TOILET BOARD COALITION

SANITATION IN THE CIRCULAR ECONOMY

Transformation to a commercially valuable, self-sustaining, biological system

A thought piece from the Toilet Board Coalition

November 2016

Unilever · Kimberly-Clark · London School of Hygiene & Tropical Medicine · The Stone Family Foundation · USAID From the American People · ADB Asian Development Bank · WSUP Water & Sanitation for the Urban Poor · Department for International Development · unicef · afd Agence Française de Développement

Grand Challenges Canada Grands Défis Canada · LIXIL · Firmenich · brac · WSSCC Water Supply & Sanitation Collaborative Council · WaterAid · WORLD BANK GROUP

Disclaimer: *The contents of this paper provide a synthesis of our discussions and findings from the Feasibility 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.*

About the Toilet Board Coalition (TBC)

The TBC is a business-led coalition. We share a common vision and are committed to providing the leadership, mentorship and investment needed to accelerate the pace of change to achieve universal access to sanitation.

We work at the systems level to co-create the necessary ecosystem to support sanitation businesses to scale. And, we work directly with promising businesses in low-income markets that have the potential to deliver smart, sustainable and resilient sanitation for all.

We have created a platform for global business leaders and pioneering innovators to join the global sanitation community in a public-private partnership with the aim to accelerate the delivery of universal access to sanitation through the market.

Circular Economy Feasibility Study Participants

We are grateful for the generous time spent with us on this study - from the inspiring and innovative small and medium sized businesses who opened their doors and plans to us - to our members and invited experts who created an infectious "can do" environment that has allowed us to dream big, and connect our starting points to real opportunities today - and to our skilled analysts who went into overtime on many occasions to make sure that all avenues presented were explored and all voices were heard. You have been a dream project team and we thank you! A full list of study participants is below.

We would like to extend special thanks to our project partners and core team: Jon Hague, TBC Partnership Council Chair and thought leader extraordinaire; Jon Lane and Neil MacLeod, our experienced Independent Directors who have provided much guidance in our process; Sandy Rodger, our Circular Economy expert; Saskia Reus, Sjef Ernes, Jan Spit and Jacqueline Barendse of Africa Funded, Aqua4All, and WASTE respectively, our analysts; Claire Balbo and Alex Knezovich our chiefs of getting it done! With much appreciation.

About this paper

In 2016 the Toilet Board Coalition ran a Feasibility Study to explore the potential role of Sanitation in the Circular Economy. The following questions were at the centre of our inquiry:

- Are there products or materials of value being upcycled from toilet resources*?
- Are there scalable business models to deliver sustainable supply of these products to the market?
- Is there commercial interest and demand from large industrial operations to become buyers into the system?

Our study engaged twelve small and medium sized businesses (SMEs) engaged in sanitation across low-income markets, and twelve experts from multinational corporations, academia, and specialists from across the "waste", or rather resource, management value chain.

Our approach was to understand the business, technical and customer demand feasibility of each of the twelve SME businesses where we saw potential for Circular Economy transactions. Our approach focused on business transactions, particularly those already occurring in the market for toilet resources, and on the potential for scale through demand from industrial supply chains.

The Circular Economy – changing the economics of sanitation

It is our vision that demand for the resources being derived from the toilet can create self-sustaining sanitation businesses and encourage investment in sanitation, reducing dependence on public and aid funding. It is our aspiration that this demand will accelerate the implementation of improved sanitation for all. In this logic, economic gains become the enabler of wider social and environmental gains. The Economics of Sanitation initiative by the World Bank's Water and Sanitation Programme (World Bank, 2016) has already showed that the economic gains from sanitation fall across society, enhancing the economy as a whole by reducing the burden of health and environmental issues, and even citizens' lost time and productivity. This initiative estimated the global benefit at $260 billion. However the challenge is to translate this widely dispersed benefit into cash flows which make business solutions viable and so drive investment. The Circular Economy model can achieve this, through increased revenues, greater efficiency, and through monetising some of the externalities. This study, and the planned next phase of work of the TBC, aim to address those needs and so demonstrate the financial case for the circular model.

This paper presents the findings of our study in the form of a thought piece on the topic of sanitation in the Circular Economy. Our intent is to present a number of business opportunity spaces, where we believe that value has been left on the table and customer needs unmet, which we recommend are to be explored further in the decade ahead.

The transition to sanitation in the Circular Economy, and unlocking promising business opportunity associated with it, will not be without risk. Our study and this paper also cites the risks in optimising and scaling the business opportunities identified, and suggests potential pathways for these risks to be overcome.

* Important Note: In the Circular Economy, "waste" does not exist as a concept. This goes beyond reduced waste, or zero waste, to systems in which, as in nature, the whole notion of waste does not exist - everything is food for the next stage. We believe language is important when the goal is to change the conversation. We have therefore replaced the term "human waste" with "toilet resources". This has not been easy, indicating just how embedded is our use of the word "waste." So bear with our unfamiliar language, and join us in starting to reframe human waste as a valuable resource.

Foreword

Sanitation in the Circular Economy

We started to think about the Circular Economy and its potential applications for sanitation when we asked ourselves: could we drive more demand for toilets if people valued the materials they produce? What are the best examples of finding new value in previously disposed waste? The answer, we thought, could lie in the Circular Economy - one man's (or industry's) waste is another man's (or industry's) treasure.

At the Toilet Board Coalition it is our mandate to identify, support and accelerate business solutions for universal access to smart, sustainable sanitation. We believe that collectively, we can enable the 2.4 billion people currently without access to reach the target of SDG 6 by 2030. In fact we believe that this goal provides savvy businesses with the opportunity of the decade - to capture unrealised business value and to address unmet needs of future consumers.

In our current experience of supporting Toilet Innovators and Sani-preneurs, we have found that in addition to creating demand for consumers to buy a toilet, the downstream part of the system is a pervasive challenge – transport/collection, and treatment. Not only for the vast numbers of communities without access to a publicly supported sewage system, but also for the treatment plants themselves.

From a business view this makes a lot of sense when you follow the experience of the user / consumer. Owning a toilet and all of the convenience that it brings will not be enough for the user if there is no effective removal of the materials it produces. Beyond the toilet hardware, what value is the toilet and its usage and to whom or what? Who can benefit or profit? Who are the buyers and sellers in the system?

It is these simple supply and demand economics that we have sought to understand with this study, and the results, we feel, are staggering. We believe that there is a big idea here, that toilet resources are commercially valuable and have the potential to kick-start the value generation from the biological Circular Economy system. In doing so we have the potential to transform sanitation from an undesirable cost into a commercially valuable and self-sustaining system.

This report provides some exciting signals through case studies of current transactions - where a marketplace of buyers and sellers of products and resources derived from toilets is already underway in local communities in low-income markets - and encourages large businesses to look into these new opportunities to take the system to scale and bring proper sanitation to all. The first mover advantage window is now!

Madhu Rao,
Global SVP Global Household Care, Unilever & Chairman, Toilet Board Coalition
January - August 2016

Mauricio Troncoso,
VP & Managing Director Western Europe, Kimberly-Clark Corporation & Chairman, Toilet Board Coalition
August 2016 - Current

Cheryl Hicks,
Executive Director, Toilet Board Coalition

Introduction

What is the Circular Economy?

The Circular Economy replaces our current linear model of take, make and dispose, with a system that keeps products, components and materials at their highest utility and value at all times. It is achieving rapid awareness and adoption, because business and political leaders are realising that economic and population growth are depleting resources and producing "waste" at levels which cannot be sustained. Resource cost volatility is already much higher in the 21st century than the 20th. Substituting the circular model involves a redesign of products, supply chains, and business models. Many business leaders see opportunities for growth through new products, services, and customer relationships.

The Circular Economy comprises two cycles (see figure on Page 5): technical (managing the stocks of finite resources) and biological (managing the flows of renewable resources). To date industry has mainly focused on the technical cycle (metals & plastics) leaving the biological cycle (or biocycle) largely untapped.

> *"The Toilet Board Coalition's approach, in working with large and small companies, is particularly appropriate to achieving change at the systems level, because it facilitates both local, decentralised solutions with direct impact on communities, and the development of new, circular, resource flows at large scale. The Circular Economy can open up new opportunities not explored with previous attempts by using a wider conception of available resource flows, new business models, and new ways of turning what are currently externalities into beneficial financial flows."*
>
> - Ken Webster, Head of Innovation, Ellen MacArthur Foundation

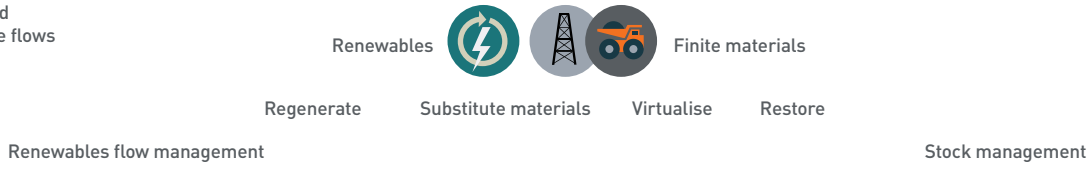
Sanitation in the Circular Economy

The United Nations (UN) have outlined 17 Sustainable Development Goals (SDGs) to be reached by 2030. In order to reach SDG 6 of securing sanitation for all, the next 15 years will witness widespread sanitation systems installations. This will open up Circular Economy and sanitation opportunities - for business and society.

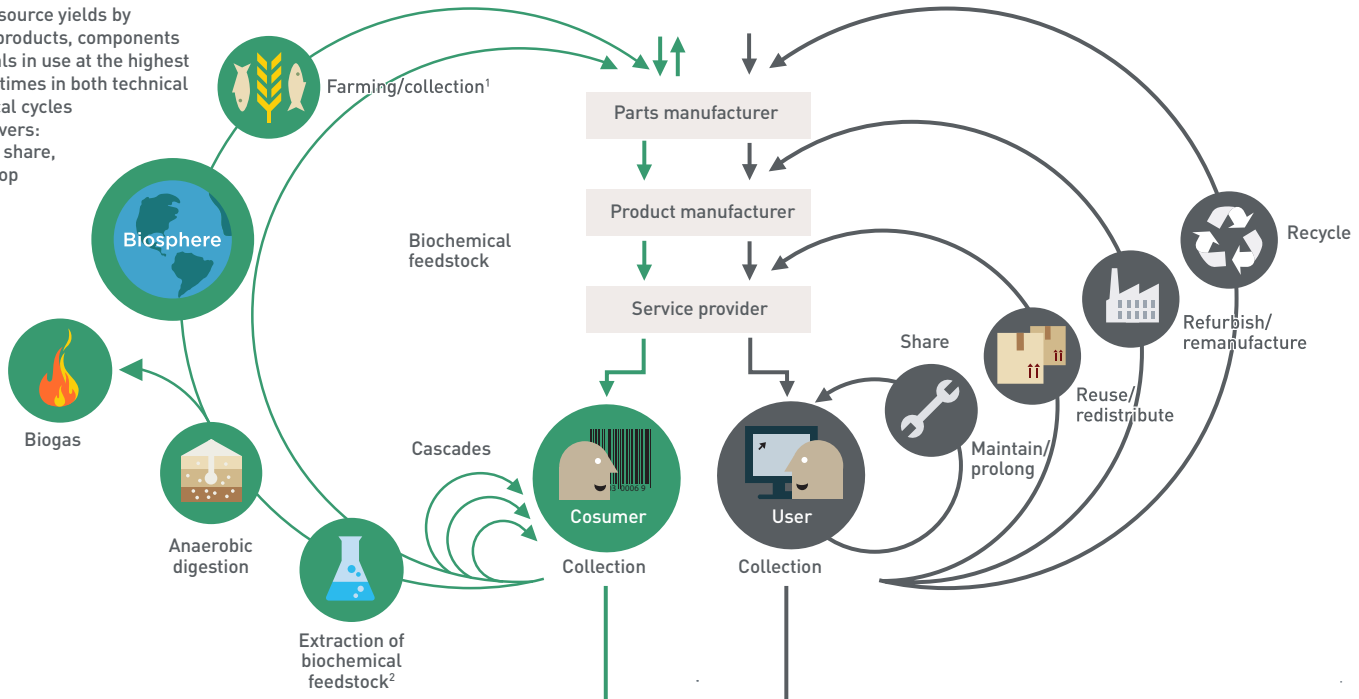
The infographic presented on pages 6 & 7 provides a visual overview of our report *Sanitation in the Circular Economy* - a continuous loop of self-sustaining value. It focuses on the biocycle, adding toilet resources to the cycle as a key component. This infographic aims to represent our key findings outlined in this section.

Outline of a Circular Economy

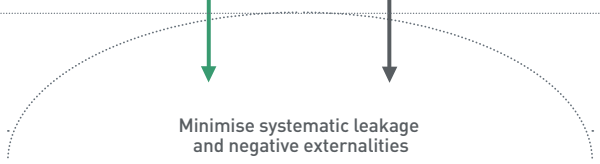
PRINCIPLE 1
Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
ReSOLVE levers: regenerate, virtualise, exchange



PRINCIPLE 2
Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles
ReSOVLE levers: regenerate, share, optimise, loop



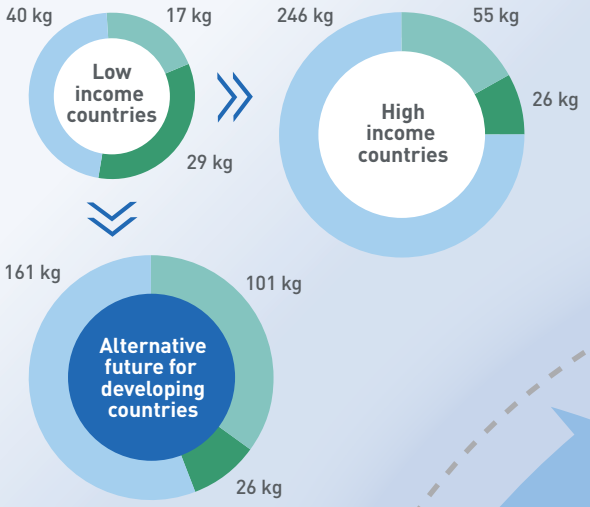
PRINCIPLE 3
Foster system effectiveness by revealing and designing out negative externalities
All ReSOLVE levers



ELLEN MACARTHUR FOUNDATION

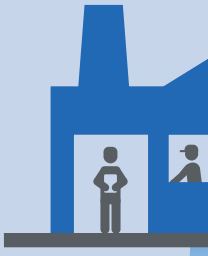
1. Hunting and fishing
2. Can take both post-harvest and post-consumer waste as an input

Adapted with special permission from Ellen MacArthur Foundation for Toilet Board Coalition use.
Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).



Leapfrog opportunity:
A holistic biocycle enables biological substitutes for technical materials (i.e. plastic and paper), reducing waste as the system and economies grow.

SME WASTE
PLANT IN EMERG



Collection of biological waste
- human waste
- food waste
- agricultural waste
- farm waste

SUPPLIER:
Currently small waste re
run by innovative entrep
and producing different

Reuse helps companies meet SDG Targets

Consumer biological waste
- toilet waste
- kitchen waste
- animal waste
- compostable packaging

Industrial biological waste
- toilet waste,
- food / market waste,
- agricultural & food waste
- farm waste
- compostable packaging

SANITATION & THE CIR

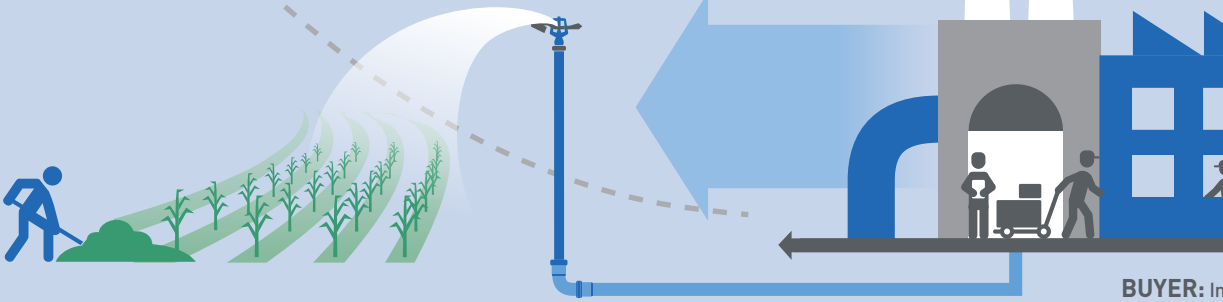
TOIL

BOARD COA

New products from up-cycled waste

REFINER/MANUFACTURER:
Produces new products from up-cycled waste to sell back to consumers and industry - thus completing the loop!

INDUSTRIAL PL
TRANSPORT UP-
PRODUCT



BUYER: In
re-user of u

RECOVERY
GING MARKETS

ecovery plants in emerging markets
reneurs using different technologies
products from the waste

TECHNOLOGY 3
INTERNET OF THINGS SENSORS

OLOGY 2
GESTION

RCULAR ECONOMY
LET
LITION

ANT / CROPS /
-CYCLED WASTE
T REUSE

dustrial plant, agriculture, transport as
p-cycled waste products & raw materials

PRODUCT 1

- Non-food crops : forest free fibre crops, flower crops etc
- Food crops

Agricultural products
Compost, organic fertilisers, nutrients such as nitrogen and phosphorus

PRODUCT 2

H_2O

Water
Water recovery and purification of wastewater

- Local agricultural irrigation
- Water intensive factory processes
- Further treatment to produce drinking water

PRODUCT 3

Energy products
Fuel, electricity, heat

- Biogas for local factories & electricity to the grid
- Bio diesel for transport
- Bio Charcoal to replace wood/ coal

PRODUCT 4

Materials for
innovative products

- Faecal matter for pharmaceutical (biome) regenerative health products and procedures
- Bio-plastics

PRODUCT 5

Protein rich materials
such as oils and protein meal

- Protein oils for consumer toiletry goods and potentially cosmetics
- Protein "meal" for pet and farm animal feed

PRODUCT 6

Health data & information
Sampling and monitoring human waste can produce valuable basic health data

- Public health: early warnings for disease outbreaks or health deficiencies
- Private health: basic health diagnostics for individuals and basic health products/ pharmaceuticals

Source: Toilet Board Coalition Feasibility Study 2016 - www.toiletboard.org

Our Key Findings

Our initial inquiry into Sanitation in the Circular Economy with entrepreneurs operating in low income markets, academics, and multinational corporations, has produced six key findings.

#1 Toilet resources are a major part of the biocycle that are mostly unexploited

#2 The Circular Economy could transform sanitation from a costly service to a self-sustaining and value adding system of resources

#3 There are 3 Circular Economy opportunity cycles for sanitation

#4 There are renewable resources available for corporate supply chains today

#5 There are innovative applications for industry in the future

#6 There are significant leapfrog opportunities for low income economies

"Large companies can help to drive change for Sanitation in the Circular Economy by providing industrial organic "waste" into the system, and becoming buyers of the value adding products that come out"

- Jonathan Hague, VP Open Innovation & Operations, Unilever

Key Finding #1:

Toilet resources are a major part of the biocycle that is mostly unexploited

Toilet resources are a major part of the biocycle. Yet they are almost always handled separately from other resources. This is, mainly, for historical reasons, because sanitation has been addressed primarily as a health issue.

We have found that toilets provide a range of valuable resources that offer multiple circular flows – for materials, energy, and water.

A more holistic approach to the biocycle would include toilet resources being blended with food and farm "waste" (which is considered a resource), plus compostable items, such as packaging. This could enable manufacturers to favour biological materials for many applications. By taking this path, low-income countries could fundamentally alter the balance of resources: it would tilt in the direction of biological versus technical, which would minimise growing issues including plastic waste.

EMERGING MARKET SANITATION SME INSIGHT: Most companies reviewed for this study are blending different biological resource streams, together with toilet resources as their input, in different combinations, to yield different outputs in the form of renewable resources, raw materials, and products. The entrepreneurs have told us that decisions taken on the input combinations were based on the biological resource streams that were most readily available to them in their local contexts. When asked, they confirmed that their technologies could work just as well with different types of biological resources, but would need to be tested. Incidentally, some companies that have been upcycling food resources are adapting their technologies to add toilet resources.

Key finding #2

The Circular Economy could transform sanitation from a costly service to a self-sustaining and value adding system of resources

Companies are already starting to implement parts of the Circular Economy for Sanitation, converting "waste" from a cost into valuable resources. This newly generated economic value can be used to equip and sustain sanitation facilities. The economic value is accompanied by social and environmental benefits. It achieves important health and hygiene objectives associated with the safe removal and treatment of toilet resources while also creating economic value vs. cost. Moreover this system helps improve the environment by reducing pollution and providing green energy.

EMERGING MARKET MUNICIPALITY INSIGHT: "*At the City of Durban, we have calculated that by upcycling our sludge through new "waste" treatment technologies available, we are able to save up to 50% in operational costs vs. current methods of treatment / storage*"

– Neil MacLeod, former Head of Water and Sanitation at eThekwini Municipality

Key finding #3

There are 3 Circular Economy opportunity cycles for sanitation

Circular Economy Opportunity 1: Maximise value from toilet resources

Here the sanitation system drives a value chain based on biological resources, which yields agricultural products, energy, water, other innovative materials, as well as health-related information (see key finding #5).

It is important to note that both household biological resources and industrial biological resources can drive the inputs into the system - and benefit from the outputs.

Circular Economy Opportunity 2: Integrated approach to resources, favouring the biocycle

The second cycle illustrates an integrated approach to resources (formerly "waste"). This maximises the use of the biocycle within the overall economy, integrating toilet resources, farm and food resources, and other compostable items. This is both a productive biocycle, and a route to reducing other "waste" challenges such as plastics.

Many TBC member companies have made public commitments to reduce their industrial "waste", often extending into their supply chains. A more holistic biological resource system can help both for outputs (as a pathway for some industrial "waste" flows), and for inputs (providing valuable materials from a reliable and renewable source).

Circular Economy Opportunity 3: Self-sustaining facilities and operations

Thirdly, Circular Economy business models could make the system self-sustaining. Typically such models change traditional ownership of plant and equipment, with the supplier providing an ongoing support service rather than making a one-time sale. The models are circular because the supplier is incentivised to support long product life, and finally to take responsibility for the product at end-of-life. The result, proven in areas such as white goods and lighting, can be reduced overall costs, and a more effective service to the customer. This model is emerging in developed markets, and we have not yet seen it applied to sanitation where it could be relevant to all parts of the system - toilets, transport/ collection, and treatment facilities. We recommend that next phases of work explore this opportunity space more thoroughly.

Participating study expert, Waste Ventures India, has advised this study on the transferable learnings of similar challenges they have faced and overcome in the technical cycles of the Circular Economy.

Waste Ventures India, *"We created Waste Ventures based on the demand for "waste management" from large corporations, housing societies and smaller towns. During the collection of recyclables from very decentralised neighbourhoods where traditional collection trucks could not access our innovation was to incentivise low income and often informal workers such as "waste pickers/scrap dealers" with innovative logistics solutions to get to hard to reach places and also by establishing a market for low value recyclables so that there is larger revenue to go after. In participating in this study we see a very interesting opportunity to apply our learnings from the collection of recyclables to the collection of biological "waste" as well."*

- Roshan Miranda, Co-founder & Director

Key finding #4

There are renewable resources available for corporate supply chains today

There are five major sources of value to be derived from the sanitation system, if it adopts the circular model. Three are available today, and two we signal as potentially significant business opportunity spaces for the not to distant future.

Working Today (Key Finding #4)

1. Energy

2. Agricultural products

3. Water

Future Opportunity (Key Finding #5)

1. Innovative products/raw materials

2. Information/health data

1. Energy

Toilet resources mixed with other biological resources can provide a green energy supply. This takes the form of biogas, liquid, or solid fuel, which can be used directly or converted into electricity and/or heat. These can fulfill a wide range of needs including cooking fuel, industrial processes, and transport (biodiesel).

Converting biological resources to energy could displace the use of fossil fuels such as coal and diesel, or wood-burning which is often related to deforestation. Hence energy from toilet resources and other biological resources is a lower-carbon option.

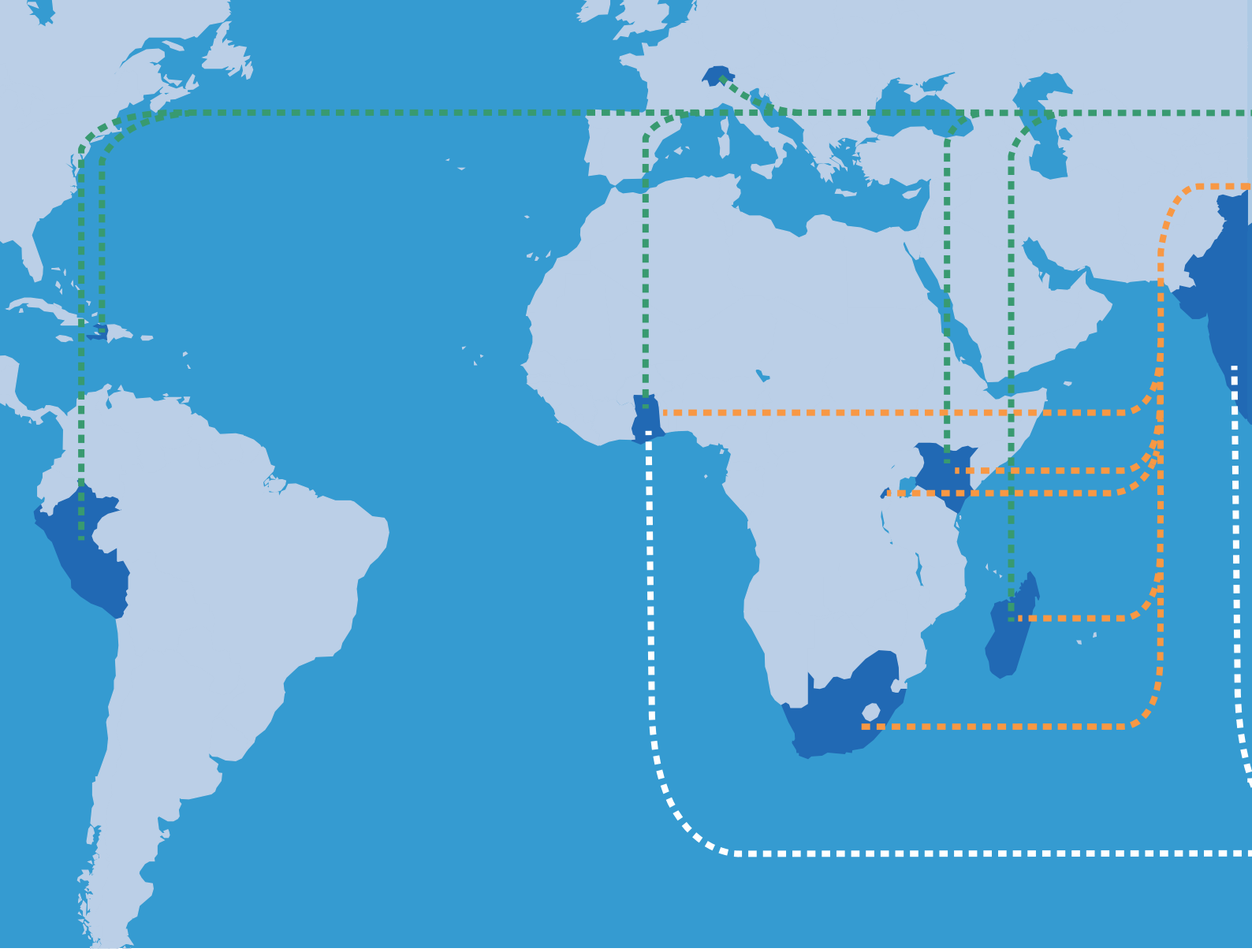
Sanivation, Kenya: *"We remove toilet "waste" that would otherwise spread infectious disease from the environment and combine it with agricultural residue to transform it into a clean burning charcoal briquette. Our 100% "waste stream" derived briquettes are not only preferred by our restaurant customers due to longer burn time and less smoke, but they also save 88 trees for every ton sold."*

- Andrew Foote, Co-founder & CEO

EMERGING MARKET SANITATION SME INSIGHT: 6 out of the 12 companies participating in this study are currently producing energy from toilet resources and successfully selling it into their local markets in Ghana, Kenya, Madagascar, Rwanda and South Africa. In some cases the energy output is the key driver of their business model in other cases it is an additional output of the digestion process together with agricultural products, for example.

SafiSana, Ghana: *"We combine human "waste", slaughter "waste" and market "waste" as inputs to our anaerobic digestion process that produces biogas, irrigation water and compost as outputs. A combination of these "waste" streams makes the business case stronger and more resilient in an unstable environment. This way we can rely on a mix of input sources while it generates a variety of valuable end-products"*

- Aart van den Beukel, Co-founder & CEO



2. Agricultural products

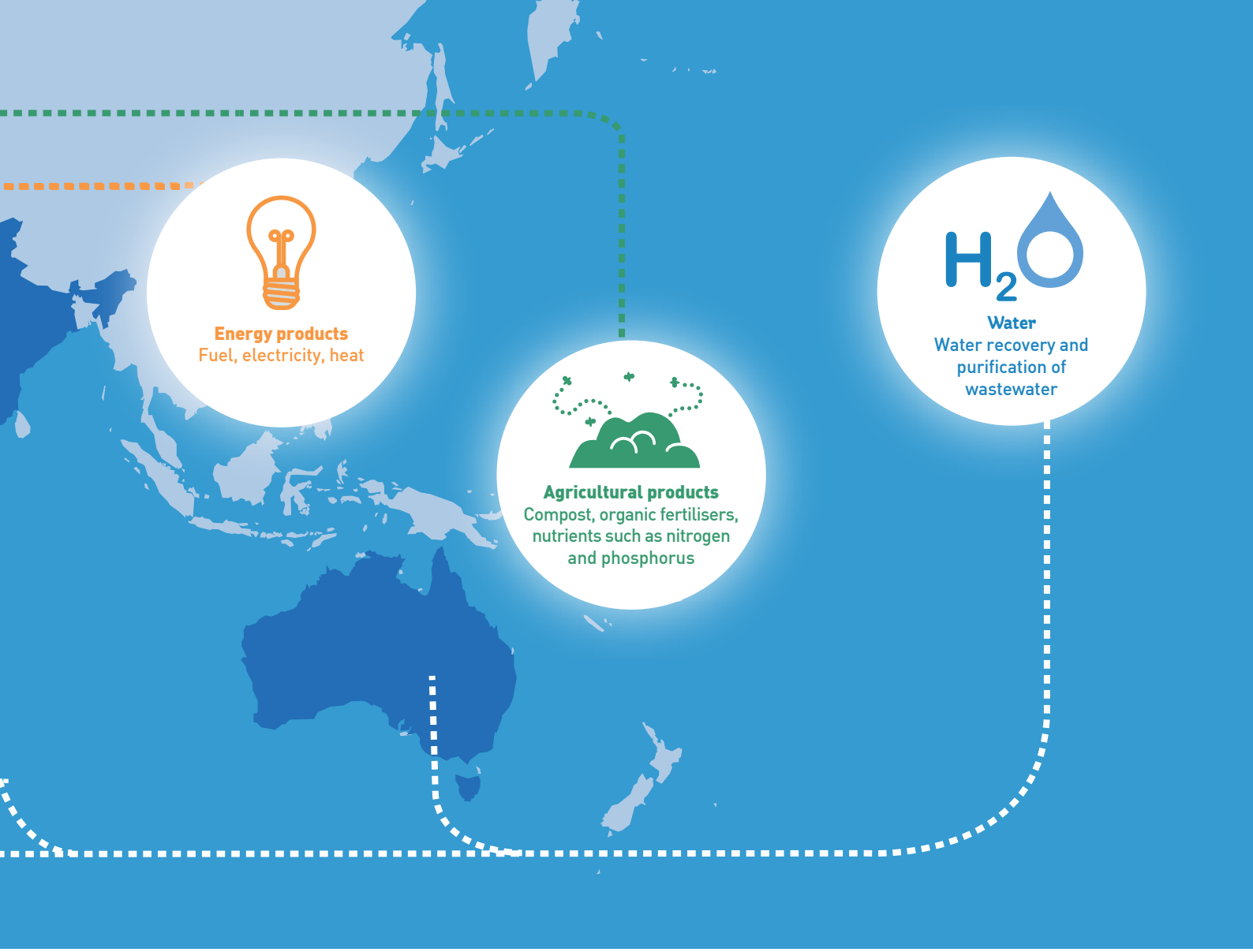
There are rich possibilities in agricultural products – compost, organic fertilisers and soil conditioners. Toilet resources mixed with other biological resources can provide a premium agricultural product.

Upcycling biological resources to agricultural products could help provide complimentary products to chemical fertilisers to address the degradation of nutrients in the soil over time, while reducing the transport impact of industrially-produced fertilisers.

Multinational corporations whose supply chains involve industrial agriculture in emerging markets have shown interest in these high performing agricultural products under certain conditions, outlined later in this paper under "Risks." Matching local supply of the products, with local operations of multinationals is a key opportunity at this point as transport of the material would off-set the cost benefits, and encounter to cross-border regulations.

Sanergy, Kenya: *"While an organic fertiliser is anything derived from animal and/or plant products, Sanergy's organic fertiliser is technically a compost because it has fully decomposed before application to the soil. This separates our product from many organic fertilisers, which decompose while on the soil, leaching nitrogen from plants and generating heat that can burn seeds and root systems."*

- David Auerbach, Co-founder & CEO



EMERGING MARKET SANITATION SME INSIGHT: 8 out of the 12 companies participating in this study are currently producing agricultural products from toilet resources and successfully selling them into their local markets in Ghana, Haiti, Kenya, Madagascar, Peru, and South Africa. They tell us that demand for these high performing agricultural products outstrips supply. They tell us that, once their customers start to use it, they don't want to go without it due to its performance enhancing qualities.

3. Water

Toilet resources are principally composed of water. Faecal matter contains up to 75% water. Urine is 95% water (Rose et al., 2015). We found many examples of companies which are already extracting the water, filtering it and producing either potable or processed grey water for use in agriculture, aquaculture or water intensive industrial operations.

Amongst our study participants, water was least in focus as a commercial output from their processes. However, this could be an area for further exploration in the future, especially when addressing water-stressed areas.

Our academic partners in the study from the University of KwaZulu-Natal in Durban, South Africa, are testing the performance in crop yields with the use of organic fertilisers derived from toilet resources to understand potential enhancement qualities.

EMERGING MARKET SANITATION SME INSIGHT: Veolia, multinational resources company and study participant, recycles treated "wastewater" from the Grammam reservoir to produce potable water for the city of Windhoek in Namibia

Eawag adds that they have found soil performance to be enhanced with the use of agricultural products derived from toilet resources over time, due to its soil conditioning qualities, but cautions that farmers may not see the increase in yield in their first application.

DEVELOPED MARKET INSIGHT: Our academic partner Eawag in Switzerland has started producing a fertiliser derived from human urine and is selling a first lot of fertiliser bottles as market research. The urine collected in Eawag's main building is stabilised in a biological process (nitrification), then concentrated into a liquid fertiliser. The resulting product does not smell, is safe to use and has obtained the authorisation by the Swiss Ministry of Agriculture to be used as fertiliser for lawn, flowers, and ornamental plants.

Key Finding #5:

There are innovative applications for industry in the future

1. Innovative new products & raw materials

From animal feed to plastics and even cosmetics and pharmaceuticals, there are already some surprising applications that could make use of material derived from toilet resources – and there are likely to be many more as we further develop the product opportunities derived from the Circular Economy for Sanitation.

In our study this area was one of the 'surprise' findings. We learned from our dialogue with several commercial sectors that much broader activity is underway to leverage the unique value and properties of toilet resources.

Veolia's research team is involved in projects dealing with the recovery of materials from toilet resources. For example, the production of feedstock for plastics, using "wastewater" as a source, has been investigated, is technically feasible, but not yet economic.

The BioCycle, South Africa: *"Our parent company started using black soldier fly larvae to recover nutrients from food "waste", reconfiguring into high quality proteins and lipids for more sustainable fish farm and chicken farm feed. Due to the issues with sanitation and "waste" management in South Africa we decided to further develop our understanding of the technology and its potential impact on the toilet resource stream. Our perseverance and continued experimentation proved successful and led us to create a new company, the BioCycle."*

- Marc Lewis, Co-founder & CEO

The whole area of regenerative health, based on the use of faecal matter for new treatments, is cited as an emergent sector. In the long term protein rich oils extracted from toilet resources could even replace more conventional sources used in consumer goods and animal feeds.

This finding seemed to signal that we are just scratching the surface in terms of future business opportunity spaces for product and material innovations to be derived from taking a Circular Economy approach to the biocycle, including toilet resources.

> NatureWorks, bio-plastics company: *"We are working on new products and applications that could fit in the biocycle, including a radically new process to produce biopolymers from feedstocks like bio-methane"*
>
> - Manuel Natal, Director of Product Development

2. Information & health data

Mining and analysing the information contained in toilet resources can drive multiple health interventions – informing disease prevention and control for public health, access to basic health information for individuals, and, with further insights, new opportunities in regenerative health products and applications.

Another 'surprise' finding of our study was the extended thinking about input and output flows in terms of data and information, as well as materials and products. In developing business opportunities, these flows equally represent valuable resources, so we felt that information flows indeed belong in the Circular Economy for Sanitation. Data privacy and ethics standards will need to be managed to optimise business opportunities.

> Current, powered by GE: *"We are entering a shift in the Smart City movement. As industrial companies are figuring out how to create a new kind of digital infrastructure, the kind that can deploy broad sets of sensors across a city economically, cities are figuring out how to engage their citizens by providing more data. As those trends combine, we will see a new revolution in urban technology that affects entrepreneurship... and quality of life for all. Sensors are being deployed across cities already. From environmental sensors that measure air quality, to vibration sensors that measure road and bridge safety, to parking sensors that identify available parking spots, we have begun to digitise our cities in steps."*
>
> - John Gordon, Chief Digital Officer, cited on Current website (Current, 2016).

From a supply perspective these areas are little developed. That said, this is certainly on the radar for designers of the next generation of smart cities, using powerful sensor technologies to enable the Internet of Things (IoT). Sanitation will need to connect into smart cities' infrastructure to optimise the expected efficiencies and value adding opportunities for citizens and consumers.

Toilet resources can be leveraged for health data. The composition of faecal matter, urine and blood contain important information to assess basic status of health.

From the demand perspective, this information could be transformative for public health in terms of early warning signals for pandemics and outbreaks such as Ebola and Cholera. From a private health perspective, this personal health information derived from toilet resources could also advance user-driven healthcare

product and business opportunities, especially in low-income markets, where Mobile Health applications are already changing the landscape of health information for the poor. Again, with a strong disclaimer that data privacy and ethics standards will need to be managed to optimise business opportunities.

Our study signaled data and health information as an important business opportunity space for the use of toilet resources in the not too distant future.

Key Finding #6

There are significant leapfrog opportunities for low-income economies

In the drive to secure sanitation for all, there is an immediate opportunity to transform how sanitation is approached worldwide, in both low-income and high-income markets, from a Circular Economy point of view. This creates a unique opportunity to leapfrog into the Circular Economy creating alternative development pathways.

Our study focused on Sanitation and Circular Economy business opportunities in low-income markets. While there are exciting transformations in progress across low-income markets, providing development and advancement for citizens and lifestyle improvements for consumers, leapfrog opportunities are usually referred to in the case of mobile phones and mobile money. Based on the findings of our study, we believe that enabling the biological cycle of the Circular Economy, to include toilet resources and all biological resource streams, could be the next transformative shift for low-income markets and their sustainable development.

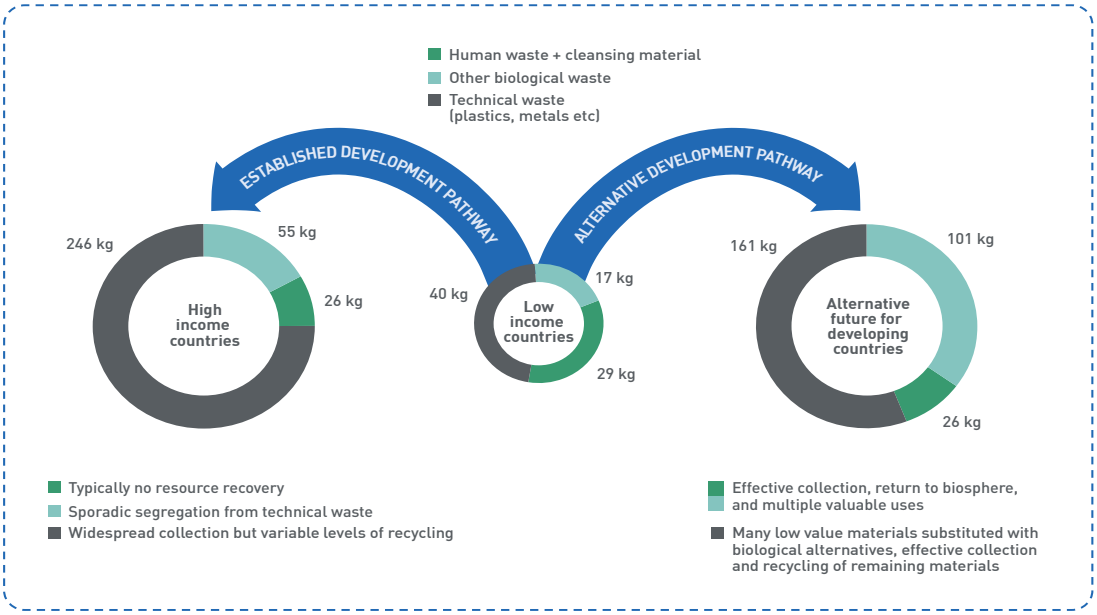
Today, low-income market "waste" is mostly biological, whereas developed markets have a much larger proportion of non-biological materials such as metals and plastics. This creates a unique opportunity to leapfrog into the Circular Economy. Low-income markets face a unique mix of needs, constraints and possibilities. These combine to produce three distinct leapfrog opportunities.

LEAPFROG #1 Install, service and grow sanitation systems that produce positive health and environmental outcomes, and also allow recovery of the value locked up in toilet resources. This can make sanitation a self-sustaining system, reducing dependency on aid and public funding.

LEAPFROG #2 Strengthen the biological cycle of the Circular Economy by designing holistic biological resource management systems that combine human, farm and solid "waste" streams. This can create value in itself and prevent the growth of other "waste" issues such as plastics.

LEAPFROG #3 Connect centralised and decentralised sanitation systems that result in a smart and sustainable future.

> *"In order to create self-sustaining systems, the technology developed is adapted to the local conditions. Bioprocessing, for example, is accelerated by year-round high solar intensity and heat, so is perfectly suitable in many low-income countries. This is one of several reasons why low-income countries' sanitation systems need not copy the solutions established in high-income countries"*
>
> - Douglas Mulhall, Business Developer with EPEA Internationale Umweltforschung



Current waste breakdown based on UNEP Global Waste Management Outlook 2015, and Compendium of Sanitation Systems and Technologies, 2nd revised edition, EAWAG Aquatic Research. Alternative future breakdown based on assumed substitution levels between 0 and 33% for selected technical materials.

The Business Case

One of our objectives with this study was to understand the business case for large and small commercial actors to invest more significantly to scale a self-sustaining Circular Economy system for toilet resources and accelerate access to sanitation for all. We found the business case to be compelling for both multinational and large corporations as well as small and medium sized enterprises operating in local contexts in low-income markets.

Opportunity spaces for multinational corporations

- **Address mounting "waste"/resource management issues with new opportunities to upcycle the "waste" as an input to the biological system**
- **Access a reliable stream of renewable resources, materials and products for global supply chains and local emerging market operations**
- **Access new materials unique to the biocycle and toilet resource streams, for R&D of new products**
- **Broaden understanding of the low-income market through collaboration with SMEs.**

Multinational corporations have the ability to provide biological inputs into the system as well as being buyers of the product and material outputs to put back into their operations. The biocycle and the Circular Economy for Sanitation offer multinationals access to a new and reliable, affordable and sustainable supply of inputs.

Toilet resources are predictable; their volumes are closely tied to population growth. More locally, they are available from corporate facilities, nearby communities, and employees' homes. Many multinational corporations have pledged to provide appropriate access to sanitation and hygiene, for all employees in all premises under company control. The longer-term vision is to go beyond the fence to advocate for access to improved sanitation for all employees along the value chain and ultimately the homes and communities where employees live - this could potentially represent a large volume and reliable supply of toilet resources. Similarly, many corporations have made commitments to reduce food "waste", agricultural and farm "waste" – all of these "waste streams" are valuable inputs into the biological system.

Multinational corporations have made public commitments to ensure improved sanitation across their global operations via the World Business Council for Sustainable Development (WBCSD) WASH in the Workplace Pledge (WBCSD, Undated) and the United Nations WASH4WORK programmes (UN Global Compact, Undated). Companies can fulfill their improved sanitation commitments and capture the toilet resources of employees to reuse in the biological Circular Economy system.

In addition, to meet national and global sustainable development targets, multinationals have made public commitments to operate on sustainable and renewable resources and materials. This has squeezed and constrained many companies to find new materials and resources to supply their operations. That makes the biological, renewable and sustainable materials and products, coming from the toilet resources value chain, an increasingly attractive option.

Multinationals can also benefit from new commercial opportunities to sell a range of innovative products and services to entrepreneurs running the local sanitation systems. This includes cleaning products, odour prevention, collection and transport solutions and digital enablement.

"LIXIL's Green Toilet System provides off-grid communities with a hygienic and sustainable solution to turn human "waste" into fertiliser. Currently under development, the system separates liquid and solid "waste", with solid "waste" being directly mixed with sawdust to eliminate odor and begin transforming the material. Beginning with the fundamental act of consuming food, the Green Toilet System will help people create a virtuous cycle that improves sanitation, expands agricultural resources and provides opportunities for sustainable businesses and employment."

- Yu Yamakami, LIXIL

Opportunity spaces for small and medium sized enterprises (SMEs)

- **Building a holistic biological "waste"/resource system including toilet resources**
- **Toilet resource collection and treatment**
- **Innovation in the creation of biological substitutes for products**
- **Innovation in the creation of new products derived from toilet resources**
- **Innovation in the services to meet local unmet needs in "waste" management**
- **Community-scale operations providing and maintaining toilets, and producing locally-relevant agricultural products, water, and energy**

Collection and treatment of "waste" in low-income markets is an acute issue where municipalities and communities are expressing an urgency for solutions. Of the 8 million tonnes / year of plastic waste entering the oceans, the majority is from low-income countries lacking effective collection and treatment (Jambeck *et al.*, 2015). Innovation is needed not only in technology but in logistics, organisation, and community engagement with "waste"/resource collection.

Biological materials represent the majority of the "waste" stream in low-income markets (UNEP, 2015), but economic growth will bring disproportionate increases in non-biological materials, such as plastics. Building a holistic biological resource system, including toilet resources, is not only valuable in itself, but enables innovation in the use of biological substitutes for a wide range of products – compostable packaging for example.

The current resource-constrained world and competition for scarce raw materials, including land, make toilet resources an attractive new source of biological material for a variety of industrial applications. The source is inherently reliable and guaranteed to grow in line with population. Innovation is needed in products derived from toilet resources, and in assurance systems and communications to ensure health concerns (such as pathogens) do not derail these developments.

Local demand for reliable energy, alternatives to soil degenerating fertilisers and more sustainable sources for animal feed, are also driving demand in local markets. Innovation is needed in small-scale processes which can allow these local demands to be met safely, reliably and at affordable cost.

The biological system and its Circular Economy is in its infancy. Fully optimising this system and leapfrogging to its self-sustaining potential will require innovation at all levels. Small and medium sized businesses and their entrepreneurs and innovators have a unique advantage to be nimble in this emergent business opportunity space, building sustainable businesses while contributing to social and environmental good.

In low-income markets, SMEs have the distinct advantage of responding to local market failures and unmet needs in order to be customer centric in their offering to the market. Local cultural norms also provide key insights into user behaviour and aspiration. This leads to better-targeted products and services, with better customer acceptance and understanding.

The table below presents a sample of industrial sectors who expressed interest in the products and resource opportunities to be derived from the biological cycle of the Circular Economy and in particular related to inputs that include human "waste".

AGRICULTURAL PRODUCTS	ENERGY	WATER	OTHER PRODUCTS / MATERIALS
Forest products	Heating /cooling / cooking	Operations in water scarce regions	Pharma
Plants grown as raw materials	Transport fuel	Water intensive operations	Healthcare
Animal feed & Pet Food	Cement		Public health
Food / beverage ingredients crops	Other industrial uses inc manufacturing, textiles, construction		Bio-plastics

Risks to be overcome

During the course of our study we identified the following key risks where the TBC, and its platform to link large and small business in collaboration through the Toilet Accelerator programme, could be helpful in advancing progress. The risks listed here do not claim to be comprehensive, but rather linked to the findings of the study, and focused on where the TBC could add value. These are risks specific to sanitation, additional to the wider risks and challenges of operating in low-income economies.

1. Pathogens and other contaminants

Human health and hygiene is a key priority when it comes to sanitation risks. Large buyers into the system have stipulated that they will need to assure that the elimination of pathogens to safe levels is certified for the safety of consumers (citizens) and the environment. This requirement is critical in both the choice of technology and its ongoing operation.

Companies participating in our study reported that this is an area that requires support. Factors to consider included:

- Labs are not always available to do the testing, and pathogen elimination cannot always be guaranteed.
- National regulations are limited. A new ISO Standard (www.iso.org) process initiated April 2016 is encouraging. The development of agreed standards and certifications will be needed to overcome this risk factor.

In addition, other contaminants will need to be managed. These include pharmaceuticals carried over in toilet resources, parasites which may be present in the human body or the treatment system, and materials incompatible with the system which are deliberately or inadvertently added to the flow. Our partners have mentioned possible solutions to these issues such as establishing quality assurance to solve the disease cycle as well as partnership development to develop healthy ingredients to avoid the accumulation of unregulated chemicals often overused in low-income countries.

2a. Yuk factor

The consumer perception of products derived from human excrement is significant. While many argue that this is a perceived risk vs. an actual risk, it remains a key area of uncertainty and therefore risk.

A survey of participating companies found that SMEs who are successfully selling their products derived from toilet resources to local customers do not see the impact of the yuk factor. However, global brands are very concerned about potential backlash. Perceived risk will need to be managed carefully.

2b. Malodour

A key barrier for sanitation, both in the use of toilets, and the work environments of sanitation-based businesses is malodour. People do not want to use toilets that smell, and workers do not want to work

in environments that smell. However, most sanitation businesses will say they do not have a malodour problem. It is an unspoken truth that, as a result, is not managed.

We found a similar result during our study, where most businesses working with toilet resources felt they did not have a malodour issue. However, upon review of their operations and costs, the results of malodour were clear - from high levels of staff turnover to the costly construction of sophisticated ventilation infrastructure. Some advisors have commented that, when properly designed, digesters can provide solutions for malodour. Real vs. perceived risk will need to be addressed more directly.

> *"From a fragrance perspective, it is our business to make everything smell good, and inviting. This is very important when it comes to creating aspirational toilet experiences, and it is also true for the workers who are tasked with handling the processing of these toilet resources. We believe that there are very interesting business opportunities in addressing malodour through the sanitation value and supply chain businesses."*
>
> - Carlos Almasque, Director Household Care and Open Innovation, Firmenich

3. Security & quality of supply

In theory there should be a reliable supply of toilet resources given that the global population should excrete their "waste" at least once per day. In reality the collection of that "waste", at all, and in a format that can be easily upcycled or reused, has been much more complicated and challenging.

Many businesses in our study had focused their efforts on the treatment of municipally collected sludge, some were also involved in the provision of toilet hardware and collection services. Most cited a volume gap in terms of security of supply, although not insurmountable with adequate investment. Few cited issues of consistent quality of the supply of resources as many have not been measuring this as of yet.

Investment will be required in providing the right toilet hardware and collection systems to ensure the right quality and volume of "waste" extraction.

Industrial sludge is a potential added solution to security and quality of supply and has been virtually un-tapped.

4. Maintenance

With many technologies and businesses models relatively new, there has been little evidence of the requirements for maintenance of the systems and technologies.

In some cases projections have been modelled but remain very uncertain. The pricing and economics will need to be updated to include more accurate projections of maintenance costs (and potential revenue as a value added service).

5. Product improvements vs. current market

The low-income market SME business models explored in this study revealed many promising opportunities for unique value-add and higher performing products in their local contexts. The economics at scale relative to current market offerings will need to be explored further in order to seize these opportunities. The risk is that SMEs lack the capacity and skills to explore and then enter these new areas.

6. Managing the fit with existing economics and incumbents

As in any change process, existing incumbents may be disadvantaged by the Circular Economy for Sanitation, leading to various forms of inertia and resistance. Existing "waste"/resource charges, fertiliser subsidies, and local food supply chains, are examples of established systems which will face such challenge. It will be vital to understand these systems, manage the relevant stakeholder relationships, and where possible build the circular model to enhance rather than compete with incumbents' operations and economics.

7. Failure to monetise externalities

While the Circular Economy approach can enhance revenues and reduce costs, the maximum business potential will be achieved if sanitation businesses can gain at least some reward for their wider impact on society such as health improvements and environmental gains. Since these benefits do not create direct revenue streams, they may depend on other mechanisms – charging fees for services, and for other benefits achieved, perhaps reflecting cost savings that stakeholders see in areas such as healthcare. Where this has to be achieved within government institutions or large utilities, such cross-funding arrangements may be hard to achieve, so new opportunities should also be explored – for example the health information opportunity mentioned above may create new value and new transactions.

Kimberly-Clark: *"There are exciting opportunities for large global companies to work together with small and medium sized companies operating in low-income markets to realise the circular economy opportunities outlined in this report. We are very interested in the new resource and product opportunities that the sanitation value chain could yield in the future."*

- Pete Dulcamara, Vice President, Corporate Research & Engineering

Conclusion

The Role of the Toilet Board

Magnifying opportunity spaces through collaboration

- Business platform - identifying business opportunities
- Brokering breakthrough collaborations between large and small businesses
- De-risking new investments with collective action
- Facilitator of mentorship, partnerships, and investment for sanitation

As the Circular Economy for sanitation system develops, it will take large and small businesses and stakeholders coming together into a vibrant commercial ecosystem for it to succeed at scale. It will take entrepreneurs and innovators with strong local connections, working with leading global corporations, to have new sanitation systems scale quickly and effectively.

The Toilet Board Coalition seeks to provide a business platform focused on identifying, supporting and accelerating business solutions for universal access to sanitation. In the case of sanitation in the Circular Economy, we seek to catalyse a marketplace that helps suppliers and buyers connect. These opportunities exist today in the direct supply of products and energy, and this scope will widen in the future with new innovations – the TBC will work on both. We have found in our study that these connections are not always obvious in terms of natural partners; and are not always easy, in terms of perceived and actual risk on either behalf.

The Toilet Board Coalition can therefore play the role to both make connections to natural partners easier, and to work through current challenges associated with perceived and actual risk.

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