond the traditional, but unsafe, practice of simply spreading human waste on the land. Proper treatment can remove pathogens and other contaminants, with testing protocols to verify safety. The resulting organic fertilisers can be applied as part of scientifically designed system which enhances soil productivity short- and long-term. And beyond compost, the cycle can also include protein products and potentially further added-value materials.

Closely connected to the biocycle, the water cycle also plays a part, with some systems using much less water than sewers, some capable of returning clean water usable for agriculture or industry.

A range of energy products are also possible, with biogas available as a fuel, including for electricity generation, solid fuels already working, and liquid fuels being researched.

The evidence from working systems is that they work best by integrating sanitation and other biological waste, such as food waste from kitchens and markets, homes and farms. This is not only technically feasible but creates more profitable business models and better re-use products. This opens an even bigger opportunity – providing a comprehensive biological waste system in a form which barely exists today. Developed countries have sewers but with little resource recovery, and sporadic collection of other biological waste – to the point that biomaterials are regarded as a contaminant in solid waste systems. Developing countries may have neither sanitation nor other biological waste systems today, but therefore have the opportunity to start from scratch with an integrated system. This opens the way for widespread substitution of materials with biological alternatives, particularly attractive for plastic where waste is becoming a major environmental issue in its own right.

Altogether this casts the Circular Sanitation Economy in the role of solution provider, for multiple markets and industries. This is why a new ecosystem is needed, since most of this is new to established operators.

## META-FINDING: *FASTER AT SCALE*

Two 2017 Toilet Board studies (this report, and its sister report “**The Sanitation Economy in India: Market Estimates & Insights.**” together address the market opportunities and commercial reality, complementing higher-level economic analysis.

Traditional analysis has highlighted the huge overall benefit of sanitation, as well as of the Circular Economy. At the same time analysis of innovative sanitation businesses has been at the very small scale where most are operating today – a scale at which few businesses (in any sector) could expect to be profitable. Continued such analysis tends only to repeat this conclusion, which is neither particularly insightful nor motivating to the sector or its funders.

The Toilet Board's work closes this scale gap, with its two studies converging in considering a notional city scale of 3 million people – a scale large enough for profitable businesses, small enough for meaningful understanding of market opportunities.

At this scale, our modelling shows Circular Sanitation businesses can be profitable. Plus, The Sanitation Economy in India conclusions suggest they may access a market of \$19-60 million, in a city of population 3 million, considering four basic re-use products – there are many additional possibilities. The Sanitation Economy in India study did not directly model a city, so this is simply the Indian national figure scaled pro rata by population – i.e. a first approximation. The derivation of the numbers from The Sanitation Economy in India study is shown in Table 6.

These two studies together lead us to drive for scale-up, rather than to seek further “proof” of financial viability of the businesses today. This is what will inform the next phase of the Toilet Board's action plan, and we invite others to join us. Medium-term goals can be targeted now to start the process, and are detailed in the conclusions.

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The Toilet Board announced in August 2017 its collaboration with the city of Pune, India, to create the world's first Smart Sanitation city. This project will become a demonstrator for the integrated implementation of the Sanitation Economy, including the circular aspects. A range of other city scale and facility scale projects are being developed, to drive the Circular Sanitation Economy towards scale-up. **We invite others to join us with these and additional projects.**

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Having established the importance and feasibility of scale, why do we also say “faster.” This is not just the aspiration to accelerate the achievement of universal sanitation – important as that is. There are two more specific points:

- Physically – The “New Grid” of the Circular Sanitation Economy can potentially be scaled faster than either sewer networks or off-grid systems.
- Financially – The Circular Sanitation Economy creates multiple revenue streams and potentially profitable businesses, so it opens new potential for commercial investment, not readily available to sewer or off-grid systems.

# CASE 1

**NEW BUSINESS MODELS** - aiming for each to be profitable at city-scale. Based on **WINNING CUSTOMERS** by selling a product or service, with a value proposition that works for the customer, at a price profitable for the supplier.

## CASE 1 OVERVIEW

The core of the Circular Economy's application to sanitation is turning "Toilet Resources" into valuable products, which bring new revenue streams into the sanitation systems.

Each product type has associated technology to convert Toilet Resources into the product; each has its own market to address; and ultimately each has its own cost and price structure, which determine the business model's financial success. Some serve local markets, others may feed bigger supply chains.

There is a growing range of such products available, based on already-proven technology. Meanwhile, further research and innovation continues rapidly – aiming at new products, and at better ways to produce the existing ones. A range of the technologies the TBC is aware of is shown in our infographics, but the picture changes constantly. The TBC does not claim to be an authority on specific technologies, nor does it pick winners and losers - rather we support a range of businesses in developing and applying a range of technologies, as part of an ongoing learning process. The optimum choice of technology and business model will be context-specific, up to a point, but gradually winning models and winning technologies will emerge, and market acceptance will grow.

This study aims to create some early evidence in this fast-developing picture – we have focused our study on four core products offered by the TBC's 2017 Accelerator Cohort companies.

**Table 5 - Circular Sanitation Economy - New Business Models from Products and Services**

IN SCOPE FOR THIS STUDY	OUT OF SCOPE FOR THIS STUDY
- products offered by TBC 2017 Toilet Accelerator Cohort	- other potential products we are aware of – these are possible future research topics
<ol style="list-style-type: none"> <li>1. Organic Compost</li> <li>2. Proteins and other products from the black soldier fly technology</li> <li>3. Electricity (generated from biogas)</li> <li>4. Solid Fuel</li> </ol>	<ul style="list-style-type: none"> <li>• Water</li> <li>• Products from vermi-digestion</li> <li>• Fertilisers from urine</li> <li>• Fish</li> <li>• Seedlings</li> <li>• Plastics</li> <li>• Consumer products</li> <li>• Fragrance carriers</li> <li>• Liquid fuels</li> <li>• Biogas</li> <li>• Transport services running on biogas</li> </ul>

The Sanitation Economy in India report contains national figures for the Indian markets for all four of these products. At this stage specific cities have not been studied, nor other countries, nor how the markets vary between urban and rural areas. However, as a first approximation, we have scaled the national numbers pro rata on population, for our notional city of 3M population - see Table 6.

**Table 6 - Summary of Figures from The Sanitation Economy in India – Market Estimates and Insights, with Extrapolation to a Notional City of 3 million Population**

(see Notes 1,2,3,4 below)	POTENTIAL NATIONAL INDIA MARKET estimated 2021 market for India, with population of 1.4 billion <sup>a</sup> in \$ billions	POTENTIAL MARKET FOR NOTIONAL CITY OF 3 MILLION national figures, multiplied by 3/1400 in \$ millions
Compost	2.0	3.4
Protein Products	0.9	1.9
Electricity	3	6.4
Solid Fuel	0.3	0.6
<b>Cumulative Total</b>	<b>6.2</b>	<b>13.3</b>
Health Data (see note 5 below)	3	6.4
<b>Cumulative Total</b>	<b>9.2</b>	<b>19.7</b>
Water (see note 6 below)	19.0	40.7
<b>Totals (see note 7 below)</b>	<b>28.2</b>	<b>60.4</b>

a. 2021 population from www.populationpyramid.net, downloaded 12 November 2017

*Notes:*

1. The 2021 market estimates are made by projecting forward based on a variety of factors, including population and economic growth, inflation, and specific factors which may grow these markets ahead of the wider Indian economy - e.g. policy on renewable energy. Within this, inflation accounts for 26% of the growth - ie to put these numbers in 2017 money, divide by 1.26.

2. The total Circular Sanitation Economy market estimates for India have been extrapolated from The Sanitation Economy in India report, however, adapted to the four product categories discussed in this report, Organic Compost, Proteins, Biogas and Solid Fuel. The Sanitation Economy in India report also adds water to the Circular Sanitation Economy market estimate, this report does not.

3. Market estimate numbers have been rounded to the nearest billion for simplicity. Numbers below a billion have been rounded to the first decimal point.

4. The capture, safe management and treatment for reuse of Toilet Resources in India is currently in its infancy. The market estimates consider the amount of Toilet Resources currently being captured and treated, with a

*margin for growth based on the current growth rate. This number is still relatively small in relation to the total amount of Toilet Resources being produced by the population. As it is not certain how the different technologies and products will develop in the Indian market, we have considered only data available today for the market estimates, however, providing a number of market insights that may provide early indications of future market potential.*

*5. In addition to the re-use products, The Sanitation Economy in India study also identified the opportunity for data as a product, driving preventative healthcare. While not a Circular Economy product per se, it is part of the overall "New Grid" we envisage. \*This is based on available data from selected product and service categories (Table 5). It does not entail detailed market research.*

*6. In addition, The Sanitation Economy in India study finds a major market for treated water, bigger than the other re-use markets combined. This is undoubtedly a major opportunity in water-stressed areas and where the sanitation systems use large amounts of water. However, this number may not be as big where water stress is a lesser issue or with systems handling Toilet Resources from pits, or container toilets with urine diversion, rather than flush toilets with sewers, where much less water is present and available to recover. As the world looks to close the global water gap of 40% more demand than available supply it is expected that water saving systems will be in favour, and therefore in the scenario where the original use of water is less, there would also be less wastewater to treat and reuse.*

*7. Creating the Sanitation Economy also creates markets in the construction and operation of the toilets and other system elements, and these are also included in The Sanitation Economy in India study, bringing the overall total to \$62 billion potential in 2021. This is all activity of value to the economy. However, in this report the other elements are not included, because they are costs to the sanitation system, whereas our interest here is in the revenues to the sanitation system.*

## CASE 1 - BUSINESS MODEL 1 - ORGANIC COMPOST – SANERGY, KENYA

### The Product – Organic Compost

Treated compost is a traditional means of returning the valuable nutrients from Toilet Resources to the soil. It should not be confused with the traditional but unsafe practice of spreading untreated human waste on the land; making compost uses well-proven processes with controlled conditions (time and temperature) to kill pathogens.

Figure 7 - Sanergy's Farm Star Organic Compost



#### ORGANIC COMPOST BUSINESS MODEL - SANERGY, KENYA

Sanergy's Farm Star organic compost is a full-service compost application solution for small- and large-scale farms that rapidly increases crop yields and improves the soil

- It is compliant with pathogen standards, and reduces pests, and weed seeds
- It has consistently helped farmers increase crop yields by 20-100% and profits by 30-120% in the first season
- It also increases soil organic matter and nutrient retention, thereby improving soil health and increasing long-term farm productivity

Source: Sanergy

Sanergy's results indicate a clear performance advantage, short- and long-term, for organic compost compared with synthetic fertilisers (see figure 8). SOIL's results echo this compared with unfertilised agriculture (see figure 9).

Figure 8 - Sanergy Crop Comparison - Organic Fertiliser vs Unfertilised



Source: Sanergy

Figure 9 (2 images) - SOIL Crop Comparison - Organic Fertiliser vs Unfertilised



Source: SOIL

For wider application, particularly with larger growers, the test is how Toilet Resource-derived compost compares with mineral fertilisers. Speaking at the TBC’s “Closing the Nutrients Loop” workshop in August 2017, Ruben Sakrabani of Cranfield University presented emerging evidence that organic compost performs at least as well as mineral fertiliser (see figure 10). Further research is needed on this, as well as developing optimal systems for compost production and application, to suit varying conditions and crops. If performance parity can be achieved consistently, then other advantages of organic compost – that it is better for long-term soil health and reduces water contamination – become winning arguments.

Figure 10 - Faecal derived fertiliser in food production/erosion control



a = compost, b = mineral fertiliser, c = mix 50/50 and d = control



Source : Perez Bajar S, Sakrabani R (2017) MSc Thesis, Cranfield University

Taking this analysis deeper requires understanding of specific nutrient flows – particularly Nitrogen and Phosphorous. This is beyond the scope of the TBC’s 2017 work but will feature in our future research, and is widely covered in other literature. Figure 11 below is one example.

**Figure 11 – Article Extract Covering Nutrient Flows from Toilet Resources in the EU**

Every tonne of nutrient which is intercepted from a waste flow and processed into a form suitable to be used to fertilise crops represents a tonne less which would have leaked into water, the air, or the atmosphere, or ended up in landfill.

There is substantial scope to recover and reuse nitrogen (N) and phosphorus (P) from the European food chain. The most promising three substrates to work on are: animal manures, sewage waste and food chain waste, especially slaughterhouse waste.

Between 2 and 5 Mt of N and 0.6 Mt of P are currently not being recovered for agricultural use from these three major waste streams. These quantities represent 18-46% of the 11 Mt of mineral nitrogen currently applied to EU crops, and 43% of the 1.4 Mt of mineral based phosphorus applied to crops.

In the case of sewage, about 10 Mt of dry sludge is produced annually in the EU, representing 3.3 Mt N and 0.3 Mt P. 42% of this sewage sludge is already being returned to agricultural soils after stabilisation.

Some of the challenges for nutrient recovery from sludge are therefore to (i) increase central collection of sewage; (ii) switch from nitrification/denitrification to ammonia stripping in order to recover N; (iii) encourage anaerobic digestion to obtain a stable sludge, produce biogas and allow for further nitrogen stripping, and (iv) support research on technologies to separate P in sludge and sludge ashes from pollutants.

Source The RISE Foundation: Nutrient Recovery and Re-use (NRR) in European Agriculture – A review of the issues, opportunities, and actions. Executive Summary, EU, 2016

### **Business Model Example – Sanergy**

Of the 2017 TBC cohort, Sanergy, in Nairobi, Kenya, are most developed in selling “organic compost,” (their term, which we are using in this report) under their Farm Star brand, made using their semi-automated process. Their information informs most of this case. Safi Sana, in Ghana also produce compost and have established a nursery using their compost to grow seedlings. SOIL, in Haiti, also shared information with us on their compost production.

As with all of the cohort companies, Sanergy have started to use a mix of organic waste materials as their feedstock, not only Toilet Resources. This gives them a larger and more flexible pool of available feedstock.

### **Early Market Evidence**

Local markets for compost vary across our sources, we saw prices ranging from \$100-400/T of compost. At its competitive selling price for compost, our modelling suggests that the organic compost business models studied have potential to be profitable at city-scale with a lower municipal subsidy (for toilet provision) than for a sewerage system.

The Sanitation Economy in India study suggested a national market for compost of \$2 billion by 2021, roughly equivalent to a \$4.3 billion market for a city of 3 million people. The national market for mineral fertiliser is around \$10 billion. The \$2 billion is based on compost displacing mineral fertiliser as limited by current supply constraints, which by definition would be released if Toilet Resources became a new source. So the compost opportunity could be larger.

Such scale up would require further development of a company like Sanergy’s distribution. Today they sell to small farmers (c 2ha), the challenge being demand generation and education. They aim to sell to large growers (c 1000ha). These not only offer volume but greater profitability for Sanergy - they may command slightly lower

compost prices, but will have a much lower cost-to-serve. Such large growers in Kenya are generally exporters. The challenge is whether export markets will accept the use of this compost.

Sanergy's research, into export markets' openness to organic compost, is shown in figure 12. This reflects a mixture of views:

- Scientific assessment - generally open to the use of Toilet Resources subject to proper controls.
- A more risk-averse approach driven by concerns of adverse reaction if it were publicised that food crops were being grown using what would be termed "human waste," or worse. Retailers are more inclined to hold this position, and the US and European retailers are ultimately the key determinant of the policies that Kenyan export growers can adopt.

**Figure 12 – Policy Landscape for Organic Compost Sales into the Food Supply Chain**

- EU: Responsibility of the farmer to ensure no breach of relevant food safety requirements. No specific ban on produce grown using fertiliser derived from human and plant waste.
- US: Fertilisers derived from human waste will need to comply with the requirements set out in the EPA Part 503 rule, requiring all sewage sludge to undergo treatment and testing before application to land
- Global Food Safety Initiative (GFSI): There is no prohibition of the use of fertiliser derived from human waste, under the condition that proper treatment procedures have been applied to eliminate pathogens.
- Global GAP: Allows the application of processed organic material, carried out following risk assessment.
- Retailers: For those supermarkets for which such information is available there appears to be a blanket prohibition of the use of a product derived from human waste and/or sewage sludge, rather than a requirement to comply with certain limit values.

Source: Sanergy, extracts from RPA study, December 2015

### The Way Forward - The Toilet Board Supports...

The Toilet Board supports the drive for greater openness of these markets, for products derived from Toilet Resources. Such acceptance will be built up over time with good evidence (data and case studies), and may best be developed by starting with less sensitive crops – non-food crops (e.g. forestry), then those subject to high-temperature processing (e.g. brewing), then food for cooking, and finally food to be eaten uncooked. The Toilet Board held a workshop on "Closing the Nutrient Loop" in August 2017, and is developing several potential projects for 2018 which will drive this forward. Consumer safety is paramount, so production of organic compost derived from Toilet Resources will require the highest standards of operations and testing, with proper verification. Plus continuing research is needed to maintain and improve safety assurances, particularly given the growing number of contaminants (such as pharmaceuticals) found in human excreta.

There is room for optimism in work already done in developed countries.

- In the UK, a "Safe Sludge Matrix" was developed (see figure 13), with the involvement of both government and retailers. Some sales of compost based on organic fertiliser are happening within this framework, for example from Geneco, a subsidiary of a regional water company, Wessex Water, already successfully operating Circular Economy Sanitation at scale in Bristol. A version of this matrix, appropriate to the context of developing countries, could be developed.

- In Sweden, there is a voluntary certification system, REVAQ, used to regulate the application of wastewater sludge on agricultural land in Sweden. The system ensures that nutrients from wastewater fractions can be sustainably reintroduced to agricultural land in accordance with national environmental regulations and goals (see figure 14).

Figure 13 - The UK “Safe Sludge Matrix”

CROP GROUP	UNTREATED SLUDGES	CONVENTIONALLY TREATED SLUDGES	ENHANCED TREATED SLUDGES
Fruit	✗	✗	✓
Salads	✗	(30 month harvest interval applies)	✓
Vegetables	✗	(12 month harvest interval applies)	✓
Horticulture	✗	✗	✓
Combinable & Animal Feed Crops	✗	✓	✓
Grass & Forage	Ungrazed	✗ (Deep injected or ploughed down only)	✓
	Harvested	✓ (No grazing in season of application)	✓

Source: UK Department for Food Environment and Rural Affairs – Agreed between Water UK and British Retail Consortium

Figure 14 - REVAQ Sweden Certification

REVAQ is a voluntary certification system used to regulate the application of wastewater sludge on agricultural land in Sweden. The system ensures that nutrients from wastewater fractions can be sustainably reintroduced to agricultural land in accordance with national environmental regulations and goals. The system provides stakeholders with information regarding the composition and end use of the sludge and sets guidelines for the continuous improvement in the quality of influent wastewater and sludge with respect to metals and other prioritised substances.

The REVAQ system started in 2002 as a development project involving Swedish Water, LRF (The Federation of Swedish Farmers), Lantmännen (agricultural supplier cooperative) and grocery chains. Swedish Water is the sole owner of the system today in its current form. Currently half of the sewage sludge produced in Sweden is treated at plants with REVAQ certification.

Source: <https://www.aquaenviro.co.uk/proceedings/revaq-the-swedish-certification-system-for-sludge-application-to-land-experiences-at-the-rya-wwtw-in-göteborg-and-challenges-for-the-future/>

## CASE 1 - BUSINESS MODEL 2 PROTEINS AND MORE - THE BIOCYCLE, SOUTH AFRICA

### The Products – Proteins and other products from the black soldier fly technology

One of the most promising emerging technologies for converting Toilet Resources into valuable products is based on the lifecycle of the black soldier fly. This is a non-pest insect species common in tropical countries. The flies only eat during their larva life-stage, when they naturally eat a variety of biological materials. The new technology seeks to industrialise this natural life-cycle, so that the larvae can be put to work, at scale, in processing biological waste. The BioCycle process produces firstly the cooked larvae, and these can be used intact, or further processed to produce protein, oil, and biochar products. Each of these have multiple potential applications.

### Business Model Example – The BioCycle



AgriProtein have already established the black soldier fly process in Cape Town, South Africa. The AgriProtein plant uses food waste, and is already established at scale, selling the resulting protein products as animal feed ingredients. AgriProtein's second plant uses the same technology, but applied to Toilet Resources. It has been set up through their subsidiary The BioCycle, and built in collaboration with eThekweni municipality (Durban, South Africa), with funding from the Bill & Melinda Gates Foundation and AgriProtein Technologies.

The separation of the two operations, and (for the time being) their product development focus and product sales, is a necessary commercial reality for AgriProtein, facing similar concerns with Toilet Resource-based products as described in the compost section above. The separation is not necessary technically, but for market reputation only.

The BioCycle's business model is underpinned by their contract with the eThekweni municipality, which included the provision of the first treatment site (see Figure 15). This guarantees a gate fee for the waste they process. This is already financially competitive, from the city's point of view, versus traditional waste processing, and with much lower environmental impact from the resulting "waste" – and this waste stream will then be eliminated when the products start to be sold.

Figure 15 - Site Location of The BioCycle plant, at Isipingo Wastewater Treatment Works, Durban, South Africa

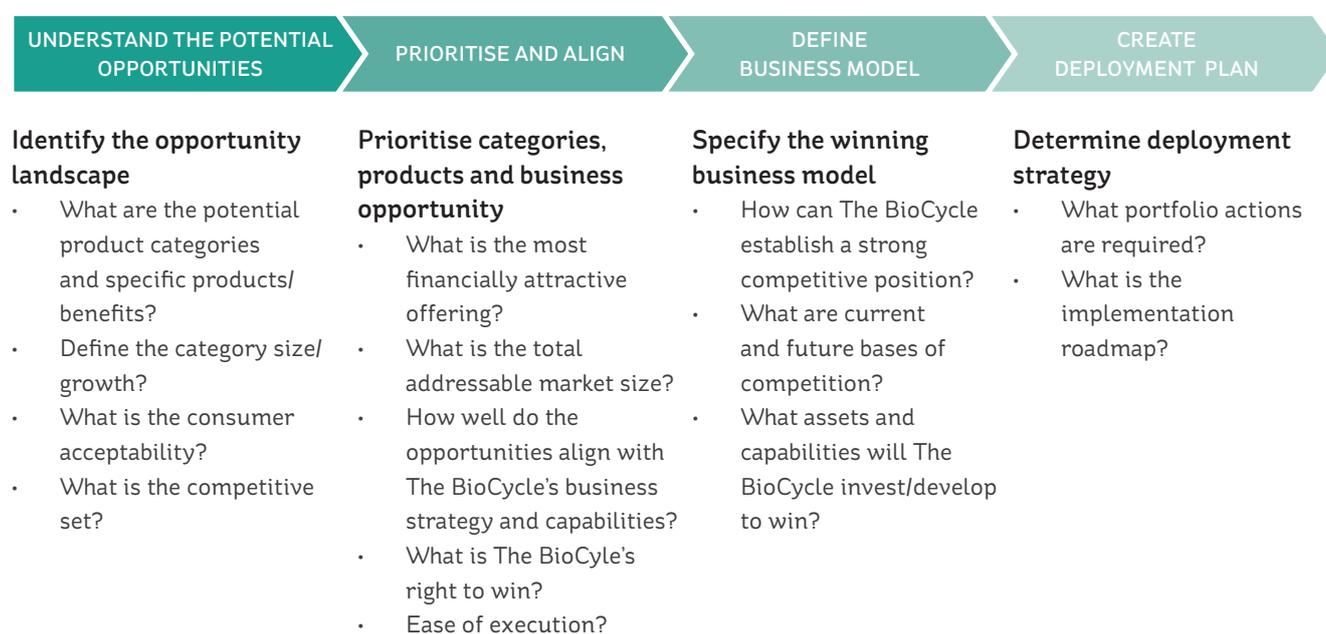


Source: Google Maps

## Early Market Evidence

There is a belief that the relevance of these high value products could go beyond animal feed to other sectors. To verify these hypotheses, assessment of potential markets is needed. This work has started in 2017, with The BioCycle mentored by Kimberly-Clark Corporation, as part of the TBC Toilet Accelerator cohort. The market assessment (see Figure 16) has considered 16 potential categories where the products could be applied, predominantly in agri- and aqua-culture, with some options in energy and other sectors. Each has been assessed in terms of the process capability, challenge in customer adoption, and competitiveness. There are already indications that these products may have a performance edge over more traditional applications of Toilet Resource-based products in agri- and aqua-culture, but this is not yet proven.

**Figure 16 - Kimberly-Clark Market Assessment questions, being applied to The Biocycle**



Source: Kimberly-Clark



With their gate fee, and preliminary estimates of product sales, our modelling suggests The BioCycle's business model has the potential to be profitable at city-scale with a lower municipal contribution than for a sewered system.

The Sanitation Economy in India study suggested a national market for poultry and aqua feed of \$17.8 billion by 2021, of which roughly 1/3 is protein, and the hypothesis is 16% of that could be based on Toilet Resources – a market of \$0.9 billion. That is based in part on supply constraints, so the actual potential could be larger, and this considers proteins only – not the only product possible from the black soldier fly technology. Scaled pro rata to a city of 3 million people, that's a potential market of \$1.9 million.

“The diversity of business models and approaches being explored by the Toilet Accelerator is exactly what is needed to identify sanitation solutions applicable across the globe. If we want the sanitation sector to scale quickly, we need to help these entrepreneurs disrupt the system. The TBC can play an important role in facilitating this, but we need a larger, broader network of stakeholders to step up and play a role to make it happen.

I see a future for the Circular Sanitation Economy where it is interconnected and integrated with the Circular Economy for solid waste management. Many of the countries that need innovation in sanitation also have significant growing challenges with municipal solid waste which is high in organic content. Creating systems, particularly in urban areas that leverage technologies and business models that are adaptable to both (particularly biological and organic waste streams) should have a greater potential for accelerating change.”

- Clay Bunyard, Research Technical Leader, Kimberly-Clark Corporation - TBC Mentor for The BioCycle

### The Way Forward - The Toilet Board Supports...

Similar to organic compost, the legitimacy, quality, and safety assurance for these new products derived from Toilet Resources will need accepted standards to move to scale. The development of standards is under way, spanning various aspects of the Circular Sanitation Economy. The Toilet Board Coalition supports these efforts with the aim to speed up the process.

## CASE 1 - BUSINESS MODELS 3 AND 4 ENERGY OPPORTUNITIES

### The Product – Energy – in Multiple Forms

Biogas is readily produced from Toilet Resources through anaerobic digestion – a well proven technology. However gas is expensive to transport. To reach the best energy markets, and so maximise value, alternative energy forms can be used. Multiple options have been found across the study's sources:

- **Produce electricity:** Use biogas to run a gas engine, producing electricity, and feeding it into the grid. The gas engine is also a well-proven technology. Safi Sana are operating this model in Ghana and this is described in Commercial Case 3.
- **Produce solid fuel:** Convert Toilet Resources into briquettes – Sanivation is operating this model in Kenya, and this is covered in Commercial Case 4.
- **Produce saleable gas:** In the UK, a gas grid exists - Geneco are cleaning their biogas to the standard needed for grid supply, directly replacing “natural” (ie fossil-based) gas.
- **Operate transport services:** Geneco also run a fleet of gas-powered city buses. A similar fleet is running in Johannesburg, powered by biogas (from biological waste but could be from Toilet Resources).
- **Produce liquid fuel:** This could be a major breakthrough but currently is at the research stage – considering an algae-based process.

## CASE 1 - BUSINESS MODEL 3 ELECTRICITY PRODUCED FROM BIOGAS - SAFI SANA, GHANA



### Business Model Example – Safi Sana

Safi Sana has the first contract in Ghana for electricity-from-waste supply into the grid, with a 10-year guaranteed price. This is renewable electricity, in line with Ghana government policy. Already the equivalent of 3000 families are being powered by Safi Sana. This and other waste-to-energy installations in Africa (using other forms of waste) sell electricity at prices in the wide range \$0.05 – 0.20/kWh, but grid contracts remain very rare.

Safi Sana are processing Toilet Resources together with food waste from industry and local markets.

### Early Market Evidence

Selling electricity at their competitive selling price, Safi Sana has potential to be profitable at city-scale with a lower municipal subsidy than for a sewerage system.

In The Sanitation Economy in India study, a national market for electricity from biogas is estimated at \$3 billion, which, scaled to a city of 3 million people, would be a market of \$6.4 million. The Indian government is incentivising renewable electricity generation, including biomass alongside wind and solar generation. The market size estimate is based on a conservative view of the available supply of biogas – so widespread production based on Toilet Resources and other biological waste could potentially exceed this figure.

Once the contract is signed, electricity production is limited only by the volumes of incoming feedstock. So this gives rapid revenue growth, buying time for the slower development of markets such as compost, where a larger number of customers need to be reached.

### The Way Forward - The Toilet Board Supports...

The key requirement is for the wider availability of grid electricity supply contracts. This will typically support governments who have policies promoting renewable energy, but it may not align with the interests of existing generators or grid operators.

Another approach is for electricity supply to an adjacent facility, not requiring a connection to the public grid. The Toilet Board supports a call to action to global businesses with facilities in low-income markets to consider their own Toilet Resources and biological waste streams as inputs into waste to energy models like Safi Sana – and the exploration of adding Toilet Resource derived electricity to their renewable energy mix. This is part of Safi Sana's strategy, developed further below in the section on Facility Contracts.

## CASE 1 - BUSINESS MODEL 4 - SOLID FUEL - SANIVATION, KENYA

This is the second energy form studied, from the list shown above.

### Business Model Example – Sanivation

Sanivation operates in two locations in Kenya, converting Toilet Resources into fuel briquettes. They use a proprietary solar-thermal pathogen inactivation and waste transformation process.



Figure 17 - Sanivation Description of their Solid Fuel Product

**Sustainable** - every tonne sold saves 88 trees and offsets 4 tonnes of CO<sub>2</sub> eq  
**Lower Emissions** - briquettes produce 66% less smoke than traditional fuels  
**Customer Savings** - longer burn time and affordable pricing saves customers 25% on their fuel purchases  
**Reliability** - reduces supply chain risk for businesses  
**Modern Cooking** - less soot leads to an improved cooking experience and less clean up after

Source: Sanivation

Figure 18 - Sanivation Graphics showing their Solid Fuel Product



Source: Sanivation

Sanivation's briquettes are an alternative fuel which offer performance advantages (see Figures 17,18) while claiming twin benefits:

- Sanitation: revenue from fuel sales has the potential to cover operating costs of waste processing, this is of great value to municipalities that struggle to keep up with urbanisation
- Environmental protection: the sale of sustainable fuels displaces deforestation and waste processing protects local water bodies

Sanivation's proprietary process blends multiple biological streams, optimising revenue and profitability per tonne of Toilet Resources.

### Early Market Evidence

Selling briquettes at a competitive selling price, Sanivation has potential to be profitable at city-scale with a lower municipal subsidy than for a sewerage system.

Sanivation is currently selling to households and small businesses, while conducting tests with industrial customers.

The charcoal market in Kenya is very large - over \$1.4 Billion, and is met by wood and charcoal sales, resulting in unsustainable levels of wood harvesting. Charcoal prices have more than doubled in the last 10 years.

The Sanitation Economy in India study assessed the potential market for biochar as a fuel, although this is not an established fuel form today in India. There is an established market for charcoal expected to reach \$1.54 billion by 2021. Assuming a small proportion of this is served by fuel from Toilet Resources, the study estimates

a market of \$0.3 billion nationally, which would be \$0.6 million scaled to a city of 3 million people. Clearly this number appears small compared with the opportunity Sanivation have identified in Kenya, where a much smaller country has a similar-size charcoal market. This needs further investigation. There may be significant national differences in fuel use. We can say that the India study did not consider fuel substitution, whereas briquettes could potentially replace coal or wood. Plus the Indian study makes no assumptions about the effect of performance or environmental advantages Sanivation are achieving in Kenya. Overall the Indian number may prove to be conservative.

### **The Way Forward - The Toilet Board Supports...**

Sanivation is pressing forward with its strategy to serve larger industrial customers. The Toilet Board supported Sanivation with advice on larger procurement requirements, and continue to support the process of finding potential customers.

## **KEY INSIGHTS - CASE 1 - NEW BUSINESS MODELS**

- All four products have performance advantages for the customer
- All four products deliver the societal benefits of sanitation and health, relevant to some, if not all, stakeholders; most also offer a climate change benefit
- All four companies are blending multiple forms of biological waste/resources, and there are examples indicating this can add significant value
- All companies need broader business ecosystems to be more developed to open up markets at scale:
  - Major food supply chains for compost
  - R&D to develop products from Black Soldier Fly process
  - Widespread grid feed-in contracts for electricity
  - Large customers for solid fuel

**If city scale can be achieved, then, selling these products at market prices, our modelling shows all TBC Cohort businesses capable of being profitable with a lower municipal subsidy than a sewered system. The Sanitation Economy in India study suggests a market of \$13.3M for the four studied re-use markets alone, in a notional city of 3 million population, with additional revenues, from health data and perhaps water, talking the market to \$19-60 million. So the challenge is to mobilise the scale-up.**

# CASE 2

**New Deals**- aiming for the commitments that will draw in investment and participation. Based on **WINNING CONTRACTS** - Gaining a longer-term commitment for the provision of a service, sufficient to enable investment in new facilities

## CASE 2 OVERVIEW

The Circular Sanitation Economy is by definition a system of multiple resource flows – Toilet Resources and other biological waste feeding in, and a range of products feeding out, with each flow having its own suppliers or customers. It greatly helps establish such a business if a major organisation can contract with the sanitation company, guaranteeing scale and continuity of one or more of the resource flows. That becomes an anchor for the business, making it much easier to establish the other flows to complete the system.

However, contracts between large buyers and small producers have proved difficult. Often there is a lack of expertise in such arrangements even though they may ultimately serve and protect both parties. Internal procurement policies may not favour innovation or smaller volumes.

We need “New Deals” in terms of contracting between large buyers and small producers in order to accelerate the pathways to scale for Circular Sanitation Economy business models. This is within the sphere of influence of the participants in the Circular Sanitation Economy.

Our analysis considered the two main types of contracts being developed by the 2017 TBC Cohort Companies:

1. **Facility Contracts** – A sanitation company co-locating with a major facility such as a factory, plantation, or mine, with the sanitation company providing sanitation, biological waste processing, and provision of energy and various materials, both for the facility and the surrounding community.
2. **Municipality Contracts** – A sanitation company contracting with a municipality for the provision of toilet services and/or associated collection and treatment.

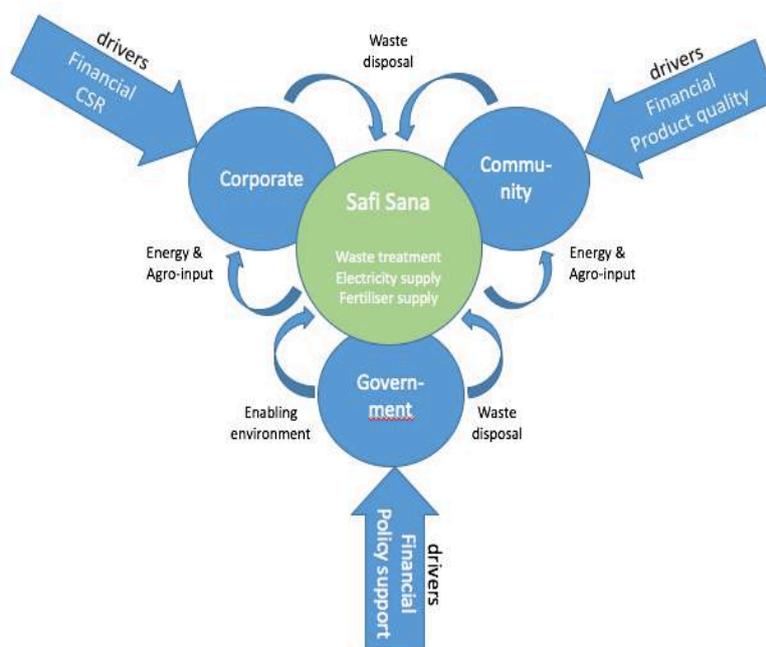
## CASE 2 - CONTRACT TYPE 1 - FACILITY CONTRACTS SAFI SANA, GHANA AND SANIVATION, KENYA

### A New Deal Example – Safi Sana

Safi Sana's first plant, in Accra, Ghana, has been developed in a municipal context, with each resource stream being added through separate agreements with the respective suppliers, customers, and logistics providers. Going forward, they have identified a faster route to establishing a new plant, by having an anchor client to underpin the core resource flows and initial investment.

- This can offer a synergistic combination of resource flows – water, energy, waste/resources, compost, as well as a sanitation service to the facility and community
- Safi Sana have developed this model with help from Unilever in their TBC mentoring capacity
- Other multinationals have expressed interest globally, including Tata

Figure 19 - Overview of Safi Sana Business Model



Source: Safi Sana

Tata Trusts, along with Tata Steel, a large multinational arm of the Tata Group in the business of manufacturing steel and operating mines, are currently evaluating the Safi Sana model of decentralised waste management for possible use in remote mining areas in India, where Tata Steel operates.

The advantages seen currently are that the solutions are relatively small but scalable, and allow for decentralised operations – However, a mining / industrial town provides the possibility of relatively low-cost aggregation of the waste resources, whether biological (such as from the employee canteen, etc.) or fecal, as offices and employee housing are in a small township.

Prabhat Pani, Tata Trusts

### Early Market Evidence

Market research is under way, to understand needs and processes and find a location for roll out.

There are 3 options for cooperation between Safi Sana and Industry:

- On-site waste treatment and product supply
- Off-site treatment - industry primarily supplies waste and preferably buys end products – already doing this with industries in Ghana
- CSR component - industry waste or end products not (fully) used but other CSR incentives are valuable like social and environment impact

Detailed criteria have been developed in four groups:

- General criteria - eg volume and type of waste available
- Industry partnership – eg CSR policy fit, land availability
- Municipality / Community – eg policy alignment
- Market - eg competitive landscape

### A New Deal Example - Sanivation

A separate example is Sanivation's second implementation, located at Kakuma refugee camp in Kenya. Sanivation was contracted by UNHCR to implement a more cost-effective sanitation approach than pit latrines, where they deployed a full-value chain service model of container-based toilets, waste processing factory, and solid fuel provision. The implementation is already showing results:

- 50% the cost of pit latrines
- High client satisfaction with toilets and charcoal briquettes
- System is self-sustaining. Refugees run it and fuel revenue covers operational costs

This is an example of a sanitation system being set up as a module within a large facility.

Figure 20 - Sanivation Operation in Kakuma Refugee Camp, Kenya



Source: Sanivation

### The Way Forward - The Toilet Board Supports...

In addition to funding the market research and facilitating the initial rounds of evaluation with Safi Sana, the TBC is developing further similar projects, potentially in India and Brazil, which combine the facility contract idea with different configurations of industry and community.

## CASE 2 - CONTRACT TYPE 2 - MUNICIPALITY CONTRACTS ALL COHORT MEMBERS

### Key Outcomes

Municipality contracts give sanitation entrepreneurs three vital guarantees, which open the door to private sector investment:

- Volume of feedstock, available over a known period of time, so that full-scale treatment facilities can be built, and re-use markets developed, confident of a reliable "supply chain"
- Concentration of collection within the chosen district, ensuring efficient operations with minimum transport and air pollution
- A modest subsidy (smaller than for a sewered system), which together with a small user fee closes the remaining funding gap.

Together these allow Circular Economy sanitation businesses to achieve scale, and therefore profitability, with a risk profile allowing private investment.

## The Importance of Scale

Scale is a vital factor for the economics of sanitation businesses. See Table 7, which indicates that the cost per capita of a sanitation system can fall by more than a third, if serving a population of 500,000 instead of 30,000.

**Table 7 - Costs of Sanitation Systems at Different Scales**

POPULATION 000S	CAPEX \$K TRUCKS	CAPEX \$K PLANT	CAPEX \$K TOTAL	OPEX \$K PER YEAR	LIFECYCLE COST 12YRS \$K	COST PER CAPITA \$ PER YEAR
30	45	300	345	40	825	2.3
100	140	850	900	110	2,310	1.9
250	320	2,100	2,400	230	5,160	1.7
500	540	4,000	4,500	390	9,180	1.5

Source: Borda - based on Devanahalli model, India, US Dollars; 1USD = INR 68.00

In addition to the financial economies in the table above, scale makes other valuable activities feasible, and these create a virtuous spiral of improvement as well as investment.

- Supplying larger customers
- Driving R&D work to create added-value products and improve processes
- Establishing an efficient supply chain for toilets and other equipment
- Providing a wider range of bundled services together with toilets

## Connecting Scale, Price, and Health Outcomes

There is also a vital relationship between the scale of a sanitation business, the health benefit for the community, and the revenues paid for toilet provision, both by users and in municipal subsidies. (In this case user revenues may take multiple forms, including direct payments by toilet users, payments through local toilet operators, or payments rolled into building rents for both domestic and other properties). This is illustrated in the Table 8. This describes a set of hypotheses discussed with the cohort and others, and widely supported, but it needs further research to add quantification – it is directional only at this stage.

- Like most businesses, sanitation faces price elasticity – i.e. at a high price there will be fewer people able and willing to purchase the service, whereas a low or zero cost to the user will open the door to many more users. This is shown on the first line of the table.
- Figure 21 has results from Ecuador showing a non-linear relationship between sanitation provision and the resulting health benefit. This is driven by the fact that, if only a few people have toilets, then everyone – even those with toilets – is still exposed to the health risks in the street and water system. Only widespread provision of sanitation brings significant health benefit. So high-priced systems, which only a few users can afford, may bring limited health benefit even to those users. This is the second line of the table.
- The question then is how that plays through to the financial model as a whole. The third and fourth lines show some of the scale factors mentioned above – the efficiency of collection, driven by a high density of collection within a given area, and the scale of both treatment plants and potential re-use markets.

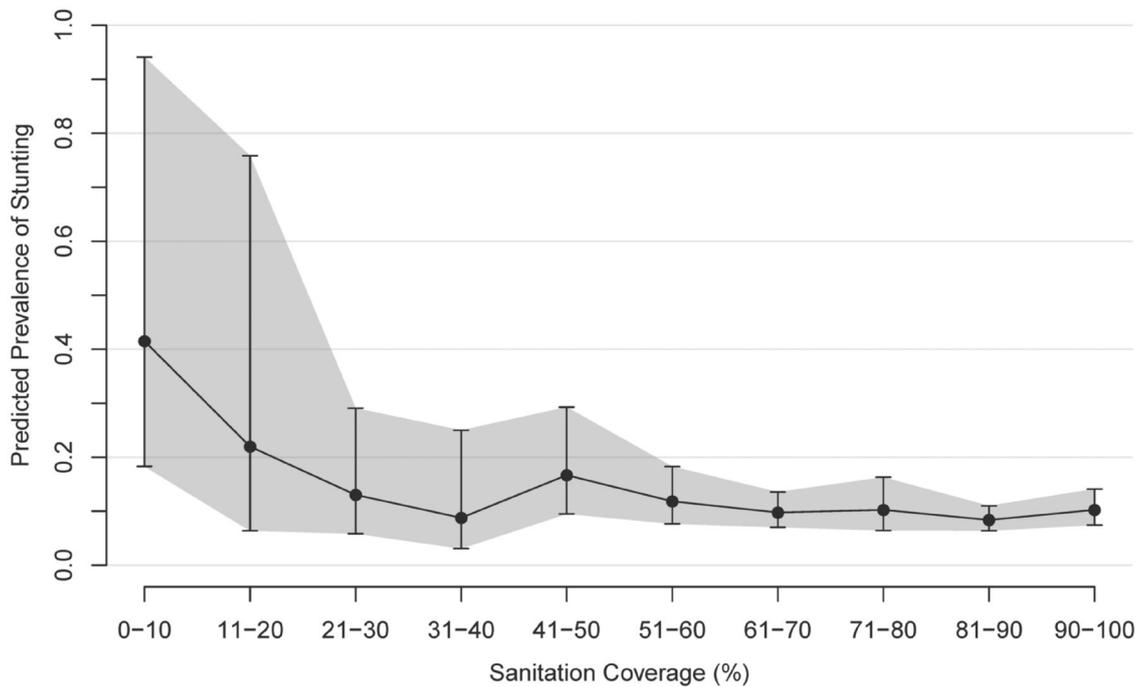
- Putting these together with the user price, the 5th and 6th lines indicate the financial dilemma. A high-user-price sanitation business might break even, but is effectively a niche business which cannot deliver significant community health benefit. A lower-user-priced business can achieve mass toilet provision, and so deliver the community health benefit, but then does need some financial help from users and/or municipalities.
- Our hypothesis is that the optimum approach is a small user charge complemented by a modest subsidy i.e. the 'LOW' price column in Table 8. This seems likely to give the best outcome for the municipality in terms of health benefit achieved per dollar of subsidy. So this would be one of the elements of a potential municipal contract.

**Table 8 - TBC Hypothesis - The Economics of Toilet Provision at Varying User Price Levels**

USER PRICE	ZERO	LOW	MEDIUM	HIGH
Proportion of Population reached	High	High	Medium	Low
Community Health Benefit	High	High	Low	Low
Efficiency of Collection	High	High	Medium	Low
Scale – larger volumes allow efficient treatment & bigger market opportunities	High	High	Medium	Low
Profitability of Toilet Service Provider (without subsidy)	Large Loss	Medium Loss	Medium Loss	Around breakeven
What happens if no subsidy?	Toilet provision can only be funded philanthropically	Toilet provision can only be funded philanthropically	Toilet provision can only be funded philanthropically	Toilet provision might be provided commercially but only as a niche market – no wider health benefit
What happens if provider's loss is mitigated by subsidy?	Good health benefit, but municipality bearing full cost	Good health benefit, with reduced municipality cost	Little health benefit, still significant cost to municipality	N/A

Indicative only - needs further research to quantify the hypothesis

**Figure 21 - Relationship between Sanitation Coverage and Health Impact**

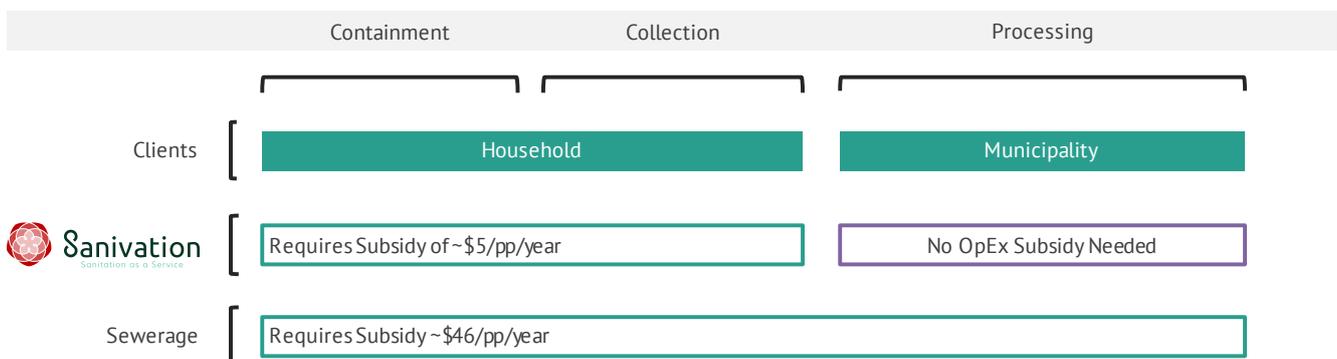


Source: I get height with a little help from my friends: herd protection from sanitation on child growth in rural Ecuador Int J Epidemiol. 2016;45(2):460-469. doi:10.1093/ije/dyv368 © The Author 2016; all rights reserved. Published by Oxford University Press on behalf of the International Epidemiological Association

**A New Deal Example - Sanitation**

Sanivation have also been evaluating the best path to scale- see Figure 22. They conclude that some subsidy will be required to ensure every household has access to improved sanitation. While few concessions for household sanitation exist, Sanivation can currently have the best margins and most impact for the urban poor by focusing on waste processing at the municipal level. In 2017, Sanivation signed an MOU with the local water service provider to be their non-sewered sanitation service provider and help the county achieve 100% of safely managed sanitation. Meanwhile the other cohort companies are also at various stages in developing municipal contracts, seeing these as a vital enabler of scale and investment.

**Figure 22 - Sanivation Graphic illustrating how a smaller subsidy is required for container-based sanitation than sewage to meet the needs of the urban poor**



Source: Sanivation

### The Way Forward - The Toilet Board Supports...

The development of effective municipality contracts, bringing benefits to both parties, will remain a central part of the Toilet Board's work going forward, with current and future cohorts as well as through our city projects in Pune and elsewhere.

## CASE 2 - KEY INSIGHTS

**Facility Contracts:** Facility scale contracts could be attractive in themselves, and take the Circular Sanitation Economy to medium scale.

- Facility contracts are being actively considered at locations including plantations, processing plants, mines, and one is already working in a refugee camp. So such contracts are not yet established, but show promise for the near future, and are directly within the sphere of influence of business – a chance for large businesses to take a lead.
- The common theme is that a single actor guarantees multiple resource flows equivalent to a town of around 10,000 people, creating a synergistic combination of:
  - Sanitation services
  - Processing other biological waste/resource streams
  - Multiple re-use options – energy, agricultural products, water

**Municipal Contracts:** Municipal contracts give a guaranteed source of feedstock, and/or a clearly established license to operate in a specific location. This de-risks the business for private sector investment, and so helps to unlock commercial investment while reducing costs.

- All companies participating in this study have agreements in place, or in development, with their local municipalities. However, contracts between municipalities and entrepreneurs are new territory and will need capacity development on both sides to achieve optimal agreements.
- Widespread implementation of sanitation is needed to achieve significant health benefit. A municipal contract can allow a sanitation business to move from niche provision to mass provision. Our preliminary analysis suggests the municipality gains maximum value by doing this with both a modest subsidy (much less than for a traditional sewered system) and a small user charge.

A cautionary note - There is a risk that municipalities expect the Circular Sanitation Economy to be entirely funded by revenues from re-use products, and so expect the system to operate without subsidies or user charges. An idealised view of the Circular Economy might support that view, with waste having such value that its re-use fully funds the service provision. Our evidence is that in sanitation, as in other sectors, this scenario can only be a long-term aspiration. First, these systems must get to scale and establish themselves much more widely in their operations and in the markets they access. Municipal support, through contracts and modest subsidies, could be an essential enabler.

# CASE 3

**New Deals** - aiming for the commitments that will draw in investment and participation. Based on **SHIFTING THE CONTEXT** - Changing the wider beliefs and practices which currently block development of the Circular Sanitation Economy

## CASE 3 OVERVIEW

Infrastructure is not only embedded in the physical sense of pipes in the ground. It becomes embedded in the understanding of all stakeholders, including citizens themselves, and reinforced by institutional structures and professional training. Established systems become refined – optimised costs, reliable technology, safe operating standards. The Circular Sanitation Economy challenges this orthodoxy in sanitation, creating uncertainty and risk, real and perceived. It is vital to understand and address the processes needed to change mindsets and build confidence around new systems.

This study focused on the context shift most directly relevant to the TBC 2017 Cohort - the case for new grids..

Other aspects of shifting the context, requiring further work in future, could include:

- The opportunity for a holistic biological waste/resource system, taking not only Toilet Resources but other biological / compostable waste, and allowing widespread substitution, particularly to reduce the issues of plastic waste. This mixing of streams already works well for sanitation businesses, but its wider impact on waste has not been studied here.
- The food industry coming to terms with the safe use of Toilet Resource-based products in agriculture. This is partly covered in Case 1, in terms of the sale of compost, but establishing this as the norm in food production, with proper safe operating practices, is beyond the scope of this year's work. The Toilet Board will continue to develop this theme, building on its "Closing the Nutrients Loop" workshop held in August 2017.
- Using sensor data from the sanitation system to drive preventative healthcare. This could have a transformative effect, allowing disease outbreaks to be mitigated with real-time location-specific information. Other applications could include targeted improvements in nutrition and water quality.

## CASE 3 - WHY CONSIDER A NEW GRID?

### Historical Context

In the 19th Century, protagonists of the early sewer systems faced opposition from scientists advocating the recovery of nutrients. Initially built with no treatment plants, sewers were (the scientists argued) effectively systems for flushing soil nutrients into the sea.<sup>3</sup> But in parallel, development of mineral fertilisers was also progressing. The current combined model of sewered sanitation, and mineral fertilisers, is exemplified by the London sewers, built in 1875, and the Birkeland-Eyde fertiliser process, commissioned in Norway in 1903. The undoubted success of these innovations cemented the linear model still prevalent today, based on one-time use of many resources. In effect, the arguments for Circular Sanitation Economy were made, and lost, at that time.

However circumstances have changed:

.....  
 3 "The sewage disposal system devised by Joseph Bazalgette in 1859 [for London] was a huge breakthrough in public health and sanitation. But his contemporary chemist Justus von Liebig had studied the Roman sewers and their efficiency in transferring vast quantities of minerals from the soils, via the collective digestive system of the Roman Empire, out into the Mediterranean." Extract from Biomimicry and Architecture (2016), Michael Pawlyn.

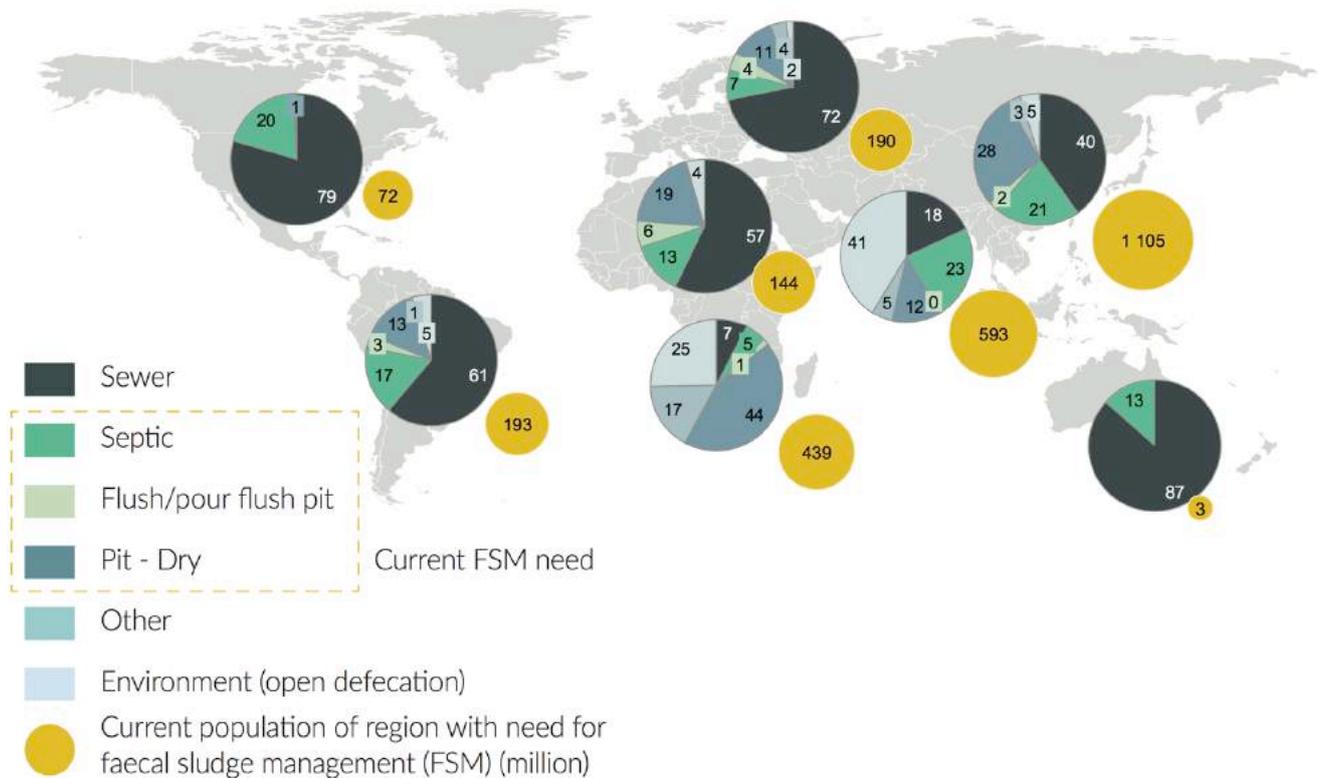
- From 1900 to 2011 global population has grown x4 and global GDP x28. Linear systems, which worked with apparently limitless resources in the 19th century, are not necessarily workable under the resource pressures of the 21st century. Visible symptoms include soil depletion, water pollution, and growing resource shortages.
- Systems long-established in the developed world are not necessarily proving feasible in developing countries, particularly those needing major infrastructure. In energy and telecommunications, more decentralised models are proving effective and can be easier to scale up.
- The biological cycle as a whole is neglected, with hardly any systematic recovery of biological waste. Instead of exploiting biological decay processes based on nature, many low value, short-lived items are made from highly durable materials which then create a serious waste issue.
- The signs are that innovation could expand the range of re-use options for Toilet Resources.

So the arguments, lost in the 19th century, may be won today.

**Current Status of Toilet and Treatment Provision, and the Need for Change**

Figures 23-25 make the point that toilet provision is lacking, and treatment even more so.

**Figure 23 - Population (%) served by different types of sanitation system**



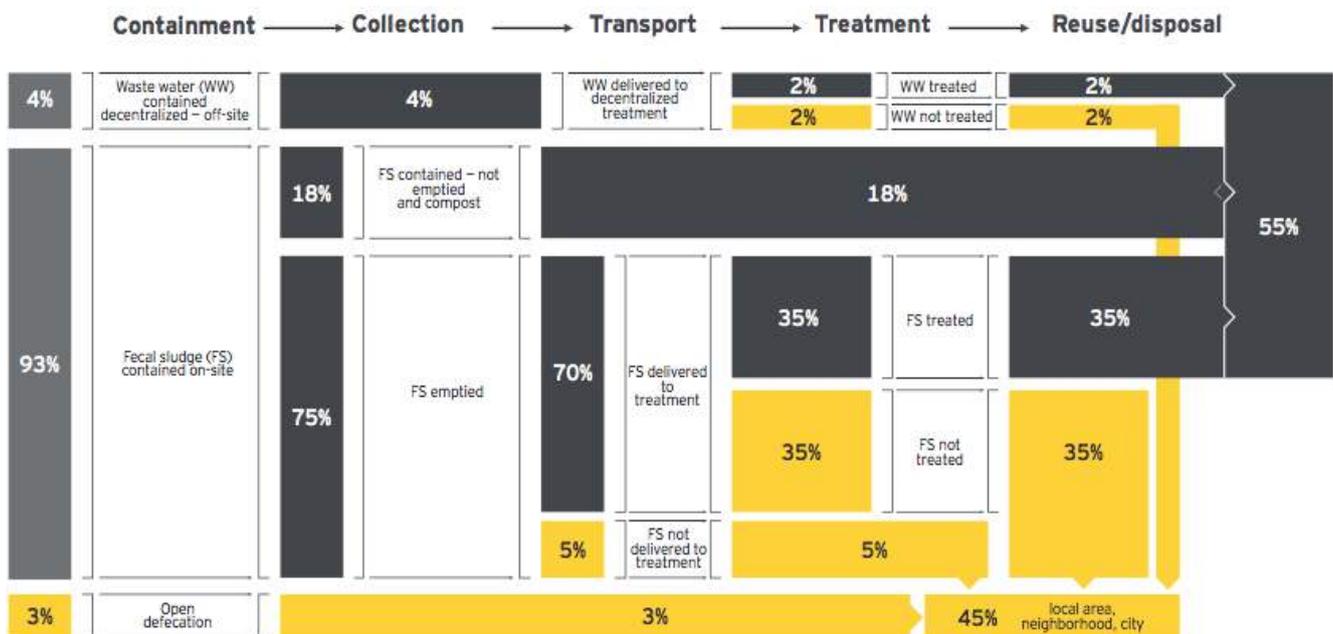
Source: Cairns-Smith et al. (2014, Fig. 8, p. 25). based on data from WHO/UNICEF JMP). Courtesy of The Boston Consulting Group.

Figure 24 - Sanivation Graphic illustrating Toilet and Treatment Provision in Kenya



Source: Sanivation

Figure 23 - EY Graphic Showing Treatment Shortfalls in Ghana



Source: EY – The World Can't Wait for Sewers (2017) Waste flows in Kumasi, Ghana, November 2015, From the SFD Report, created through field based research by WEDC as part of the SFD Promotion Initiative.

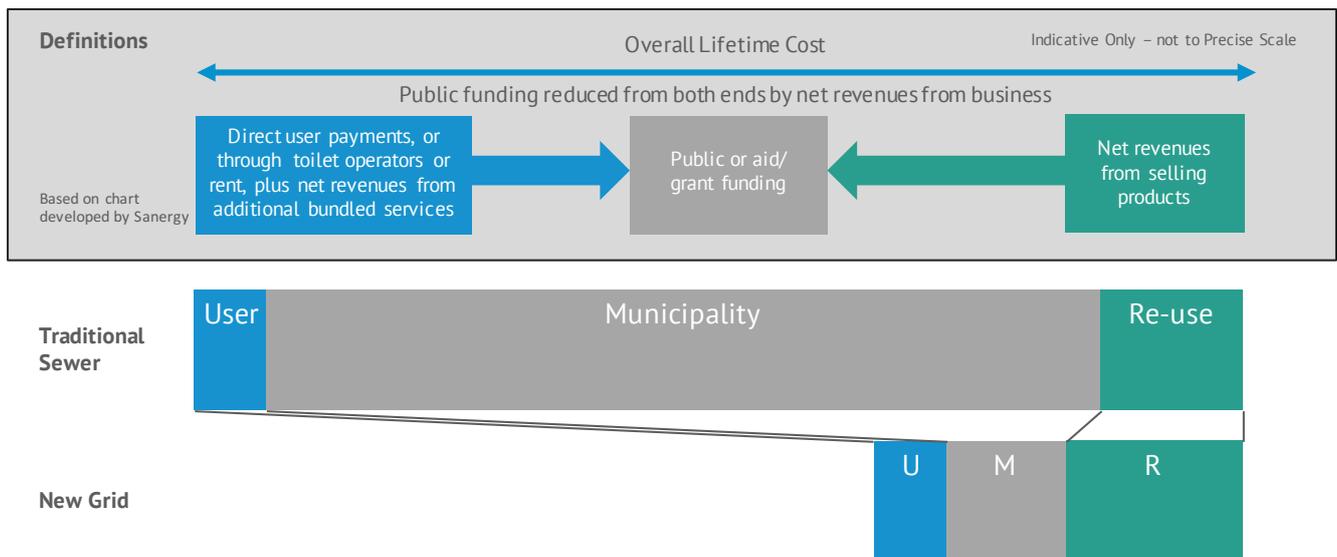
So the extensive efforts to reach the 2.3 billion people without sanitation, have hardly closed the gap. Whatever the merits of the systems being tried, it must be worth trying alternatives. The critical question is what kind of systems can achieve scale up, at an accelerated pace compared with previous systems? The TBC's view is that this will be systems which (1) are relatively low cost, (2) adaptable to the fast-changing development of population and cities, and (3) yet capable of working at the scale required for major cities. Our hypothesis is

that traditional sewer systems struggle to pass the first two tests, and off-grid systems may fail the third. The Circular Sanitation Economy envisages a “new grid” and new business models which meet all three criteria. This new grid comprises interconnected material, energy, and information flows, within a Circular Economy model.

### The Economics of The New Grid

Figure 25 illustrates why the Circular Sanitation Economy offers significantly lower costs, overall, and especially for municipalities.

**Figure 25 - Cost Structure of Sewered and Non-Sewered Sanitation**



Based on the chart developed by Sanergy

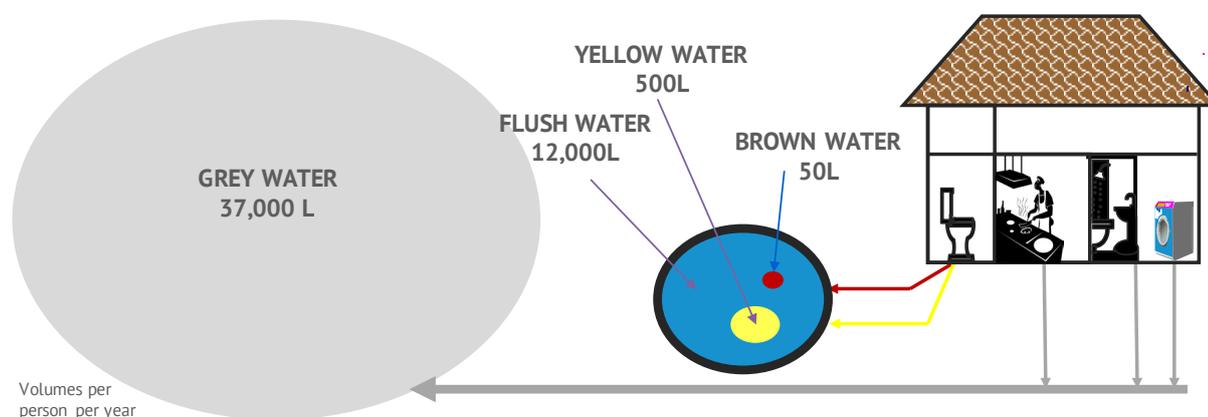
- We have gathered evidence from the TBC cohort (Africa), from Borda (India), and from a recent World Bank study (Africa), and the conclusion is that the overall cost of Circular Economy solutions (i.e. before netting off any revenues) is lower than for sewers by a factor ranging from x2 to x14. The wide range reflects many different circumstances, but the point is that the gap seems to be large in all cases.
- Additionally, there are revenues available which further reduce the public cost, from both ends:
  - A range of additional services can be bundled together with toilet provision. This is illustrated by Samagra in India (see Figure 26), which has converted public toilets into community hubs with multiple services provided. This could extend into data being derived from the system driving preventative healthcare.
  - Re-use products can be recovered, as already discussed earlier in this report. Sewer systems are not ideal for this, since they introduced dilution and contamination (see Figure 27)

**Figure 26 – Example of Services Bundled with Toilet Provision - Samagra - India**

Samagra operates as an offline-online service providing a community hub and business that includes the provision of quality communal toilets as one of the many customer offerings. Distinctively, Samagra seamlessly bundles other aspirational and value-added services such as financial services via savings account support, access to digital product services via mobile phone recharge stations and television subscriptions, and access to life-improving products and services via assisted e-commerce all in concert with the use of their quality toilets. Essentially, Samagra creates a community centre network in which clean and safe public toilets are the nucleus. Effective partnerships with municipal institutions and other service providing organisations have enabled Samagra to utilise and upgrade existing toilet infrastructure from which their “one stop shop” business model for slum-dwellers is catalysed. The host of bundled and valued services that is provided by Samagra has proven to be attractive in retaining toilet users and promoting hygienic sanitation behaviours while also making profit. Revenue is generated through vendor subleases and advertisements throughout the Samagra space.

Through the 2017 Toilet Board Coalition’s (TBC) Toilet Accelerator programme, Unilever worked with Samagra to build their management team, innovate on digital opportunities in media, customer insights, and remote management, to unlock new revenue streams and translate partnership leads into sustainable contracts and resources for operating expenses (OpEx) and capital expenditures (CapEx).

**Figure 27 - Borda Graphic Illustrating the Dilution Effect of Sewers**



Example based on Mumbai, India - Proportions will vary by location

Source: Borda

We are not claiming that sewered systems are incompatible with revenues associated with toilet provision, nor that resource recovery is entirely impossible (though not ideal). But the key point is that non-sewered systems start from a much lower total cost – there appears to be little realistic prospect of these revenues substantially offsetting the cost of building a sewer system.

### Wider Considerations on the New Grid

The additional advantage for the New Grid is flexibility. Such systems are made up of smaller physical components, some of them literally portable (lorries replacing pipes in the ground). These can be deployed incrementally and flexibly as cities develop. Whereas sewers require the layout, sizing, and core technologies to be determined at the outset, the New Grid can be improved progressively as new technologies and business models emerge. The system actively encourages innovation, benefitting the users and the participant organisations.

The New Grid approach is potentially more compatible with wider collection of biological waste. While conceptually this waste could also be flushed into a piped system, that would require even more water and create many practical problems with blockages. Some citizens in developed countries have kitchen sinks and some toilets with machinery to break down solid items, but this is hardly likely to be a universal solution. Much more likely (we believe) is a convergence of sanitation and (biological) solid waste collection, using well-designed containers and vehicles to consolidate multiple biological resource streams, including sanitation, ready for combined processing.

Clearly sewers already exist in parts of most cities, and will remain the best option in some areas. Innovation is possible with sewered systems too, as evidenced by Geneco's success in the UK. So this is not a confrontation between sewers and the New Grid, but rather a question of how the New Grid can include sewers as part of a fully effective system.

This is a very different and unfamiliar system, however, not only in its physical engineering and financial structure, but in its organisational approach. It is an ecosystem of private and public sector organisations. Its adaptability and capacity for innovation mean that it is a system constantly changing and learning, rather than something locked in for many decades, like traditional infrastructure.

### Barriers

Overall we need to be realistic that there are many barriers (real and perceived) to be overcome to mobilise this change:

- General perception of being an inferior solution, influential in dynamic of voters / politicians - large sewer projects look impressive!
- Transport, in areas with poor road access. *Solutions are being developed for this using a variety of container and vehicle designs*
- Perception that decentralised systems require maintenance at many locations. *Sewer systems also need extensive support across a city*
- Mindset and Education. Municipal engineers are taught only about large sewage systems - systems run by small entrepreneurs are unfamiliar / uncomfortable
- Standards and regulation are not established for decentralised systems. *Work has started on ISO standards - more is needed, with regulation to follow*
- Payment systems are well established for sewered sanitation, and will need to be developed to be equitable with non-sewered systems
- Markets need to be developed, at scale, for products and services - see Commercial Case 1
- Existing interests, legitimate or otherwise, may align with existing systems or with the provision of sewers.

There are however encouraging signs from the systems already being implemented by sanitation entrepreneurs. One such example is the recent customer feedback from SOIL in Haiti - see Figure 28.

Figure 28 - SOIL Graphic with Customer Satisfaction Results



Source: SOIL

### The Way Forward

The TBC conclusion is that sewers should no longer be the taken-for-granted sanitation solution, but that preferences for sewers will be hard to shift. On the other hand, the most attractive model requires interconnection of sanitation within a Circular Economy model, which is not readily achieved with off-grid approaches. The “grid” in this case is different – no longer traditional pipes in the ground, but a new set of material, energy, and information flows.

- The cost case for non-sewered sanitation is strong with a large cost advantage, in two parts:
  - The overall cost (capital + operating costs) is lower by at least x2 and perhaps as much as x14. This is based on evidence from three sources covering both African and Indian examples.
  - Circular Sanitation further reduces the public element of cost, because of business revenue opportunities, which “squeeze” the public cost from both ends.
    - » In addition to charging modest user fees, sanitation businesses can bundle toilet provision with a range of other services, helping to fund the toilets and collection. Deriving data from sensors in the system may create further value by informing preventative healthcare systems.
    - » Non-sewered systems are more suitable for re-use, converting “Toilet Resources” into valuable products. Sewers bring considerable dilution and often contamination, making re-use more difficult and expensive.
- That said, cities are often attracted to big-ticket capital projects, and some are successful in winning the necessary funding. So flexibility arguments may be even more persuasive. The New Grid can be implemented incrementally, adapting to fast-growing low income cities, rather than depending on long-term commitments to layout and technology.
- There are downsides, real and perceived, which need to be addressed thoroughly. To overcome the deep preference for sewers, better evidence is needed:
  - That non-sewered sanitation can be consistently clean and safe, based on recognised standards
  - That the overall cost advantage is replicated in different conditions
  - That there is real momentum towards business eating into the public cost – with bundled user services, and profitable re-use options
  - Of some first examples emerging of real scale (say 100,000 people)

Taken together, the key insights from the commercial cases above lead us to conclude that **A NEW BUSINESS-LED SANITATION MODEL IS EMERGING - “THE CIRCULAR SANITATION ECONOMY” - AND IT OFFERS IMPORTANT BENEFITS FOR BUSINESS AND SOCIETY.**

Specifically, our key findings are that Circular Sanitation business models:

1. **can be profitable at scale**, and at lower cost than traditional sanitation systems. This is the core finding, together with the sister report identifying a market of \$19-60 million for a city of 3 million people. These combined conclusions are the grounds for believing that it will be possible to build a commercially viable ecosystem.
2. **work within a rapidly scalable “new grid”** – a new network of material, energy, and information flows, based on Circular Economy and Smart Cities systems. This is differentiated both from traditional sewer networks, and from fully decentralised “off-grid” sanitation. Its key advantage, over both, is a flexible physical and financial structure which facilitates rapid scale-up.
3. **open up new opportunities within a new ecosystem comprising entrepreneurs, utilities/waste operators, large businesses across diverse sectors, and cities/municipalities.** This will draw in new participants, and new investment, to the Sanitation Economy.
4. **build a working biological cycle**, in a form largely absent in both developed and developing countries today. This closes the nutrient loop, improving agricultural productivity short and long term, and creates a working pathway for all forms of biological waste.

These conclusions translate into distinct opportunities for each of the four types of participant organisation, as set out in Key Finding #3 above.

## THE PATHWAY TO SCALE

The imperative now is to drive for scale-up. We believe there is limited value in further “proof” of financial viability of the businesses today, which is likely to confirm only the obvious fact that the current businesses are small and not yet profitable. A core set of processing technologies and business models are already well proven. The nature of the “new grid” is that, unlike a sewer system which needs to be fully detailed at the outset, this is sufficient basis to start the scale-up process. Improving processes and technologies can be added flexibly as the systems develop, and other participants join in, accelerating the learning and investment. This approach will inform the next phase of the Toilet Board’s action plan, and we invite others to join us.

Medium-term goals can be targeted now to start the process, as illustrated in Table 9.

Table 9 - Pathway to City Scale

<b>TODAY</b> Population 1,000s-10,000s	<b>MEDIUM TERM</b> Population 10,000s-100,000s	<b>LONG TERM</b> City scale Population 1,000,000s
<ul style="list-style-type: none"> <li>• Small businesses, each operating at 1-2 locations</li> <li>• Limited commitments from municipalities or major companies</li> </ul>	<ul style="list-style-type: none"> <li>• Multi-location businesses working</li> <li>• Several municipality and facility contracts running</li> </ul>	<ul style="list-style-type: none"> <li>• Well-established operators with a range of owned and franchised operations</li> <li>• Major city contracts in place</li> </ul>
<ul style="list-style-type: none"> <li>• Core of technologies well proven</li> <li>• R&amp;D started on re-use options</li> </ul>	<ul style="list-style-type: none"> <li>• R&amp;D yielding new re-use processes and products, and more value from blending streams</li> </ul>	<ul style="list-style-type: none"> <li>• Higher value products in use</li> </ul>
<ul style="list-style-type: none"> <li>• Entrepreneurs engaged in widespread experimentation on all aspects</li> <li>• No effective supply chain for equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Business focus emerging, with businesses specialising in different aspects of operations and technology</li> <li>• Operations and designs covered by ISO standards</li> <li>• Equipment supply chain becoming established</li> </ul>	<ul style="list-style-type: none"> <li>• Modular businesses, using modular equipment and well established standards</li> </ul>
<ul style="list-style-type: none"> <li>• Local markets for compost and energy products</li> </ul>	<ul style="list-style-type: none"> <li>• Major growers using organic compost</li> <li>• Growing number of grid contracts</li> </ul>	<ul style="list-style-type: none"> <li>• Major brands accept organic compost on food crops</li> <li>• Multiple instances of grid power supply</li> </ul>
<ul style="list-style-type: none"> <li>• Bundling working in Pune and rolling out in India</li> </ul>	<ul style="list-style-type: none"> <li>• Bundling working in multiple locations</li> </ul>	<ul style="list-style-type: none"> <li>• Brands making widespread use of product, service, and communications opportunities bundled with toilet provision</li> </ul>
<ul style="list-style-type: none"> <li>• All blending multiple waste streams</li> </ul>		<ul style="list-style-type: none"> <li>• Holistic biological waste/resource system understood, and use widening – e.g. compostable packaging</li> </ul>

The Toilet Board announced in August 2017 its collaboration with the city of Pune, India, to create the world's first smart sanitation city. This project will become a demonstrator for the integrated implementation of the Sanitation Economy. A range of other city scale and facility scale projects are being developed, addressing the medium and long term opportunities outlined in the table above. We invite others to join us with these and additional projects.

## APPENDIX 1 - NOTES ON THE MODELLING METHODOLOGY

The amount of municipal support (gate fee) was calculated for each option on a \$ per tonne of "Toilet Resources" basis (i.e. not including flush water).

The level of support needed was based on providing a private sector investor a commercial Internal Rate of Return ("IRR"). The IRR was applied to pre-tax and interest project cashflows in real terms (not including price inflation).

The project cashflow included upfront capital costs and over the useful life of the treatment facilities the municipal gate fee, third party revenue (i.e. sales of resources including fertiliser, electricity and fuel), major maintenance costs, and operating costs.

All options included cashflows for toilet provision, transfer of the material to the treatment facilities (sewage pipes for conventional sewage and road transport for the decentralised options), treatment processes, and sales of end resources.

For simplicity it was assumed that the population would remain stable over the useful life of the facilities. In a situation where population growth is likely it is expected that the decentralised options would have a benefit over conventional sewage that additional capacity is easier to add on to meet demand as: the individual treatment facilities are economical at smaller capacities; the treatment construction time is shorter; and increased road transport movement is likely to be easier to implement than increasing the sewage pipe capacity.

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