Integrated Functional Sanitation Value Chain

The Role of the Sanitation Economy

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Meet the editors

Dr. Peter Emmanuel Cookey is a Chief Lecturer with the Rivers State College of Health Science and Management Technology, Port Harcourt, Nigeria. He received his PhD in Environmental Management from the Prince of Songkla University, Hat Yai, Thailand. For the past 28 years, Peter has served as a higher education lecturer, trainer, speaker, magazine publisher, writer and sanitation professional, and co-authored the IWA Publications book *Regenerative Sanitation: A New Paradigm for Sanitation 4.0* and also contributed a chapter (Safe-Sanitation: Adaptive-Integrated Management Systems (SAIMS): A Conceptual Process Tool for Incorporating Resilience) in the book *Water, Climate and Sustainability* published by Wiley. He teaches postgraduate classes and mentors research as Adjunct Lecturer with the Institute of Geoscience and Environmental Management, (IGEM), Rivers State University, Nigeria; worked as a Senior Lecturer/Researcher on non-sewered sanitation with the IHE Institute of Water, Delft, Netherlands and a Senior Research Specialist with the Asian Institute of Technology (AIT), Bangkok, Thailand. Peter also trains future sanitation professionals at bachelor level on water, sanitation and hygiene courses to prepare them for work, entrepreneurships and research in the sector. His interdisciplinary academic background, covering health, environment, science, technology and governance, supports a versatile work experience in the private and public sectors covering governance, regulations, impact assessments, monitoring and evaluation, research, academic work, consulting/training and on global water and sanitation entities such as the Water Supply and Sanitation Collaborative Council (now the Sanitation and Hygiene Fund) in Geneva as well as being a pioneer member of the International Standard Development Committee of the Alliance for Water Stewardship team that developed and delivered the first global water stewardship standards. He also initiated and facilitated the Rivers State Water and Sanitation Sector reforms and co-chaired the drafting of legal and governance instruments for water and sanitation in the State. All of these experiences, along with being the co-Founder of the EarthWatch Research Institute (a non-profit) of Nigeria, co-Publisher of the *EarthWatch Magazine* and co-Convener of the EarthWatch Conference on Water and Sanitation, give Peter

an in-depth and comprehensive perspective on the core issues of sanitation with personal and rich insights. You can find Peter's many academic articles such journals as *Humanities and Social Science Communications* (Nature); *Journal of Water Sanitation and Hygiene for Development* (IWAP); *Journal of Ocean and Coastal Management* (Elsevier) and *Ecological Indicators* (Elsevier); *Lakes & Reservoirs: Research and Management* (Wiley); *Hydrology* (MDPI); and *Journal of Water Resource and Hydraulic Engineering* (World Academic Publishing).

Dr. Thammarat Koottatep is Professor of the Environmental Engineering Management in the Asian Institute of Technology (AIT), Thailand. He is an internationally recognized professional on faecal sludge management, sustainable sanitation systems, nature-based technology for waste and wastewater treatment, and water reuse technology. His major scholarly contributions include publications of more than 60 refereed international journal papers, 3 books, and 9 book chapters. He has invented several toilet and sanitation technologies, one of which is patented to his credit, and several are filing. He has jointly developed professional master's degree programs in regenerative sanitation and marine plastics abatement. He has secured significant funded projects including, research and training grants, and most notably, the Bill & Melinda Gates Foundation grants on "Decentralized Wastewater Management in Developing Countries: Design, Operation and Monitoring" and "Development of Fecal Sludge Management Toolbox". He has contributed significantly to capacity building in faecal sludge management and decentralized wastewater treatment systems in Thailand and abroad, including capacity strengthening for experts, planners, and policy makers.

Dr Walter Thomas Gibson studied Natural Sciences at Corpus Christi College, Cambridge and went on to take a PhD in Medical Biochemistry at the University of Manchester. He subsequently had a long career in industrial R&D with Unilever, mostly at the interface between research, product development and marketing, as a scientist, R&D leader and resource manager. He worked at the Colworth and Port Sunlight laboratories in the UK, as well as the Hair Innovation Centre in Compiegne, France, and Unilever Technology Ventures in San Francisco. His major achievements were building a hair growth research programme, helping to launch the organics brand, reshape Unilever's corporate research strategy and establish an effective research capability in China. In these roles he worked closely with Unilever brand and technical leaders across the world and was also closely involved in major external partnerships with leading universities. His final role in Unilever was as Head of Biosciences for Home and Personal Care, during which time he interacted closely with the hygiene group at the London School of Hygiene and Tropical Medicine (LSHTM) and became closely involved in Unilever's external partnership with UNICEF. These experiences generated a strong desire to use what he had learnt in consumer-led

innovation to help address the lack of new products in hygiene and sanitation, and in 2007 he set up Bear Valley Ventures to help catalyse innovations in these areas. He became a visitor at LSHTM under the guidance of the late Professor Val Curtis and this led to him directing a major research and innovation project in on-site sanitation (funded by a grant from the Bill & Melinda Gates Foundation to LSHTM) in 2009–2012. This resulted in two innovations to improve sanitation in low-income settings: the Tiger Toilet and the use of black solider fly (BSF) larvae to treat human faecal waste. He has since worked closely with a range of organisations in several countries to help develop and take these innovations to market.

Dr. Chongrak Polprasert is currently Professor of Civil and Environmental Engineering at the Thammasat School of Engineering, Thammasat University, Thailand. He received his Ph.D. in civil and environmental engineering under a Fulbright scholarship from the University of Washington, Seattle, USA, and began his career as Research Assistant at the International Development Research Centre in Ottawa, Canada, working on a low-cost sanitation and resource recovery project with the World Bank. Professor Polprasert was a faculty member at the Asian Institute of Technology (AIT) during 1997–2009, held the AEON Group Chair of Environmental Engineering during 1991–1995 and was Dean of the School of Environment, Resources and Development from 1996 to 2005. He was appointed as Director and Professor at the Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Thailand, during 2009–2012. His research during the past 40 years has been in the areas of sanitation, waste reuse and recycling, and hazardous waste engineering and management. He has supervised over 120 master's theses and 23 doctoral dissertations conducted by international students. Professor Polprasert has published more than 120 papers in international refereed journals, in addition to conference and workshop proceedings. He is the author of the IWA Publishing book *Organic Waste Recycling – Technology and Management*, now in its third edition. Professor Polprasert has served in the US National Academy of Sciences panel on productive utilization of wastes in developing countries and the Water Environment Federation task force on natural systems for wastewater treatment. Professor Polprasert was the recipient of the Biwako Prize for Ecology (Japan), Outstanding scientist award (Thailand), Thailand Research Fund publication award, Outstanding researcher award in engineering and industry (Thailand), elected fellow of the Graduate School of Engineering, the University of Tokyo, Japan, fellow of the Royal Institution, Thailand, and listed in World's Top 2% Scientists (Career category). He has served as visiting professor/scholar at the United Nations University; the UNESCO-IHE Institute for Water Education, Delft, the Netherlands; Lulea University, Sweden; Tohoku University and Kyoto University, Japan. The above works have led Professor Polprasert to a number of appointments to committees and advisory bodies in both Thailand and abroad.

Meet the contributors

Dr. Olufunke Cofie is the West Africa Regional Representative for the International Water Management Institute (IWMI), responsible for leading IWMI's research in the sub-region. She is also the Flagship Lead for Water and Land Solutions, CGIAR Research Program on Water, Land, and Ecosystems. Her research is on water and sanitation linkages to agriculture and smallholder agricultural water management, counting over 20 years of field experience in international development research. She co-developed a waste-based soil ameliorant marketed in Ghana. In addition to her scientific research capacity, she has held research leadership positions for about 15 years. She has also consulted for international organizations, including the World Bank, UNEP, IFAD, and International NGOs, and serves on several Scientific Committees and Management Boards. A former university don, she holds a PhD in Soil Science and a Master's degree in Business Administration. She has published over 100 scientific articles through diverse outlets.

Jack Sim, a.k.a. "Mr Toilet", founded the World Toilet Organization in 2001. In 2013, 19 November was designated as UN World Toilet Day – the day is now celebrated globally each year to raises awareness of the need for action to end the sanitation crisis. Jack Sim became a Schwab Fellow of the World Economic Forum in 2005, Ashoka Global Fellow in 2006, and named a Heroes of the Environment for 2008 by Time Magazine. Jack broke the global taboo around toilets and sanitation by bringing it to centre stage with his unique mix of humor and serious facts.

Mayowa Abiodun Peter-Cookey With a childhood poring over encyclopaedias and ancient history books as her leisure activity, Mayowa Abiodun Peter-Cookey has been on a quest for knowledge and what it is capable of for a long time. Years later, a Bachelor in Philosophy degree gave her the foundation she needed for this quest for knowledge and learning; pairing this with her passion for writing and knowledge transfer, she launched the EarthWatch Research Institute, Nigeria with her husband and others, where she served as Administrator of the EarthWatch Conference on Water and Sanitation and co-Publisher/Chief Editor of the *EarthWatch Magazine* and co-Convener of the EarthWatch Conference on Water and Sanitation. The focus of most of her work has been water and sanitation and after 20 years of consulting and training in the sector and a Master's of Science in Human and Social Development that explored the concept of skill upgrading for informal workers, she has turned her attention to knowledge and skill capacity upgrades to improve sanitation conditions as her doctorate pursuit. Mayowa is a part-time lecturer with the School of Foundational Studies, Rivers State College of Health Science and Technology, Nigeria where she taught students of the School of Medical Sciences introductory courses in Philosophy and Logic. She has published articles on skill upgrading and co-authored book chapters on resilient sanitation and lake basin management and conference paper on sanitation education; and is a silent partner in many other writing projects upon which she hones her skills. She is the patient and content wife of Peter Cookey and proud mother of Hadassah, their precocious two-year-old.

Dr Harinaivo Anderson Andrianisa is Associate Professor of Water and Environmental Engineering with 22 years of experience in project management, R&D, consultancy, education and capacity building related to water, sanitation and environmental issues in sub-Saharan French speaking countries, principally West Africa and Madagascar. He joined the International Institute of Water and Environmental Engineering (2iE) in Burkina Faso in 2012 as Senior Lecturer of Urban Water and Sanitation. Now Head of the Water, Sanitation and Hydro-Agricultural Development Engineering Department, his interests are focused on pro-poor water/wastewater technologies and sustainable services, water and soil pollution in watershed affected by artisanal mining, circular economy and urban mining. Prior to joining 2iE, he was the Managing Director of a consulting company in Madagascar. Dr Andrianisa was an ERASMUS+ Fellow in 2019, a Japan Government Mobukagakusho Fellow from 2002 to 2008, and a Japan Society of Civil Engineers Research Prize winner in 2006. He is actively involved in various professional network including the Global Sanitation Graduate School initiative. He is married with three children.

Asengo Gerardin MABIA is both a Water and Sanitation and Agronomist Engineer. Junior Water and Sanitation Consultant at the International Institute for Water and Environmental Engineering (2iE) since 2021, He obtained his Master's degree in Water, Sanitation and Hydro- Agricultural Development Engineering at 2iE in 2021. He is currently working in technical support and organizational capacity building of small and medium enterprises in the WASH sector in Burkina Faso, at 2iE Incubator. He has been involved in many studies on faecal sludge management in Burkina Faso using a value chain approach and inclusive urban sanitation such as "Scoping study and rapid needs assessment for the establishment of a Capacity Hub network for inclusive urban sanitation in four (4) West and Central African Francophone countries: case of Burkina Faso" and "Reconceptualization and rethinking of the Facility Integration, Installation and Construction stage of the sanitation value chain (SVC): a case study in Burkina Faso". One of his main drivers is to advance access to sustainable sanitation in developing countries.

Mahugnon Samuel AHOSSOUHE is a Water and Sanitation Engineer. He obtained his Master's degree in Water, Sanitation and Hydro-agricultural Development Engineering from the International Institute of Water and Environmental Engineering (2iE) of Burkina Faso in 2021. Mr. Ahossouhe worked as a Technical Assistant Trainee at the Drinking Water Treatment Department of the National Office of Water and Sanitation (ONEA) in Burkina Faso. He did his end of training internship at the Department of Water, Sanitation and Hydro-Agricultural Development Engineering at 2iE and wrote his master's thesis on the 'Reconceptualization and Rethinking of the "Sanitation Services" stage of the "Sanitation Value Chain (SVC)": a case study in Ouagadougou, Burkina Faso'.

Foreword

2021 was the 10-year anniversary of the International Faecal Sludge Management (FSM) conference. What started off as a small conference in Durban, South Africa has become a growing field focused on non-sewered sanitation. Seeing the progress that has been made over the past 10 years is something to be celebrated – the advances in research, tools, frameworks, and knowledge exchange have shown us the need for expanding the types of sanitation technologies, but also that in 2022 two-thirds of the world's population are still without access to safely managed sanitation.

The initial deadline for the UN's Sustainable Development Goals was set for 2030, which is now just 8 years away. As the sanitation field has grown and adapted, so must our reference point and research. This book helps to bridge the complex nature of the sanitation value chain to bring a holistic and integrated view of the multiple and different actors involved in creating safely managed non-sewered sanitation. We have so often approached development issues as singular issues, creating silos.

The recent global COVID-19 pandemic caused a lot of the world to quickly shift their thinking, and what we at the FSM Alliance observed was how many of our established ways of thinking and our approaches showed the limitations of the silo approach. While Deepak Chopra has been viewed as controversial at times in the medical community, I found this quote on how we move forward very relevant to how we have viewed sanitation in the past:

> . . . *We use reductionist mental models that break up complexity into small pieces to examine the components of things at ever finer levels of granular detail – hoping we can put them back together coherently. But escalating crises prove we have exhausted the usefulness of this paradigm. Almost every major challenge humanity is facing, from cancer and climate change to food and consciousness, needs complex systems thinking to solve.* Chopra, D. (4 May, 2021) To survive our technological transformation, civilization needs a cognitive revolution. Yahoo Life. https://www.yahoo.com/lifestyle/deepak-chopra-survive-technological-transformation-civilization-needs-cognitive-revolution-154120760.html?guccounter=1

The current sanitation problem has largely been approached as a technical problem and it has been largely engineers approaching the issue from that perspective. Our failure to provide improved access to sanitation has been mostly viewed as not having the right technical solutions.

Scientific American recently published an article written by an engineering student, Grace Wickerson, on the limitations of looking at the world's problems from only an engineering perspective or viewed from the framework of

> *"technical-social dualism, the idea that the technical and social dimensions of engineering problems are readily separable and remain distinct throughout the problem-definition and solution process*." Wickerson, G. (24 February, 2022) The Culture of Engineering Overlooks the People It's Supposed to Serve. Scientific American. https://www.scientificamerican.com/article/the-culture-of-engineering-overlooks-the-people-its-supposed-to-serve/

There are numerous nontechnical parameters that must be considered when thinking about sanitation planning.

The City-Wide Inclusive Sanitation (CWIS) framework has also pushed our sector to expand out from purely an engineering point of view.

> "*With its focus on equity, a CWIS approach challenges investment and service delivery norms that have excluded many communities and marginalized groups from safe sanitation facilities and services. A CWIS approach includes their interests and voices as core objectives of and resource for planning, design, and implementation of services*." The Bill & Melinda Gates Foundation. (Undated). https://cwiscities.com/#cwismle https://s3.amazonaws.com/resources.cwis.com/learning/88/BMGFCWISFactsheet.pdf

All three of these examples represent vastly different industries, but the core theme is the need to expand our approach and use a more complex systems thinking approach. This type of integrated systems thinking will be necessary as the threats to our modern world continue to ignore the neatly drawn paradigms we've built in the past to categorize and respond to societal challenges.

This new publication and the new Integrated Functional Sanitation Value Chain (IFSVC) helps to address this issue by expanding the paradigm that we have used to approach sanitation solutions, with a focus on the role that both public and private entities will need to play. This book expands and operationalizes the CWIS framework by helping to translate into a new approach that looks at stakeholders that have not been included in the past. Chapter Two also begins with an emphasis on starting with consumer insights and how this has been overlooked in the past, particularly for low–middle income countries, and that not following human-centred design principles can have serious consequences, such as "*[w]ithout following a process like this there is a real risk that solutions will fail to have the impact they are intended to deliver, either through lack of demand or lack of use or both, even if they function well technically*". It also identifies that this is a non-linear approach, just like much in our human daily lives. The new IFSVC also includes chapters on sanitation advocacy, management systems, incorporates the role of the private sector, and the circular sanitation economy. Expanding to include these topics helps everyone involved in sanitation to shift their thinking and therefore designing solutions for an ecosystem and not just a singular technical issue.

The FSM Alliance is optimistic about the changes in our thinking that this book advocates for and is committed to helping advance this new expanded paradigm as we draw closer to 2030. We would also like to congratulate and thank the lead authors and all the contributing authors involved in the creation of this new approach to the sanitation value chain.

Jennifer Williams
CEO, FSMA

Foreword

When Peter Cookey and the author team reached out to the Toilet Board Coalition with the concept of this book in 2020, we were delighted to support. We can't help but think back to the humble launch of the sanitation economy framing in 2017 at SIWI's World Water Week in Stockholm. Our members, including leading businesses, investors and development organizations in the sector had pioneered this thinking in the founding of the Coalition in 2015 and to see it represented at World Water Week felt catalytic. Since that day, we have been fortunate to welcome thousands of innovative thinkers across our platforms to learn about the untapped value and opportunities of the sanitation economy.

In 2020, at the onset of the global COVID19 pandemic we sat (virtually) with Peter to walk through the vision of this book, the voices and breakthroughs that could feature in it and the impact we could jointly envision this piece to realise. To see and read the full piece in its fruition is an immense credit to the remarkable efforts of Peter Emmanuel Cookey, Thammarat Koottatep, Walter Thomas Gibson, Chongrak Polprasert and their contributing authors. Here, we again feel an electric buzz, this time of a tipping point being reached in our sector.

We are thrilled at the global uptake of the sanitation economy framing over the last five years. This book, illustrating the stakeholders, roles and processes of the sanitation economy adds rich detail for local and national advocates interested to grow thriving sanitation economies in their communities. The authors demonstrate wonderful breadth of understanding and expertise on the sanitation economy and the power of an integrated, functional approach to the value in sanitation systems. We anticipate this book to rapidly be looked to as foundational literature for those pursuing careers in the sanitation landscape.

What we see when we look at sanitation, much like the authors, is a landscape of value – anchored in consumer relationships, renewable resources, impactful data and information about public health. We see an industry centred on human interaction, protecting and nurturing our planet. This is the philosophy behind why we were founded, to uncover and showcase the value in sanitation services and product provision. The

framing of business opportunities and a global marketplace of sanitation-related services and products – the sanitation economy - was an organic next step.

The book's objective, to direct attention towards building an expansive Integrated Functional Sanitation Value Chain, giving birth to sanitation economies around the world, is superbly aligned with our values. Since the introduction of the sanitation economy framing, we have seen a dynamic shift in the understanding and value of market-based approaches to sanitation. Individuals in the important roles of advocacy, knowledge management and the enabling environment around these markets have increasingly understood the importance of this approach. Consequently, support from leaders and the donor and investment sector is now coming into alignment. The 2021 WHO/Unicef JMP report outlined that a quadrupling of progress is needed to achieve SDG6 on time – acceleration likely only to be achieved through strategic catalytic investment that moves beyond traditional funding models and brings innovative financing and private capital into the sanitation economy. As we globally learn how to work better with private sector stakeholders of all sizes in this sector, we will come to embrace not only their financial support but also their insights, wisdom and very importantly, their skills. The outlining in this book of roles and potential influences scoped for each stakeholder group of the Integrated Functional Sanitation Value Chain is an important step towards recognising and harnessing the unique value and impact that each individual in the IFSVC can bring.

We know Peter Emmanuel Cookey, Thammarat Koottatep, Walter Thomas Gibson, and Chongrak Polprasert's work here will further advance understanding and alignment across the sector. The concept of IFSVC enables academics and practitioners of a breadth of professions and studies to grasp the vast opportunities of the sanitation economy and an Integrated Functional Sanitation Value Chain. The inclusive and integrated approach presented in the following pages sets the stage for improved operations and facilitated relationships across and throughout the value chain, thus inviting greater engagement and accelerated progress.

We are routinely encouraged and emboldened by the success we see emerging around the world; the businesses at the heart of the sanitation economy that are growing two, three, four times faster than they were five years ago; the investment we see flowing into the sanitation economy in a more catalytic, informed and sustainable way; the re-prioritisation among leading donors to focus on market-based approaches and private sector engagement. We are learning and we are accelerating.

Alexandra Knezovich
Managing Director
Toilet Board Coalition

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Preface

The concept of the integrated functional sanitation value chain (IFSVC) was proposed from our previous book on *Regenerative Sanitation: A New Paradigm for Sanitation 4.0* (section 6.3), based on the need to track the sanitation value chain (SVC) from stages of product design and development, manufacturing/production, facility integration, installation and construction, sanitation services, sanitation biomass recovery and conversion, marketplace and sales, sanitation advocacy, sanitation management knowledge, and governance as well as a system of enabling environment. The need to rethink the SVC has become necessary in order to provide better information and comprehension of the firms, businesses, enterprises and organizations that operate within the sanitation industry from input suppliers to the end market buyers. Through the development of efficient and effective IFSVC, the sanitation sector could enhance the achievement of the SDG 6 and foster the generation of additional finance, income, and employment for different groups who engage along the value chain, and in so doing contribute to other SDGs. IFSVC development building on entrepreneurial dynamics could improve safely managed sanitation services, competitiveness and value addition.

While integrated and functional safely managed sanitation services and poverty reduction constitute the goals of the IFSVC, clearly achieving this will require improvements in the operation and interactions of sanitation businesses, firms and enterprises. Production and service delivery is the philosophy that guide the objectives of this book. Thus, the IFSVC enables businesses and enterprises to evaluate their processes so that they can provide the greatest opportunities to reduce operational costs, optimise efforts, eliminate waste, and improve health and safety, as well as increase profitability. The concept of IFSVC enables the academicians, professionals, practitioners, businesses and entrepreneurs to see mixed economic, environmental and social gains not realized by the traditional sanitation value chain, thus bringing a much wider range of companies and other stakeholders into active engagement with sanitation systems and services. With this approach sanitation can also provide some solutions for water security, energy security, food security and health.

This book explores concepts, frameworks, principles and practical case studies that support and represent an IFSVC for sewered and non-sewered sanitation systems. The authors and contributors identified and examined practical and operative linkages within a systemic loop that capture various functions at different stages of activities within different enterprises and production/service processes related to sanitation management and economy from design and production to final market and user. This involves

enterprises and ventures within each stage of the IFSVC as well as those businesses directly and/or indirectly involved with providing safely managed sanitation services/products across the local, national, regional and global supply chain and in particular communities where they operate. The focused intention is to direct thinking towards building an expansive SVC that supports the growth of the sanitation economy. Also, this book showcases up-to-date research findings to support the concepts, frameworks, and principles presented therein, and also applicable cases that highlight leading sanitation and related businesses, education and research organizations as well as global supply chain ventures involved in the provision of safely managed sanitation products, services and facilities; and do so from the IFSVC perspective.

The structure of the book is inter- and trans-disciplinary and is made up of ten chapters aiming to come in handy as a tool that provides guidance on defining elements necessary for the development and upgrading of SVC to IFSVC. This book provides effective and efficient learning material and the book is active in its presentations in that it helps the user/reader to practice what was learnt. The **Chapter Objective** introduces the user/reader to the focus of the chapter. The **Take Action** section challenges the user/reader to do something with the knowledge gained. The section on **Journal Entry** helps the user/reader to review issues in an objective manner and to make notes that can be referred to at a later date. The **Reflection** section focuses on the ability of the user/reader to analyze and interpret the issues raised based on facts and the real situation on the ground. The **Guiding Questions** section provides learning exercises for the user/reader to further improve their knowledge, skills and competency. It is hoped that all these sections will challenge the minds of users/readers of this book enough to find answers and solutions in areas where they never existed before.

Chapter 1 introduces the readers to the concept of the integrated functional sanitation value chain (IFSVC) and its relationship to sanitation economy. Chapter 2 highlights the need to identify innovations to generate higher value end-products that would transform the economics of the final stage of the chain and drive closer integration. Chapter 3 raises the case for manufacturers in developing and developed countries to become more integrated into the sanitation manufacturing value chain in order to drive demand and affordability. Chapter 4 provides a detailed insight into the complexity of integration, installation and construction services. Chapter 5 emphasizes the importance of extending public–private partnerships, and improved coordination of all the actors in service delivery. Chapter 6 focuses on sanitation biomass recovery and transformation by enhancing resource recovery and reuse in a circular sanitation bioeconomy. Chapter 7 gives an indication of the size of the sanitation market and requirement for growing the sanitation economy. Chapter 8 focuses on sanitation advocacy business models that support a common cause by creating high social impacts with a sizeable market for sanitation products and services. Chapter 9 reveals how building a strong foundation in sanitation knowledge management could cope with the complex dynamics inherent in the sector, as this is vital to unlocking value across the IFSVC. Finally, Chapter 10, stresses the importance of strengthening linkages between all actors and stakeholders, along with the role that governance can play. Attempts to address these challenges will require the transformation of the sector to a more economically viable state, especially for the non-sewered parts of the sanitation spectrum. In conclusion, companies, entrepreneurs, enterprises and all stakeholders need to map and understand their sanitation business value chain to be able to make the best of the sanitation economy.

The principal audiences for this book include undergraduate and graduate students of sewered and non-sewered sanitation, environmental and biological sciences, environmental and public health, community health, engineering, and emerging sanitation management as well as researchers, professionals, practitioners,

advocacy-agents, regulators, knowledge providers, policy makers and solution providers in related fields in both developed and developing countries. This book can be used as a textbook to teach; a resource for research; a reference for professionals and practitioners; and for planning and implementation of sanitation solutions; advocacy and intervention; developing, sharing and managing sanitation knowledge, as well as developing and implementing institutional and regulatory frameworks.

This work was written within a year and half and relied on the direct and indirect support of many people. We are grateful to Jennifer Williams of the Faecal Sludge Management Alliance (FSMA) for their supporting this book for online open access and agreeing to do write a Foreword for this book. We are also grateful to Daigo Ishiyama of LIXIL, Babitha George of Quicksand, Marc Lewis of the BioCycle, David Auerbach and Sheila Kibuthu of Sanergy, Eduardo Perez of Global Communities, Alison Parker of Cranfield University, Sejal Tembwalkar of 3S India, Claire Furlong of IHE-Delft, Geoff Revell of WaterSHED, Atitaya Panuvatvanich of Asian Institute of Technology (AIT), John Sauer of PSI, Jim Lane of Sanivation, and Ling Tao of US National Renewable Energy Laboratory (NREL) for their input, comments and image provision. Significant contributions by Mayowa Abiodun Peter-Cookey, EarthWatch Research Institute, Port Harcourt, Nigeria are also appreciated.

We would like to express our sincere appreciation to Mark Hammond of IWA Publishing, London, and the entire IWA staff for their professional support in the publication of this first edition.

Peter Emmanuel Cookey
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Port Harcourt, Nigeria
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Abbreviations and symbols

Abbreviations	Meanings
ABHS	Alcohol-based hand sanitizer
ASPs	Activated Sludge Plants
AD	Anaerobic digestion
AW	Agricultural waste
ASSC	Augmented sanitation service chain
BoP	Base-of-Pyramid
BMGF	Bill & Melinda Gates Foundation
BOL	Beginning of life
CAGR	Compound annual growth rate
CEPTs	Combined Effluent Treatment Plants
CBS	Container-based sanitation
CoPs	Communities of practice
CSR	Corporate social responsibility
CSE	Circular sanitation economy
CE	Circular economy
CBE	Circular bio-economy
Covid-19	Coronaviruses
DBO	Design-build-operate
EWP	End Water Poverty
ETPs	Effluent Treatment Plants
EOL	End-of-life
EU	European Union
FPW	Fermentation processing waste
Forestry residue	Forestry residue
FW	Food waste
FS	Faecal sludge

FSTPs	Faecal sludge treatment plants
FSM	Faecal sludge management
GHGs	Greenhouse gases
GoI	Government of India
GVCs	Global value chains
HTL	Hydrothermal liquefaction
HTC	Hydrothermal carbonization
IFSVC	Integrated functional sanitation value chain
ICT	information communication and technology
IC	Intellectual capital
IYS	International Year of Sanitation
KA	Knowledge Application
KAD	Knowledge Acquisition/Capturing
KE	Knowledge Evaluation
KSR	Knowledge Storage and Retrieval
KCD	Knowledge Creation and Development
KD	Knowledge Dissemination
KP	Knowledge Protection
KM	knowledge management
KMS	Knowledge Management System
KR	Knowledge resources
KI	knowledge innovations
KE	Knowledge Economy
KIFs	Knowledge intensive firms
KIOs	Knowledge intensive organisations
KIBSFs	knowledge intensive business services firms
KISA	Knowledge Intensive Services Activities
KIS	Knowledge Intensive Services
KIAs	Knowledge Intensive Activities
KVC	Knowledge value chain
KExps	Knowledge experts
KEnts	Knowledge entrepreneurs
KWers	Knowledge workers
LB	Lignocellulosic biomass
LM	Livestock manure
MTA World	Mondragon Team Academy
MPW	Marine processing waste
MDGs	Millennium Development Goals
MSEaP	Manufactured sanitation equipment and allied products
MOL	Middle-of-life
MNCs	Multinational corporations
NGOs	Non-governmental organizations

NLB	Non-lignocellulosic biomass
OHS	Occupational health and safety
O/M	Operations and maintenance
PPP	Public private partnership
ReGenSan	Regenerative Sanitation
ROI	Return-on-investments
SA	Sanitation advocacy
SAC	Sanitation advocacy campaign
Sani-K	Sanitation knowledge
Sani-KMart	sanitation knowledge market
SWA	Sanitation and Water for All
SDC	Sanitation advocacy campaign
SDOs	sanitation advocacy organizations
SS	Sewage sludge
SIVC	Sewer Infrastructure Value Chain
STPs	Sewage Treatment Plants
SDGs	Sustainable Development Goals
SAMaT	Sanitation advocacy management tool
SACV	Sanitation advocacy value chain
SDPs	Sanitation-derived-products
SGVC	Sanitation global value chain
SFIIC	Sanitation facility integration, installation and construction
SFIICVC	Sanitation facility integration, installation and construction value chain
SMPE	Sanitation manufactured products and equipment
SMPVC	Sanitation manufactured products value chain
SMVC	Sanitation manufacturing value chain
SBRC	sanitation biomass recovery and conversion
SBRCVC	sanitation biomass recovery and conversion value chain
SSVC	Sanitation services value chains
SaniM-KVC	Sanitation Management Knowledge Value Chain
SaniM-K	Sanitation management knowledge
Sani-KM	Sanitation knowledge management
Sani-Kmart	Sanitation knowledge market place
Sani-KRs	Sanitation knowledge resources
Sani-KWers	Sanitation Knowledge Workers
Sani-KExps	Sanitation Knowledge Experts
Sani-ERT	Sanitation Education, Research and Training
SSC	Sanitation service chain
S-SP	Small-scale producers
SPVC	Sanitation production value chain
SHPE	Sanitation/hygiene products enterprises

SSE	Smart sanitation economy
SSC	Sanitation service chain
SVC	Sanitation value chain
SUSANA	Sustainable Sanitation Alliance
TBC	Toilet Board Coalition
UN	United Nations
UNIDO	United Nations Industrial Development Organization
USAID	United State Aids for International Development
UCD	User- Centred Design
UDDT	Urine diverting dehydrating toilet
VC	Value chain
VIP	Ventilated improved pit latrine
WSSCC	Water and Sanitation Collaborative Council (now Sanitation and Hygiene Fund)
WC	Water closet
WTE	Waste-to-energy
WSP	Water and Sanitation Program
WHO	World Health Organization
WTO	World Toilet Organization