

THE SANITATION ECONOMY at CITY SCALE

A Roadmap For Smart Sanitation In Cities IN PARTNERSHIP WITH THE PUNE MUNICIPAL CORPORATION NOVEMBER 2019



FOREWORD

Digital technologies and data are opening up new ways to re-think sanitation services in cities.

Smart Sanitation Cities have the potential to unleash innovation, economic growth, and development with speed and scale. Mapping and monitoring toilets, treatment and health via Smart City control centres creates new Sanitation Intelligence and a new lens through which to translate citizen and city sanitation needs into targeted solutions and new value creation.

The Business & Sustainable Development Commission's *Better Business Better World* report (2017) places water and sanitation infrastructure in cities amongst the 60 biggest market opportunities related to delivering the Global Goals. Furthermore, its value could be worth at least \$ 12 trillion a year in market opportunities and generate up to 380 million new jobs by 2030 with more than half this value in developing countries.

Many cities lack reliable information about public and community toilet usage; the quality of wastewater and sewage running through the system; and the spread of infectious disease. Monitoring and analysing this data presents new opportunities to provide more efficient and effective public sanitation services in the world's growing cities.

Making this data transparent enables an open innovation platform for businesses and innovators to provide new solutions that will improve the lives of billions of citizens in cities.

New digital technologies - including smart sensors - available today can be placed throughout sanitation systems in a city to provide real-time user, resource and health information that will save the city money and create new revenue opportunities for business. The power of earth observation, satellite imagery and geospatial data can unlock insights that were once invisible.

New data on public and community toilet usage, wastewater and sewage quality and disease circulation can lead to significant savings in sanitation management and health costs in cities.

Sanitation Economy revenue streams can be generated through new public toilet business service models, and the up-cyling of wastewater and sewage into energy, organic fertilisers and reusable water in cities.

New Sanitation Intelligence unlocks significant cost savings and new revenue potential for cities and businesses in toilets, treatment and health.

Smart Cities around the world are applying smart sensoring technologies throughout cities to understand traffic and pollution patterns to improve services. Since 2018, the city of Pune, India, in partnership with the Toilet Board Coalition, has provided an open innovation lab in the city to test available digital technologies that can be applied to public toilets and treatment centres. This has led to the testing of new business models and a first attempt to understand the market potential for smart sanitation approaches.

In this report we share the findings of this two year study. The results are compelling for any city mayor or Smart City business supplier to apply digital technologies to sanitation systems in cities. Globally real-time monitoring of sanitation systems in cities can provide insights into the advancements towards Sustainable Development Goal 6 - universal access to safely managed water and sanitation.

We call on city decision makers to implement new and available digital technologies to monitor public and community toilet usage, quality of sewage and wastewater for up-cycling, and infectious disease circulation and in doing so unlock significant benefits for the city, its citizens and businesses.

Prabhat Pani Rajeev Kher C Senior Advisor Chief Executive Officer Executi TATA TRUSTS Saraplast Toilet Toilet Board Coalition Steering Committee

TATA TRUSTS



Cheryl Hicks Executive Director & CEO Toilet Board Coalition







Every smart city has the ability to map and monitor public and community toilets, sewage treatment centres, bacteria and viruses via Smart City Control Centres.

WHAT IS SMART SANITATION FOR CITIES?

THE DATA STORY

The Sanitation Economy transforms what was once thought an unaffordable cost for cities into scalable business opportunities, offering cities, businesses and citizens sustainable sanitation systems, renewable resources and new Sanitation Intelligence. The Sanitation Economy, when integrated into a Smart City, offers enhanced trust and transparency between citizens, operators and regulatory bodies while boosting the local economy.

A key underlying principle of the Sanitation Economy is that sanitation is not a system apart, but an integral and visible part of wider infrastructure, services, and resource flows. Sanitation can be included in Smart Cities' architecture through data monitoring of public and community toilet usage, sewage treatment operations, infectious disease circulation and other health indicators. These technologies provide unique opportunities for municipal authorities to retain regulatory oversight of their cities sanitation services while partnering with business and investment to build, refurbish, operate and maintain the system.

The Sanitation Intelligence produced from a Sanitation Economy approach within a city enables more efficient and informed decision-making, leading to vital cost savings for the city, better services for citizens and innovative revenue generating opportunities in partnership with the private sector.



Toilet Economy

Smart public and community toilets optimised by environmental, usage and health sensors enable valuable Sanitation Intelligence for city decision-makers, operators, businesses, and users.



Circular Sanitation Economy

Circular sanitation models, applied to Toilet Resource collection and treatment, offset cost of operations with monetisation of the re-use of resources. Metering of Toilet Resource flows enables efficient recovery and conversion to reuse products (i.e. energy, compost and water).

WHAT IS SMART SANITATION FOR BUSINESSES?

Smart sanitation and the digitisation of sanitation systems open up multiple new business opportunities beyond traditional sanitation services. New technologies applied to sanitation enable increased efficiencies, new innovations, environmental sustainability, and direct citizen and consumer engagement opportunities.

Digital sanitation business models create new sources of value. New services are made possible by digital capability, in effect adding value to the toilet itself. Digital technologies help to monetise the value in the Toilet Resources flowing through the sanitation system, and data itself can have value where it is the vital ingredient unlocking new products and services.

Data capture and monitoring throughout the system offers continuous data streams that can be a game-changer, revealing previously unknown information. This feeds new insights such as what is in our Toilet Resources, what they can be used for, where they go after treatment, and what they can tell us about our health. This new information can lead to new products, services, access to renewable resources, and preventative health interventions.



SMART HEALTH

Smart Sanitation Economy

Real-time surveillance for infectious disease circulation via sensors and sampling in public toilets that provide early warning of potential public health outbreaks.



Mapping bacteria, viruses and chemicals, neighbourhood by neighbourhood at the sewage source, we can optimise real-time disease and antibiotic resistance tracking and provide better health policy in cities.



Flood waters are well-known to contain raw sewage and other hazardous contamination posing health threats to water sources. Monitoring of water systems in cities by creating highly sophisticated maps, combined with data inputs can run natural disaster scenarios and response plans - made possible through the power of earth observation, satellite imagery and geospatial data.



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Pune Municipal Corporation

India's cities are embarking on a massive digital transformation. Pune as India's first Smart Sanitation City provides a blueprint for all Smart Cities to fully capitalise on the emerging technologies described in this report to enhance basic infrastructure and achieve optimised and aspirational smart sanitation at the same time.

SCALING UP SMART SANITATION IN CITIES 2020-2025

The Sanitation Economy at city scale is a place where data flows securely between local businesses, government and Smart City officials and citizens, increasing the level of sanitation services provided, creating new and valuable insights and improving the health and safety of the citizens - while saving a city money and growing sustainable local businesses.

Each stakeholder has access to NEW Sanitation Intelligence to inform their decision making whether that be which public toilet to use, where to allocate city resources or where to expand their business.

THE IMPACT STORY - SANITATION INTELLIGENCE IN PUNE, INDIA

TOILET ECONOMY

- Toilet usage
- Toilet cleanliness, maintenance & operations
- Citizen/consumer insights

Environmental and usage sensors are collecting frequency of use, light, temperature, humidity and transmitting to the operator and the city's control centre.

Establishing toilets as Wi-Fi hotspots enables opportunities for consumer and citizen insights and the transmission of educational materials.



CIRCULAR SANITATION ECONOMY

- Oversight of treatment operations and performance
- · Pollution levels in air and water bodies
- · Location of roving collection vehicles

Operations and maintenance sensors are currently tracking tank levels, water flow, water temperature, cleaning cycle status and pump status.

Sensors to track wastewater and sewage quality can provide information about nutrient loads in order to assess the most appropriate re-usage output (i.e energy, organic fertiliser, water).

SMART HEALTH

SMART SANITATION ECONOMY

- Geo-tagged data on disease prevalence throughout the city
- Feedback loops on city interventions around health and hygiene

Tests of sewage from the source provide real-time virus surveillance enabling detection of bacteria and circulating viruses for public health planning.

THE SANITATION ECONOMY AT CITY SCALE

THE ECONOMIC STORY

In a city of 4 million people, 100 % coverage of the Smart Sanitation Economy approaches for public and community toilets can yield up to \$ 58 million in annual revenues and 2 billion litres of Toilet Resources that can be converted into an estimated market of \$ 42 million per year for reuse products (energy, organic fertiliser and water).

100 Smart Cities in India could yield up to \$ 908 million in new market revenues from smart public and community toilets alone.



New markets for digital health applications via smart sanitation still to be fully understood.

Bringing new smart technologies to sanitation systems enables more ambitious levels of services and reach to citizens on a much larger scale which is needed in many cities. Self-cleaning, wifi-enabled, solar-powered, sensor technologies can make good quality toilets safe and accessible to all. Smart Sanitation is not out of reach.





(Ecofys & Toilet Board Coalition, 2019)

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Monitoring the System

Public and community toilet usage Toilet operations and maintenance needs Disease circulation Quality of wastewater and sewage for up-cycling User feedback - cleanliness, experience, needs

THE SANITATION ECONOMY AT CITY SCALE

Benefits

SMART TOILETS

- Improved provision of sanitation facilities (aspirational toilets) leading to an increase in usage
- Better decision making with access to accurate timely data leading to cost reduction in operations
- Employment opportunities

Sensors to track daily:

Public and community toilet usage Volumes of wastewater and sewage collected and up-cycled Quality of wastewater and sewage collected and up-cycled Quality of waterways (rivers, lakes) to detect sewage contamination Bacteria, viruses and chemicals - biomarkers for disease from toilets and sewage Ambient environmental indicators such as light, heat, moisture, from toilet blocks User / customer feedback

Economic: costs and revenues Social: toilet usage, health and hygiene, user satisfaction, ODF status Environmental: safely managed wastewater and sewage; resources enabled (energy, fertiliser, reusable water) Governance: regulatory oversight

Toilets - insights on user behaviour and operational needs Treatment - insights on volume and quality fluctuations; market demand for up-cycled resources Health - insights on disease circulation and response needs

SMART TREATMENT

- Promotes the circular economy principles through resource recovery resulting in overall cost reduction
- Increased environmental sustainability through reduction in pollution levels
- Improved monitoring of treatment facilities
 performance through digital monitoring

SMART HEALTH

- Monitoring of community health indicators
- Identify early warning of disease outbreaks through geo-tagged data to empower appropriate interventions
- Overall reduction on community health
 expenditure through more effective
 preventative measures

NEW MARKETS

- Opportunities for Sanitation Economy
 entrepreneurs to operate and maintain toilets
- Opportunities for tech companies to introduce digital technologies and data services
- Opportunity for development of medical product and service needs of a community
- Increasing access to primary care facilities

Vision

All data from various devices monitoring the sanitation system are integrated with the Smart City's Command and Control Centre.

Dashboards for the decision makers lead to efficient provision of sanitation services, resource recovery, and preventative action on community health, thereby saving costs for the city in the long run and providing improved sanitation services to citizens.

TECHNOLOGY ENABLERS

Digital technologies available today, when applied to sanitation systems, open up vast new opportunities for innovative approaches to safely managed sanitation delivery. Using data captured throughout the system, stakeholders can monitor, manage and respond in real-time.

As the world embarks on a massive digital transformation our ability to fully capitalise on emerging digital technologies and data for sanitation will be one of the leading drivers of sustainable and resilient sanitation systems for the future.



ECONOMIC DATA COLLABORATION

Sustainable Development Goals

There is now abundant evidence that public-private data collaboration can deliver a measurable impact. The results can be seen in faster decision-making during natural disasters and disease outbreaks, better insights on addressing the complex challenges related to poverty, health and employment and more precise indicators to measure the achievement of the Sustainable Development Goals (SDGs).

Data Collaboration for the Common Good Enabling Trust and Innovation Through Public-Private Partnerships World Economic Forum Produced in Collaboration with McKinsey & Company April 2019

http://www3.weforum.org/docs/WEF_Data_Collaboration_for_the_Common_Good.pdf

ENVIRONMENTAL & USAGE SENSORS

Wireless environmental sensors capture data that informs a greater understanding of our environments and how human behavior impacts these environments. Data is time-stamped, place-tagged. obeys common protocols and automatically uploads to a centralised database via low-power Wi-Fi.

TerMITes underpin qualitative environmental observations with ongoing quantitative measurement, gathering real time data on presence and motion detection, humidity, pressure, ambient light levels, motion, carbon dioxide, and temperature. We're trialling them in Pune to better understand their potential for sanitation.

EMPOWER INNOVATION A Pune Example:

In the Smart Sanitation City Project we have piloted the use of off the shelf technologies like footfall counters and customer feedback devices and placed them in the sanitation systems. The real time availability of actual number of users at any given point of time and the related feedback after usage has been immensely useful to the operator of the sanitation space. We found that the usage in pilot locations has more than doubled in a year and the operator is able to address the customer feedback on daily basis by resolving complaints, if any.

DATA VISUALISATION - STAKEHOLDER DASHBOARDS CERN Collaboration Spotting

A dashboard-based visualisation and navigation platform for large and complex datasets, that uses graphs and data abstraction techniques to help experts in converting big data into knowledge and actionable insights.

The Toilet Board is exploring the potential of Collaboration Spotting, a technology developed at CERN, to map the Sanitation Economy Network of stakeholders and beginning to aggregate Sanitation Economy data in an open platform for carefully controlled use by businesses, investors, and governments.

– THE SANITATION ECONOMY AT CITY SCALE –

THESE TECHNOLOGIES ARE AVAILABLE TODAY TO BE DEPLOYED IN SANITATION SYSTEMS IN CITIES AROUND THE WORLD TO FULLY LEVERAGE THE BENEFITS OF SMART SANITATION APPROACHES.













Our tests with robotic sampling technologies in sewer systems have shown that sampling nearest to the source, i.e the toilet, provides the best information in terms of biomarkers for health or the identification of bacteria and viruses circulating in communities for public health response.

Pliit

Eric Alm, Alm Lab MIT



We have been working over the past two years to test digital technologies in public toilets in Pune with an innovative business model: Toilets for Her. Footfall sensors help us to understand the usage levels. Environmental sensors indicating heat, moisture, and odour help to understand operations and maintenance needs, and wifi enabled customer feedback technologies help us to understand the needs and satisfaction of the user.

> **Ulka Sadalkar,** Founder, Ti Bus, Saraplast

) SMART TOILETS

The Sanitation Economy links toilets to a city's data infrastructure. Smart Toilets enable a city and an operator to better understand their stakeholders behaviours and desires – resulting in better services, more toilet usage and revenue generating business models.



Providing a Smart Toilet Community Sanitation Centre and Kiosk for urban and peri-urban slum communities, fortified by vandal-proof stainless steel fabrication. Sensors gather tangible data on user behaviour. They facilitate auto-flush and auto-clean, minimising the number of staff needed. Yet, simultaneously, improving response time for maintenance issues and decreasing operational costs.

A Pune Example:

The Toilet Board Coalition has worked with the Pune Municipal Corporation (PMC) to develop a new vision for public toilets to not only provide better sanitation services to citizens but also capture data on usage, feedback, and environmental parameters like temperature, light, humidity and health indicators. The aim being to reduce the overall operating costs through insightful data on users, their health and environment and also make use of this data to develop more sustainable, revenue generating business models.



FOCUSED ON WOMEN -Ti Centres

Ti Centres (Ti), by 3S India, provide women and girls with exceptionally clean public toilets in Pune. The toilets are refurbished from old buses and positioned above existing sewerage and water infrastructure underground. They employ a female attendant who ensures the toilets are clean and safe. Ti have experimented with a range of revenue generating possibilities and have found that a combination of revenues from toilet usage, sales from a small café kiosk and external advertisement are sufficient to cover their operating costs especially in recreational areas such as parks. This is the sweetspot combining profit and impact: delivering a vital sanitation solution while maintaining a sustainable business.



Suvidha PUBLIC TOILET CENTRE -

Developed through local consumer insights, Unilever, with the support of Municipal Corporation of Greater Mumbai and Pratha Samajik Sanstha, built the Suvidha Centre in Mumbai in 2016. It is a pay-per-use toilet facility. The centre also offers a laundry facility, which has been one of the main revenue drivers, while releasing time for women in the community to pursue productive tasks. Grey water from the laundry is treated and used for toilet flushing, reducing the overall water footprint. Users can also utilise shower facilities, and safe drinking water through vending machines. The Centre also provides job opportunities to the local community, employing eight people per centre



SMART TREATMENT

For many cities looking to implement or improve their sanitation offering it is the treatment portion of the picture that becomes the most expensive and challenging. The Toilet Board Coalition advocates for a 'new grid' approach which builds on existing infrastructure and combines sewered solutions (if they already exist) with innovative new decentralised models for collection, realigning the flow of nutrients, energy, capital and data.

Imperative in the Sanitation Economy approach is the safe collection of Toilet Resources and transformation of the waste into valuable resources that can then be sold back to cities and industries.

The introduction of smart technologies to this system not only enables key operational efficiencies but can give cities the regulatory strength through shared data feeds to ensure they are providing, through the market, appropriate services to their citizens. The Toilet Board Coalition has developed a Sanitation Economy Toolkit for cities and industries looking to assess their resources and the best path forward.

A Pune Example:

The Toilet Board Coalition worked with the city to identify the size of market for Toilet Resource derived products and provided the city with a list of business solutions for setting up decentralised sanitation systems and technological options for processing the sludge from the existing STPs. Pune has committed to buy back half of the processed water, and agreed to make changes in its policy to make it mandatory for industries to use treated water. Pune's Baner Sewage Treatment Plant is running the SCADA System and remotely monitoring: tank levels, water flow, water temperature, cleaning cycle status and pump status, which are currently being integrated with the Smart City's Command and Control Centre.



"While digitisation of wastewater treatment has a track record in many cities for operations optimisation purposes – applying digital technologies to toilets to optimise user experience, and to Toilet Resources to optimise resource up-cycling and health is something that should make all cities stand up and take notice for the new benefits it can provide." –

– Johann Clere, Veolia 🛛 😡 VEOLIA



SATELLITE DATA ON AIR & WATER POLLUTION - SatSense

SatSense – provides effluent monitoring in rivers and water bodies through earth observation and AI technologies. Based on Inherent Optical Properties (IOPs), water characteristics like total suspended matter (TSM), chlorophyll-a concentration (CHL) and colour dissolved organic matter (CDM) are assessed. Rivers near urban areas with relatively high TSM & CDM provide a good indication of effluence and untreated sewage.



BIOMASS

REMOTE MONITORING -

Biomass Controls kelv°n App

A decentralised waste management and resource recovery solution based on the pyrolysis technology that is scalable with real-time monitoring and control capability through the kelv^on mobile application. Biomass Controls has developed a mobile app that allows itself (and its clients) to monitor, in real-time, in one view, machines in different locations.

SMART HEALTH

Technological advances around preventative care and precision medicine are converging and moving us to greater and more patient-centric health systems. Sanitation systems can provide routine data collection and health monitoring tools, all while creating new value for the sanitation system and shifting disease outbreak responses from reactive to preventative.

Crucially, health data from sanitation becomes an earlywarning system for disease outbreaks, driving faster, better response systems for city governments. Current operating procedures and business models are still relatively new and unproven. But the evidence shows that a more efficient and effective health service is possible.

A Pune Example:

Over two thirds of the Pune's sickness related hospital visits in 2018 were for diseases that can be diagnosed through smart sanitation – installing systems that can give cities, health professionals and ultimately citizens this information in a faster and simpler way will help primary care facilities and physicians work more effectively.



WORLD ECONOMIC FORUM

THE INTERNET OF MEDICAL THINGS (IoMT)

The internet of medical things (IoMT) is a healthcare application of IoT technologies and envisions a network of connected devices that sense vital data in real time. The burgeoning of IoMT has been enabled by the development of wireless sensor-based systems, nanotechnology and miniaturisation. It is now possible to join the dots between personal digital devices, connected medical devices, implants and other sensors. It means sensors collect data, microcontrollers process, analyse and wirelessly communicate data, and microprocessors enable rich graphical user interfaces. IoMT now has an established role in a broad range of healthcare applications to support clinical decisions, reduce incorrect diagnosis, improve quality of services through the management of chronic diseases and monitoring of hospitalised patients.

World Economic Forum, Health and Healthcare in the Fourth Industrial Revolution, 2019

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Underworlds UNDERWORLDS PROJECT

A vast reservoir of information on human health and behavior lives in our sewage, but this vast resource remains untapped. We envision a future in which sewage is mined for real-time information that can inform policy makers, health practitioners, and researchers alike. The Underworlds Project is an innovative, open, cross-disciplinary data platform for monitoring urban health patterns, shaping more inclusive public health strategies, and pushing the boundaries of urban epidemiology.

The Underworlds Book, Massachusetts Institute of Technology, 2019

CALL TO ACTION HOW CITIES CAN GET STARTED

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STEP 5: Invite business and innovators to the development of an innovation lab to create new solutions for sanitation delivery and experience, via smart sanitation approaches

STEP 4: Smart sanitation policy recommendations

STEP 3: Wastewater and sewage treatment plants apply sensors to capture volumes of wastewater and sewage - monitoring waste contained. Apply sensors to identify quality of wastewater and sewage - to optimise recycling options

STEP 2: Public and community toilets apply sensors to capture footfall daily - monitoring toilet usage. Apply sensors to monitor moisture, heat, odour, and cleaning for operations and maintenance. Apply sensors to identify infectious disease circulation monitoring public health and response.

STEP 1: Map all public & community toilets, wastewater and sewage treatment sites to the Smart City Control Centre via geolocating technologies and monitor in real-time

About the **TOILET**

Established in 2015, the Toilet Board Coalition (TBC) is a business-led partnership platform with the goal to accelerate the transition to the Sanitation Economy. Our ambition is to transform sanitation systems from unaffordable public costs into robust marketplaces of sustainable business value.

The TBC is facilitating private sector engagement; large company - small company partnerships; and publicprivate collaboration to contribute to the achievement of Sustainable Development Goal 6 - universal access to water and sanitation.

We run the Toilet Accelerator, the world's first accelerator programme dedicated to Sanitation Economy business solutions that are smart, circular, and resilient to address the unmet sanitation needs of the world's most vulnerable.

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



LEARN MORE AND DOWNLOAD AT WWW.TOILETBOARD.ORG

