
Sustainability and Digital Engineering Management

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Sustainability and Digital Engineering Management

**African case studies
in sustainable digital
transformation**

Edited by
Arnesh Telukdarie

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This comprehensive book, *Sustainability and Digital Engineering Management*, serves as a valuable guide for individuals dedicated to incorporating sustainable digital practices into the field of engineering management. Drawing from a wide range of real-life case studies within diverse African industries, the book offers a rich and multifaceted perspective on the seamless integration of sustainable digitalisation into engineering management. By actively tackling sustainable development goals through digital transformation, this book provides actionable solutions and knowledge for scholars, policymakers, and industry professionals.

Hlobisile Natasia Mahure,
University of Cape Town, South Africa.

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Dedication

This book pays tribute to the pioneers and visionaries committed to creating a sustainable future for future generations. It honours the efforts of numerous organisations, academics, and industry professionals who are dedicated to leading the way in digital transformation while prioritising the preservation and protection of the planet. Their innovative ideas and unwavering commitment to sustainable digital transformation in Africa have played a significant role in paving the way for a future that embraces sustainability through digital innovation. The case studies showcased in this book are intended to inspire the next generation of leaders.

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Preface

Sustainability and Digital Engineering Management: African case studies in sustainable digital transformation delves into the intricate relationship between sustainability and digitalisation within the field of Engineering Management. It extends beyond the traditional focus on digitalisation in engineering, providing practical insights for integrating sustainability strategies into digitalisation efforts. Drawing from real-world industry experience, this book offers solutions to current industry challenges while addressing sustainability concerns, ensuring that development meets present needs without compromising future requirements. It takes an interdisciplinary approach, promoting collaboration between industry experts and academic professionals to provide comprehensive knowledge. This book is a valuable resource for students, offering practical discussions and case studies of implemented solutions for a variety of sustainability challenges. It is also beneficial for academics and professionals at master's or MBA levels, as well as practitioners such as engineers and project managers seeking to integrate sustainability principles into digitalisation efforts within engineering projects.

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About the editor

Professor Armesh Telukdarie is a well-known expert in digital businesses and a professor at the Johannesburg Business School, University of Johannesburg. In addition, he holds the position of Adjunct Professor at Johns Hopkins University and serves as a Visiting Scholar at London South Bank University. Professor Telukdarie is also affiliated with the University of the Witwatersrand and Kaunas University of Technology, Lithuania. At the Johannesburg Business School, he serves as the research chairperson, focusing on areas such as Industry 4.0, Society 5.0, sustainable development, business optimisation, and manufacturing systems. His impressive body of work includes the publication of over 350 peer-reviewed works and extensive industry consulting.

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Mpho Godfrey Nkadimeng: Mpho Godfrey Nkadimeng holds the position of Data Scientist and Research Coordinator at the University of Johannesburg. In this role, he combines consulting with research to tackle industry challenges. His primary focus is on developing data-driven systems that not only enhance operational efficiency but also address real-world problems impacting people's lives. Mpho's projects range from creating automated data pipelines to utilising machine learning for improved decision-making, all aimed at streamlining processes. However, his commitment goes beyond the technical realm, as he is dedicated to leveraging data for tangible societal benefits, such as enhancing workforce development programmes and optimising service delivery in key industries. With industry experience at Sigmoid Analytica, Mpho has shown proficiency in applying advanced technologies like computer vision and data integration to practical business applications. His driving force is not just technical innovation, but also the belief that data, when used thoughtfully, can significantly improve life by reducing inefficiencies and enabling smarter, more empathetic decisions. Holding a BCom in Information Management and a postgraduate diploma in Data Science, Mpho's research is centred on how artificial intelligence and data science can drive meaningful change, from enhancing workplace strategies to gaining a deeper understanding of the human side of operational issues.

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Chapter 1

An introduction to *Sustainability and Digital Engineering Management: African case studies in sustainable digital transformation*

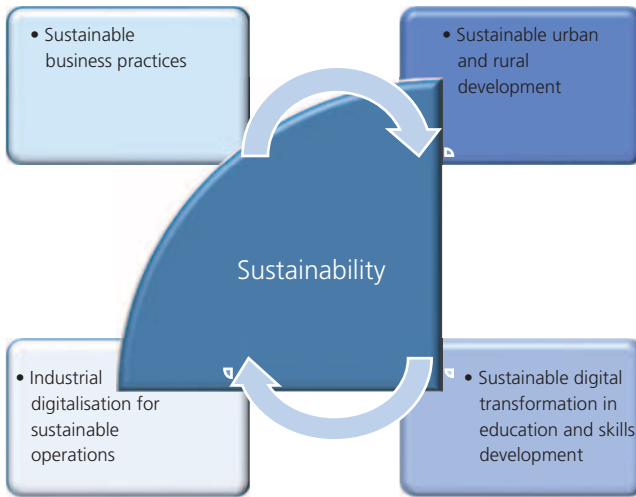
Arnesh Telukdarie and Mahure Hlobisile Natasia

Introduction

The incorporation of sustainability principles into digital engineering management has become vital in today's rapidly advancing technological landscape. Sustainability entails meeting current needs without compromising the ability of future generations to meet their own needs. It encompasses environmental stewardship, economic profitability, and social responsibility. Digital engineering management, on the other hand, focuses on implementing digital tools and techniques to optimise engineering processes. The intersection of these two fields promotes innovation, competitive advantage, efficiency, and long-term value creation in engineering while minimising environmental impact and advancing sustainable development goals (SDGs). However, despite the consensus on the importance of taking a sustainable approach, there is still a significant gap between awareness and implementation. While digitalisation offers significant benefits, there is a lack of actionable strategies for implementing it in a way that aligns with SDGs. Therefore, *Sustainability and Digital Engineering Management: African case studies in sustainable digital transformation* provides comprehensive case studies from diverse industries, demonstrating how digitalisation can be harnessed to promote sustainable development. The book offers first-hand knowledge on implementing digitalisation to establish sustainable businesses, urban and rural communities, mines, and various other industries, serving as a practical guideline for implementing sustainable digitalisation in these sectors. Furthermore, the book equips professionals with the necessary tools and strategies to effectively integrate digitalisation innovations while incorporating environmental, social, and economic goals. By providing a blueprint for translating theoretical sustainability concepts into real-world applications, the book serves as a manual for implementing SDGs across different industries, making it suitable for professionals in a wide range of sectors.

The book is divided into four main themes. The first theme focuses on industrial digitalisation for sustainable operations, while the second theme delves into sustainable business practices. The third theme includes chapters on sustainable urban and rural development, and the final theme covers digital transformation in education and skills development, as indicated in [Figure 1.1](#). The structure of the book is explained in detail below.

Figure 1.1 Summary of the book's structure



The first theme of the book, 'Industrial digitalisation for sustainable operations', provides practical guidelines for implementing digital strategies to enhance efficiency, sustainability, and productivity in industrial operations (Figure 1.1). The first chapter in this section, titled 'Smart water management for sustainability', delves into the digital management of water resources through smart water management (SWM) systems to promote sustainability. It examines how digital technologies optimise water distribution, reduce losses, and ensure efficient resource use. Chapter 3 of the book explores the integration of green hydrogen production with artificial intelligence (AI). The authors delve into the role of AI in optimising green hydrogen production processes to achieve sustainability. This section explores how AI-driven approaches can enhance efficiency, cut costs, and minimise the environmental impact of green hydrogen production facilities. In addition, the chapter discusses the integration of AI technologies, like machine learning algorithms and predictive analytics, into hydrogen production systems, and their potential to hasten the transition to a low-carbon economy. Chapter 4 of the book, titled 'Sustainability and uranium digitalisation', explores how digitalisation impacts the uranium industry by focusing on improving environmental and operational efficiency. It discusses the integration of digital technologies into uranium mining and processing operations, emphasising the benefits of real-time data analytics, automation, and remote monitoring in enhancing safety, productivity, and sustainability. This chapter also details successful implementations of digital solutions in the uranium sector and their implications in fostering sustainable mining practices.

The fifth chapter, titled 'Satellite imagery for water leak detection', focuses on the application of AI in identifying leaks in various systems to minimise resource wastage and boost sustainability. The chapter explores AI-driven leak detection technologies, such as acoustic sensors, predictive analytics, and anomaly detection algorithms, and their effectiveness in

pinpointing and addressing leaks in water pipelines, industrial equipment, and infrastructure. Furthermore, this chapter showcases successful implementations of AI-powered leak detection solutions and their positive impact on resource preservation and minimising environmental risks. The final chapter explores the application of digital tools and strategies to optimise healthcare systems for sustainability. It provides detailed insights into the practical steps involved in integrating digitalisation to enhance operational efficiency and overall sustainability in the healthcare sector.

The second theme of the book, titled ‘Sustainable business practices’, provides practical strategies for organisations to minimise their environmental and social impact while improving their economic viability. This part consists of three chapters. Chapter 7, ‘Business processes for digital sustainability’, explores the digital transformation journey of the Chemical Industries Education and Training Authority (CHIETA), one of South Africa’s 21 Sector Education and Training Authority (SETA) organisations. The chapter offers insights into the complexities and strategic innovations necessary for businesses to maintain a competitive edge in the digital age. By reading this chapter, readers will gain practical guidelines on how to develop and integrate digitalisation into their organisation’s business processes. Chapter 8, ‘Strategies for sustainable digitalisation: advancing ESG metrics’, offers recommendations for developing an environmental, social, governance (ESG) matrix to address the limitations of traditional ESG reporting techniques, such as lack of transparency, comparability, and consistency. The chapter outlines the development of a digitalised ESG matrix and highlights the importance of incorporating digitalisation to improve sustainability reporting. This case study is particularly relevant for students studying sustainable business practices, environmental management, digital innovation, the fourth industrial revolution, and the evolving landscape of ESG reporting. In Chapter 9 of the book, ‘The use of robotic process automation and artificial intelligence in designing a digital system landscape’, the focus is on integrating digital strategies to promote sustainable business operations. In today’s fast-paced technological landscape and amidst growing environmental concerns, businesses face mounting pressure to adopt digital solutions that not only boost efficiency but also support sustainability. This chapter thoroughly examines best practices for different digital strategies utilised by businesses to reduce environmental impact, improve resource management, and enhance overall sustainability performance, which concludes the second theme of the book.

The third theme of the book, ‘Sustainable urban and rural development’, offers practical guidelines for sustainable planning and development in urban and rural areas to create healthy, inclusive, and resilient communities. The first chapter of this section is titled ‘Enhancing sustainable rural development through collaborative innovation’. This chapter focuses on the barriers and challenges that impede innovation, creativity, and productivity in rural areas. Overall, the chapter provides practical guidelines for implementing digital strategies for sustainable rural development through a system model, paving the way for a more informed, strategic, and impactful approach to addressing challenges and fostering development within rural communities. The last chapter in this theme focuses on urban waste management solutions. It details practical recommendations for digital solutions to urban waste management promoting sustainable city development. The chapter outlines the measures taken by the City

of Johannesburg and the University of Johannesburg in response to the waste management challenges faced by the city.

The final theme of the book, ‘Sustainable digital transformation in education and skills development’, provides practical guidelines based on real-life case studies on how to utilise digital tools to improve the education sector, enhance skills development, and ensure accessibility and effectiveness. The first chapter in this section, ‘Green learning management systems’, discusses the creation of the skills supply and demand database (SSDD) as a groundbreaking solution to unemployment in the chemical sector. It acts as a centralised database of sector-qualified individuals, enabling seamless interactions among employers, learners, and the CHIETA. This leads to improved employment rates, increased job contracts, and enhanced employability outcomes. This case study not only impacts the chemical sector but also explores the wider implications of the SSDD, representing a change in labour supply and demand systems. Therefore, the chapter offers valuable insights into integrating digitalisation in education, transitioning from paper-based methods to environmentally friendly digital tools, and improving efficiency and sustainability by highlighting unique features and methodologies.

The second chapter of this theme titled, ‘Modernising vocational welding education’, delves into the use of virtual reality (VR) technology in vocational education and training (VET) programmes to promote sustainable development. This is a response to the growing demand for cost-effective and advanced technical skills training. The chapter showcases successful initiatives that utilise VR simulations to enhance practical training, improve learning outcomes, and fill skills gaps in various industries. It explores the potential of VR to revolutionise VET delivery methods and prepare learners for sustainable careers in an ever-changing digital landscape. The third chapter, ‘Sustainable business intelligence in Master of Business Administration programmes’, provides insights into how the Johannesburg Business School (JBS) implemented a strategic digital tool to address complex challenges in managing Master of Business Administration (MBA) administration processes. This case study outlines the adoption of modern technology and software engineering practices to streamline operations, ensure compliance with regulations, and enhance stakeholder satisfaction. It highlights the complexities associated with MBA administration, such as cohort management, examination oversight, supervisor appointments, and cohort analytics, emphasising the necessity of a sophisticated digital solution. Overall, the case study details the agile development process, adoption initiatives, testing, and quality assurance measures, as well as the deployment of the digital solution.

The fourth chapter of this theme, titled ‘Exploring historical data trend analysis in the Chemical Sector Occupational Skills Forecast Tool’, focuses on the use of AI to predict skills needed in the context of sustainable workforce development. This chapter explores AI-driven methods for forecasting future workforce needs, identifying emerging skills trends, and aligning education and training programmes with industry demand. It delves into the implications of AI-driven skills forecasting for promoting sustainable economic growth, reducing skills mismatches, and enhancing workforce resilience in light of technological advancements. The final chapter in this section, titled ‘Transformative innovation: harnessing AI for sustainable research practices’, provides valuable insights and best practices for integrating AI into research practices to achieve sustainable outcomes.

Each chapter is meticulously structured to include a comprehensive case study, which is paired with detailed teaching notes. These teaching notes are essential resources that provide the relevant information and materials necessary for understanding, teaching, and fully engaging with the case study. They play a crucial role for instructors, enabling them to deliver content in a practical and relatable manner, effectively immersing students in real-world industry experiences. Moreover, industry professionals can leverage these teaching notes to deepen their understanding of the case studies, enhancing their practical knowledge and application in their respective fields. The teaching notes found in each chapter encompass several key components, as indicated in Table 1.1. All of these elements work together to provide invaluable information for both instructors and industry professionals, making each chapter a rich resource for effective teaching and learning.

To sum up, the book is divided into different themes, each with a set of chapters providing practical guidelines on sustainable business practices, sustainable urban and rural development, digital transformation in education and skills development, and industrial digitalisation for sustainable operations. It eloquently explores sustainability principles and their seamless integration into digital engineering processes. The book emphasises the need to reduce environmental impact, promote social equity, and ensure economic viability in various industries. It presents numerous real-world case studies showcasing successful implementations

Table 1.1 Structure of teaching notes in book chapters

Teaching notes	
Synopsis	A brief overview of the case study, highlighting its key points.
Teaching objectives	Clear goals that outline what students should achieve or understand by the end of the lesson.
Research methods	An explanation of the methodologies used in the case study, providing context for the findings.
Keywords and subject code	Important terms and classifications that are relevant to the case, facilitating easier navigation and reference.
Assignment questions	Questions that are designed to stimulate discussion and critical thinking among students and other readers.
Additional materials	Supplementary resources that expand on the topics covered in the case study, allowing for a more thorough exploration.
Suggested core readings	Recommended literature that provides further insight and background, enriching the learning experience.
Teaching plan and timing	A structured outline for instructors on how to deliver the lesson effectively, including time allocations for different activities.
Analysis of assignment questions	Guidance on how to approach the assignment questions, including possible answers and interpretations.
Key learnings	A summary of the essential takeaways from the case study, reinforcing the primary lessons for students.

of sustainability-centric digital engineering practices, demonstrating how digitalisation addresses industry-specific challenges while considering sustainability principles. Table 1.2 provides a summary of the digital tools used in each chapter. In addition, the book highlights the barriers encountered and the opportunities that arose during the implementation process. It offers practical insights into successfully implementing sustainability-centric digital engineering management across various industries, making it an invaluable resource for anyone aiming to achieve SDGs while leveraging digital engineering practices for growth and innovation in each industry.

This book offers a comprehensive exploration of the intersection between sustainability and digitalisation in engineering management, expanding beyond the typical focus solely on digitalisation in engineering. It provides practical guidance for incorporating sustainability strategies into the pursuit of digitalisation in engineering management. The book leverages real-world industry experience and success stories to serve as a practical roadmap. By adopting an interdisciplinary approach and promoting collaboration between industry experts and academic professionals, it serves as a valuable source of comprehensive knowledge. One of its key strengths is the ability to offer solutions to current industry challenges while addressing sustainability issues, ensuring that development caters to present needs without compromising future requirements. The book will be an invaluable resource for students, providing practical discussions and case studies on implemented solutions across a range of sustainability challenges. Additionally, the book is intended for academics, and students pursuing a

Table 1.2 An overview of digital tools utilised in the book

	Sensors	Big data analytics	Internet of things	Artificial intelligence	Cloud computing	Virtual reality
Chapter 2	X	X		X		
Chapter 3		X		X		
Chapter 4		X	X	X		
Chapter 5		X	X			
Chapter 6		X				
Chapter 7				X		
Chapter 8		X		X		
Chapter 9		X		X		
Chapter 10				X		
Chapter 11				X		
Chapter 12		X		X	X	
Chapter 13						X
Chapter 14		X		X	X	
Chapter 15		X		X	X	
Chapter 16				X		

master's or Master of Business Administration (MBA) degree. It also caters to practitioners, such as engineers and project managers, and executives who aim to integrate sustainability principles into engineering management.

REFERENCES

- Emina KA (2021) Sustainable development and the future generations. *Social Sciences, Humanities and Education Journal (SHE Journal)* **2**(1): 57–71.
- Farley HM and Smith ZA (2020) *Sustainability: If It's Everything, Is It Nothing?* Routledge, London, UK.
- Lim KYH, Zheng P and Chen CH (2020) A state-of-the-art survey of Digital Twin: techniques, engineering product lifecycle management and business innovation perspectives. *Journal of Intelligent Manufacturing* **31**(6): 1313–1337.