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Mohammad Dastbaz
Christopher Gorse *Editors*

Sustainable Ecological Engineering Design

Selected Proceedings from the International Conference of Sustainable Ecological Engineering Design for Society (SEEDS) 2019

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ISBN 978-3-030-44380-1 ISBN 978-3-030-44381-8 (eBook)
https://doi.org/10.1007/978-3-030-44381-8

Cover credit: Photograph taken outside the Waterfront building, University of Suffolk, Neptune Quay Ipswich

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

We held the Inaugural Sustainable Ecological, Engineering Design for Society Conference in 2015 at Leeds to try and bring together researchers from across the world to exchange ideas about our common problems and the challenges our planet face. Three weeks after our first SEEDS conference, 150 world leaders attended the "UN Sustainable Development Summit" in New York to discuss the challenges facing our plant, the fast disappearing natural resources. The conference set a vision for 2025–2030 to develop a "plan of action for people, planet and prosperity". Five years on it is both ironic and dangerous that we have influential voices around the world that there is a climate disaster happening and that we have significant responsibility to try and reverse our history of deliberate and destructive impact on our environment over the past centuries. It is also refreshing that the weight of public opinion has forced significant changes in government behaviours across the world.

Through research and proven practice, the aim of the SEEDS conference, each year, is to foster ideas on how to reduce negative impacts on the environment while providing for the health and well-being of society. The professions and fields of research required to ensure buildings meet user demands and provide healthy enclosures are many and diverse. In 2019, the SEEDS conference addressed the interdependence of people, the built and natural environments, and recognized the interdisciplinary and international themes necessary to assemble the knowledge required for positive change.

The selected proceedings of SEEDS 2019 presented here is organized into six sections covering: Sustainable Development and Urban Spaces; Sustainability Education; Project Management in Sustainability; Energy and Energy Efficiencies; Sustainable Retrofit and Lifecycle Assessment and Ecology and General Sustainability.

We hope that SEEDS 2019 selected proceedings provide a platform for interested policy makers, researchers, practitioners and educators to discuss the recognized and important problems affecting sustainable built environment.

Dunboyne, Ireland
Ipswich, Suffolk, UK
Leeds, UK
February 2020

Lloyd Scott
Mohammad Dastbaz
Christopher Gorse

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About the Editors

Mohammad Dastbaz graduated in Electrical and Electronic Engineering and went on to do a PhD in "Design, Development and Evaluation of Multimedia Systems" at Kingston University. In 1989, he established one of UK's first multimedia computer companies called "Systems 2000 Ltd." and was one of the only companies alongside Philips Corporation to participate in the UK's first Multimedia Systems Exhibition at London Olympia in 1990. He Joined Kingston University in 1994 as a research lead for developing multimedia-aided learning packages and has since worked in number of UK Universities, progressing to become the Dean of School of Computing and Engineering at the University of East London. In 2011, Professor Dastbaz joined Leeds Metropolitan University (now Leeds Beckett University) as their dean and pro-vice-chancellor for Faculty of Arts, Environment and Technology.

Professor Dastbaz remains research active and has published over 60 refereed journal, and conference papers, books and book chapters. He is on a number of editorial boards of international journals, has been chair of a number of international conferences (including IEEE's Information Visualisation) and remains a member on a number of international conference committees. His latest publications include an edited volume on "Green Information Technologies"; "Building Sustainable Futures—Design and the Built Environment" and a series of four edited volumes on "Technology and Sustainable Futures" published by Springer.

Professor Dastbaz is a Fellow of the BCS—The Chartered Institute for IT, Fellow of the Higher Education Academy, and a Fellow of Royal Society of Arts (RSA).

Christopher Gorse is the director for the Leeds Sustainability Institute, located at Leeds Beckett University. The building performance and sustainability research unit that Professor Gorse leads has amassed one of the most comprehensive sets of actual building thermal performance data in the UK. The work has informed government policy and regulation, is used extensively by industry and is now embedded in the work of the International Energy Agency's programme to inform whole building testing and performance measures. The research team has extensive knowledge and expertise in whole building performance tests in the field and laboratories, hygrothermal and thermal modelling, building simulation, elemental building component testing, energy and behaviour monitoring.

Work extends across domestic and industrial developments, refurbishment and retrofit projects and looks at the impact and effectiveness of interventions and changes. The efficiencies of building fabric, services and renewable energy technologies are a major focus of the group's work. The more extensive work of the Sustainability Institute includes energy, waste, business and social governance, information and communication technology, corporate social responsibility, planning, ecology, process management and project management, all engaged in reducing negative impact on the natural environment.

Professor Gorse leads a sub-task group for the International Energy Agency, Annex 58, on whole-scale building testing, working with over 30 international partners. More recently, Professor Gorse led a major contract project funded by the Department of Energy and Climate Change to undertake research on the Core Cities Green Deal Go Early project. The work involved the intensive and extensive monitoring and evaluation of buildings that are benefiting from Green Deal and Eco funding in the Leeds area.

Lloyd Scott is a professor of Academic Advisor and Partnership Co-Ordinator in the School of Surveying and Construction Management at Dublin Institute of Technology (DIT). He joined the DIT as a lecturer in Construction Management and Technology in 2000. He is currently supervising 7 PhD researchers. Apart from his lecturing, supervision, research, and academic administrative duties, Lloyd has completed a PhD in the field of Built Environment Education and has developed a framework for assessment led learning strategies for Built Environment education. In 2014 he accepted the position of 'Professor of Practice' at the Haskell and Irene Lemon Construction Science Division in the College of Architecture at the University of Oklahoma. Along with this he has produced many peer-reviewed conference and journal papers. He serves as the Associate

Editor of the International Journal of Construction Education and Research. His research interests include modern approaches to thermal performance in domestic construction, development of sustainable energy sources and their practical application in Ireland and project delivery methods for a sustainable environment in Ireland. He also serves on the editorial board of Structural Survey an academic journal that publishes contemporary and original research in building pathology and building forensics, refurbishment, and adaptation. In 2016 Lloyd accepted the position of Research Fellow at the Sustainability Institute at Leeds Beckett University.

About the Authors

Mohsen M. Aboulnaga has 35 years of vast experience in higher education, high-level government posts and consultancy in sustainable cities, climate change, sustainable development and sustainable energy. He is a qualified architect in Egypt, graduated from Cairo University with BSc Arch (1979) and MSc in Housing Economic (1985), and holds a PhD from The University of Leeds in the UK (1991), https://www.leeds.ac.uk/. Dr. Aboulnaga is a professor of Sustainable Built Environments at Cairo University, https://scholar.cu.edu.eg/mohsen_aboulnaga/. He is a registered senior expert on Urban Energy Policy at European Union–NEAR, ENPI South, https://www.ces-med.eu/. He is an associate partner of European Sustainable Development Network in Vienna, https://www.sd-network.eu/; a permanent member of World Renewable Energy Congress/Network in the UK, https://www.wrenuk.co.uk/; a senior expert at Union for Mediterranean in Barcelona, https://ufmsecretariat.org/first-platform-sustainable-urban-development/, and UNESCO Inclusive Policy Lab in Paris, https://en.unesco.org/inclusivepolicylab/users/mohsen-aboulnaga; as well as a member of UrbanFarm 2020 International Jury in Italy, https://site.unibo.it/urban-farm/en. He is an invited speaker to 425 international conferences and has 200 international publications and presentations. He trained 520 government officials of Ministry of Petroleum—Egypt on strategy planning, SDGs and Energy Efficiency as well as 168 government officials in Kazakhstan and Azerbaijan on green cities strategies. Professor Aboulnaga is the author of a book *Urban Climate Change Adaptation*, https://www.springer.com/gp/book/9783030054045, plus ten book chapters (Springer and Elsevier).

Clinton Aigbavboa is vice-dean for the Postgraduate Studies, Research and Innovation and head of the Sustainable Human Settlement and Construction Research Center. He is also an editor for the *Journal of Construction Project Management and Innovation* (JCPMI). He has written a number of conference papers and journal articles and published a book on human settlement. He also holds a PhD from the University of Johannesburg.

Ghizlane Ben Baha graduated with distinction from the MSc Strategic Project Management course at Leeds Beckett University, after previously reading Architecture at Cambridge. Her research into Programme Management challenges assumptions held by the contemporary theory of Programme Management.

Colin A. Booth is associate head of Research and Scholarship in the Faculty of Environment and Technology at the University of the West of England, Bristol (UK). He holds the distinguished titles of Visiting Professor of Civil Engineering and Visiting Professor of Sustainability at prestigious international universities. He is the author/co-author of 8 books and ~180 scientific papers. His research interests include sustainability in the built environment, environmental management in construction, property level flooding, sustainable drainage systems (SuDS), climate change adaptation strategies, built environment studies and urban pollution.

John Bruen trained and qualified as Charted Architect in the UK and Ireland. He holds an additional Masters in Construction Project Management and a PhD in Architecture. He has trained and qualified as a Certified Passive House designer with the Passive House Institute in Darmstadt, Germany. He runs his own architectural practice focusing on contemporary energy-efficient design in a variety of contexts and has contributed to the Construction Project Management Masters in Queens University, Belfast.

Alan Bugg joined the faculty of the McWhorter School of Building Science at Auburn University in 2016. Prior to joining the faculty at Auburn, he worked for the U.S Army Corps of Engineers in a variety of positions for over 33 years. Mr. Bugg earned a bachelor's degree in agricultural engineering in 1983, a master's degree in Business Administration in 2003 and a master's degree in Building Construction in 2011, all from Auburn University. Mr. Bugg is a registered Professional Engineer in the State of Alabama, a certified Project Management Professional (PMP) and a certified DBIA Design-Build Professional.

Richard Burt trained and qualified as a Chartered Building Surveyor in the UK. He holds a master's degree in Construction Management and a PhD in Architecture from Texas A&M University. He is currently the McWhorter Endowed Chair & Head of the McWhorter School of Building Science at Auburn University in Alabama.

He currently serves on the Board of Directors of the AGC Education and Research Foundation and the Board of Trustees of the American Council for Construction Education. Dr. Burt also serves as the co-coordinator of the International Council for Building (CIB) Working Group WG089—Education in the Built Environment.

Colin Butlin graduated with distinction from the MSc Strategic Project Management course at Leeds Beckett University, and is a senior practitioner with extensive project practice experience in the development and delivery of capital projects in the UK.

John Lester Clarke, BSc (Hons), PGCE, MSc, PhD is currently deputy module leader at University of Estate Management in Reading. He has worked as a public and private sector building surveyor and on several low environmental impact buildings in the UK and overseas, utilizing strawbale, adobe, rammed earth and timber framed structures and other sustainable materials and has taught a broad range of built environment topics in schools, colleges and universities to a wide variety of learners. His teaching and research interests are in developing and promoting economic, social and environmental sustainability related to the built environment.

He has an honours degree in Building Surveying, a master's degree in Renewable Energy & Architecture and a Postgraduate Certificate in Education. He completed his PhD entitled "Sustainable Buildings: Sustainable Behaviour?" in 2013. This focused on how sustainable buildings, throughout their design, construction, operation and use, impact on sustainable construction practices and the behaviours of key stakeholders.

Fidelis Emuze, PhD is professor and head of the Department of Built Environment and head of the Unit for Lean Construction and Sustainability at the Central University of Technology, Free State (CUT), South Africa. Lean construction, health, safety, and well-being and sustainability constitute the primary research interest of Dr. Emuze, who is a National Research Foundation (NRF) funded researcher that have published over 200 research outputs in the last 7 years. Dr. Emuze is the editor of *Value and Waste in Lean Construction* (published by Routledge), *Valuing People in Construction* (published by Routledge), and co-editor of *Construction Health and Safety in Developing Countries* (published by Routledge). Dr. Emuze is a member of editorial advisory boards of international journals including the ISI indexed Proceedings of the Institution of Civil Engineering–Municipal Engineers. He is a member of the Association of Researchers in Construction Management, and the Board of Directors of the Engineering, Project, and Production Management association (EPPM-Association). Dr. Emuze is the international coordinator of CIB TG59—People in Construction task group.

Thomas Franzen has 11 years' experience in engineering design and recently graduated with a Bachelor of Engineering (Civil) with First Class Honours at the University of Southern Queensland (USQ) and was awarded the University Medal. Tom also holds a Bachelor of Business Administration and a Diploma of Civil Construction Design. He was awarded the 2018 IPWEA (NSW) David Abbott Young Public Works Leader of the Year. David Thorpe is associate professor (Engineering/Technology Management) at USQ, where he has a strong interest in sustainable engineering management. Prior to joining the university, he worked in engineering design, construction and research management.

Mark Gazzard is a Chartered Building Surveyor and Chartered Building Engineer and is a former postgraduate student in the Faculty of Environment and Technology at the University of the West of England, Bristol (UK). His research interests include construction technology, project design and implementation, sustainable infrastructure and environmental management.

Peter Gudde is a researcher at the University of Suffolk looking at the sustainability of the UK energy transition. He has been involved professionally in sustainability for over 25 years, currently working in the public sector supporting energy infrastructure projects. He was a director of a solar company and in the due diligence team during its acquisition. He was a founder of the Suffolk Climate Change Partnership and in 2006 wrote one of the first local authority Climate Action Plans in England. He is a Chartered Environmentalist and Waste Manager and holds degrees from the Universities of Durham and Cranfield.

Rajat Gupta is director of the Oxford Institute for Sustainable Development at Oxford Brookes University. Rajat's research interests lie in evaluating building performance from a socio-technical perspective, local energy mapping, smart energy systems and scaling up energy retrofits. Rajat is currently PI of a £1.5 million UK-India EPSRC-DST project on residential energy reduction in India (RESIDE). He is also Co-I of £8 million EPSRC Energy Revolution Research Consortium (EnergyREV: Core), PI of EnergyRev Plus project on *smart energy tools* and lead academic in the £13.8 million Innovate UK Local Energy Oxfordshire (LEO), a smart local energy system demonstrator. He is a member of EPSRC and ESRC peer review colleges.

John Heathcote trained as a civil engineer and delivered a broad range of engineering and business improvement projects in a 22-year career in practice. He holds an HNC in civil engineering, and an honours degree in project management and an MBA from Sheffield Hallam University's Sheffield Business School. He now lectures and researchers into the management of projects, based at Leeds Beckett University, where he has been for 17 years. John has been a visiting lecturer at the University of Applied Sciences Wuerzburg-Schweinfurt. Chairing the APM's Value Management Specific Interest Group for 5 years promoting an interest in projects as an open system concept, John's research takes an interest in reconceptualizing

normative project management to exploit their latent value, something that might be key to creating a more sustainable future.

Samaa E. Helmy is trained and qualified architect in Egypt. She graduated from Cairo University with BSc Arch in 2014 and holds a MSc in Architecture–Biomimicry Architecture in 2018 from the same university. She is registered in the PhD degree programme at Department of Architecture, Faculty of Engineering at Cairo University since March 2019. Ms. Helmy is currently teaching assistant at Architectural Engineering and Technology Programme (AET) at Cairo University and also teaching assistant at Architectural Department, Misr University for Science and Technology (2017–Present). In addition, she is assisting Professor Aboulnaga in many projects and courses, namely Smart Building (2016–present). She received a 3-week summer school training on "Sustainability and Energy Conservation in Architecture" at the University of Lincoln in the UK (2012).

Siyabonga Jikeka currently works for the National Department of Public Works, South Africa, as a director: Construction Project Management.

He obtained a National Diploma in Building Science from the then Eastern Cape Technikon in April 2004, a B-Tech in Quantity Surveying in April 2009, and a Master of Science in Built Environment: Property Economics and Valuations in April 2014 from the then Nelson Mandela Metropolitan University.

Siyabonga is a registered Professional Quantity Surveyor with the South African Council of Quantity Surveying Profession.

Shaherah Jordan is a third year doctoral candidate at the University of East London. Her work focuses on different factors that could impact electric vehicle adoption in London including the built environment and socio-economic demographics. Her thesis focuses on cultural attitudes to money and finance as a potential factor in electric vehicle adoption. She holds an MBA from the University of East London.

Hadi Kazemi is a senior lecturer and researcher into project and construction management at Leeds Beckett University. He holds Civil Engineering and Construction Management degrees from the University of Surrey and Sheffield Hallam University.

Nokulunga Mashwama is an assistant lecturer in the Department of Construction Management and Quantity Survey at the University of Johannesburg. She earns Masters in Construction Management from the University of Johannesburg. She is a PhD candidate in Quantity Surveying with the University of Johannesburg. She has published a number of conference papers. She has worked for the industry for 9

years as quantity surveyor with Owen Thindwa and Associate Chartered Quantity Surveyors and Construction Companies as a site quantity surveyor.

Barry McAuley is a Chartered Construction Project Manager and full-time lecturer in Digital Construction and Engineering within the School of Multidisciplinary Technologies at Technological University (TU) Dublin. This role involves the teaching and development of new academic programmes within architecture, engineering, and construction (AEC) analytics, Building Information Modelling, and Digital Construction related courses. He is also the current programme chair for the MSc in applied BIM and Management course. Prior to his current position, Barry spent a number of years working in the construction and facilities management sector, which enabled him to develop his managerial skills through employment in a number of diverse roles. He completed a PhD in 2016, which focused on using BIM to demonstrate how early integration of Facilities Management professionals into the design team can result in reducing life cycle costs. On completion of his PhD, Barry spent 2 years working as the primary postdoctoral researcher on the CitA Lead Enterprise Ireland funded BIM Innovation Capability Programme of Ireland. As a result of his research to date, he has had a significant body of work published through a combination of industry reports, conference proceedings and journal papers. This has resulted in Barry been named one of "Autodesk 40 under 40 Construction Champions of 2019" which acknowledges and recognizes extraordinary professionals under 40 years of age within the global AEC industry.

Michela Menconi holds a master's degree in architecture, from Florence University, in Italy, where she specialized in Building Conservation and Restoration Technology. She has worked in different practices, in Italy and in Germany, on a range of projects, from new design to adaptation and repair of heritage buildings, for the public and private sector. She is currently doing her PhD on retrofit strategies for traditional listed dwellings (TLDs), in School of Environment and Technology, University of Brighton, where she has also worked as a part-time lecturer for the past 7 years. Her main interests include modelling and energy simulation for analysis of energy performance of TLDs and heritage conservation.

Paul Mundy trained and qualified as a building surveyor, working in the UK construction sector for 10 years. Having undertaken a master's degree in Sustainable Development in Practice at the University of the West of England, he is currently researching sustainable construction within the UK, to bring research and experience together. Working in the role of senior lecturer in Building Surveying at the University of the West of England and using his research to influence his teaching provides graduates with sustainability literacy to take forward and shape the industry in their practice.

Niamh Murtagh is a Senior Research Fellow at the Bartlett School of Construction and Project Management, University College London (UCL). An environmental psychologist by discipline, Niamh's focus has been on applying insights from psy-

chological theory to a sustainable built environment, investigating the psychological underpinnings of pro-environmental behaviour in construction professionals including planners, architects and builders. Niamh was managing guest editor for a Virtual Special Issue of the *Journal of Cleaner Production on Sustainable and Resilient Construction*, and has published in, and is a regular reviewer for, journals including *Journal of Environmental Psychology, Frontiers, and Environment and Behavior*.

Dean Myers My name is Dean Myers and I am a Sustainability Officer with a Registered Provider of social housing in West Yorkshire. My interests are energy efficiency and renewable energy technologies. I am a 5th Year PhD student with Leeds Sustainability Institute at Leeds Beckett University studying overheating risk in the UK's first large-scale Passivhaus retrofit. The aim of my research is to inform improvements in design and installation of future low-energy buildings. I was awarded the Building Performance Evaluation award at the SEEDS Conference 2019 for my latest conference paper.

Mpho Ndou is a trained and qualified professional quantity surveyor. He holds a master's degree in Construction Management and is currently a PhD candidate at the University of Johannesburg, South Africa. He is affiliated with both the local and international Professional Counsels of Quantity Surveying with a membership status of Pr.QS and MRICS, respectively. Similarly, he also serves as an academic assessor at the Royal Institution of Chartered Surveyors (RICS).

His research interests are in Sustainable Development, Environmental Science, and Ecological Economics.

Chibuisi Chinasaokwu Okorieimoh is a trained teacher and a doctoral research student in the School of Electrical and Electronic Engineering at Technological University Dublin, Ireland, under the supervisions of Professors Brian Norton and Michael Conlon. He holds a Diploma in Computer and Basic Physical Sciences, Bachelor of Science Education in Physics, master's degree in Solar Energy Physics and Material Science (all from University of Nigeria) and Master (Mobility) in the master's degree programme of Physics from University of Valladolid, Spain. He was among the 2019 Global Teacher Awardee.

He is currently a part-time assistant lecturer in the School of Multidisciplinary Technologies at Technological University Dublin, Ireland.

Gloria Osei is a PhD student at Anglia Ruskin University, Engineering and the Built Environment, and has a master's degree in civil engineering from City University, London. Gloria has also obtained an associate lecturer position teaching undergraduate Architect students.

Alice Owen trained as an engineer and worked in policy development before completing her PhD; she is now associate professor of Business, Sustainability and Stakeholder Engagement at the Sustainability Research Institute in the University of Leeds; Dr. Kathryn Janda trained in architecture and is a Principal Research Fellow

in Organisations and Non-Domestic Buildings in the Bartlett School of Environment, Energy and Resources at UCL. Dr. Kate Simpson trained as a building surveyor and worked in further education before becoming a researcher at the Turing Institute, as part of Imperial College London. All three authors work in pragmatic, interdisciplinary and high impact ways.

Noel Painting, BSc Grad Dip Arch MRICS has been at the University of Brighton since 1992 and is currently course leader of the BSc Quantity Surveying degree. His research is in design, procurement and cost management on which he lectures at undergraduate and postgraduate levels. Noel was a member of the ARCOM scientific committee from 2006 to 2012 and is currently an external examiner at Leeds Beckett University. He has validated courses internationally and has been part of six CIAT accreditation panels for BSc Architectural Technology courses.

He also carries out consultancy for a major music festival promoter with a focus on health and safety.

Federica Pascale is a senior lecturer in Architectural Technology, Anglia Ruskin University. Federica was involved in Phase 2 of The Health and Care Infrastructure Research and Innovation Centre (HaCIRIC), which was a collaboration between existing research centres at Imperial College London and the Universities of Loughborough, Reading and Salford.

Mehmet Koray Pekeriçli, MSc, PhD has received his Bachelors in Architecture at Middle East Technical University in year 2000. He received British Council Chevening TEV Scholarship and received a master's degree in Construction Management at Reading University, UK, in the year 2000. With the support of NSF and Turkish Higher Education Scholarships he pursued his PhD studies at Carnegie Mellon University, PA/USA between 2003 and 2006. He took part in KIM-Grand Challenge Project as a researcher at Reading University between 2006 and 2011, and completed his PhD thesis there. He has been teaching and conducting research at Middle East Technical University since 2011. His interest areas cover Construction Management, Building Information Management, Sustainable Buildings, Intelligent Buildings, Smart Cities, Responsive Environments, and Building Informatics.

Neil Pickavance is a staff Senior Construction Planner (Scheduler) in the UK construction industry, currently at the UK construction arm of the world's largest non-state-owned construction and engineering company. With 25 years' full-time experience at Tier 1 contractors Neil has held senior and lead planner/scheduler roles on numerous major UK projects. Technically qualified in building and construction, a full member of the Chartered Institute of Building (MCIOB), and holding a master's degree in Project Management (Construction) from Nottingham Trent University, Neil is currently undertaking a part-time MPhil/PhD Built Environment at Liverpool John Moores University, investigating construction project management cultures.

Poorang Piroozfar is a Principal lecturer (associate professor) of Architectural Technology, the academic program lead for BSc (Hons) Architectural Technology and MSc Digital Construction, and the director of Digital Construction Lab at School of Environment and Technology, University of Brighton. People, environment, information and technology are at the heart of Poorang's research where different methods are triangulated to formulate the most viable solutions. He has numerous research outputs, and together with his research team, he has won several research grants and awards for his research on building performance and evaluation, building energy simulation, facility management of complex heritage buildings, responsible and future-proof energy retrofits, life cycle assessment of buildings, double-skin and PV integrated façade systems as well as values and frames in design for sustainability.

Alison Pooley is currently the deputy head for the School of Engineering and the Built Environment, Anglia Ruskin University. Alison has worked as a housing officer in East London and was in architectural practice for several years before going on to teach at the Centre for Alternative Technology, Wales, where she taught on postgraduate programmes for nearly 10 years.

Kenneth M. Rampou is an assistant director—Real Estate Investment Services at the Department of Public Works and Infrastructure in the Republic of South Africa and serves as a member of the Regional Green Building Technical Committee. The author has an avid interest in green buildings and the circular economy and is currently studying towards and MSc in Project Management, having recently completed a BSc Honours in Quantity Surveying at the Nelson Mandela University, with research co-supervision under the guidance of Ms Sharon Dent and Professor Geritt Crafford.

Josie Rothera is the course director for MSc Civil Engineering at Leeds Beckett University. Josie is a Chartered Engineer with the Institution of Civil Engineers, an Associate of the Association of Project Management, a Fellow of the Higher Education Academy and an Early Career Researcher. Josie has also recently been appointed as a Panel Member for the Institute of Apprenticeships and Technical Education. Josie has over 10 years' experience of project site management on contracts over £10M, often the sole female representation on the delivery team. Josie is a company director of STEER Support and Mentoring CIC, which supports undergraduates in transitioning into Built Environment careers.

Lloyd Scott is a professor of Sustainable Construction Technologies and head of the Knowledge in Sustainable Construction Research Group at the Technological University Dublin (TU Dublin), Ireland. He is also vice-chairman of the Board of the Association of Researchers in Construction Management (ARCOM) and chair of the Sustainable Environmental Engineering in Design for Society (SEEDS) Conference (2018–2020).

He is a visiting professor of Practice in Sustainable Construction at the College of Architecture, Oklahoma University, USA (2014–), and an active member of the editorial board of Mass Timber Construction journal (2018–). His research focuses on building performance, mass timber construction and sustainable knowledge and expertise in the sAEC sector. He has collaborated on planning/design build student competitions and studies with the University of Oklahoma and the Milwaukee School of Engineering. The competitions have been part of the Associated Schools of Construction (ASC) program, where he served as a board member of the ASC (2011–2018).

Eric Simpeh is currently a lecturer and the acting head of Department of Construction Management and Quantity Surveying at Cape Peninsula University of Technology. He holds a PhD degree in Construction Management from Nelson Mandela University, a master's degree in Construction Management and Bachelor of Technology in Quantity Surveying from Cape Peninsula University of Technology. Eric's first venture into research was in 2012 when he developed a rework probability model for assessing rework occurrence in construction projects. His areas of research interest include sustainable construction and resource optimization in construction.

John Smallwood is the professor of Construction Management in the Department of Construction Management, Nelson Mandela University, and the principal, Construction Research Education and Training Enterprises (CREATE). Both his MSc and PhD (Construction Management) addressed construction health and safety (H&S). He has conducted extensive research and published in the areas of construction H&S, ergonomics, and occupational health (OH), but also in the areas of health and well-being, primary health promotion, quality management, and risk management.

Lilian Nwanyisonde Smart is currently a PhD research student in the School of Art, Design and Architecture, Global Disaster and Resilience Centre, University of Huddersfield, United Kingdom. She holds an MRes in Government and International Affairs, Durham University, and a master's degree in International Relations, University of York, all in the United Kingdom. Lilian has worked as a teaching assistant as well as research assistant, Global Disaster and Resilience Centre, University of Huddersfield, United Kingdom. She was the chairperson of a Postgraduate Research conference on Sustainable Development held in the University of Huddersfield, UK. Has won several awards including the prestigious presidential honours award. She is currently working with the Student Union, University of Huddersfield, on a project under the Inspiring Future Leaders program as the project manager of BAME students' mental health.

John P. Spillane is an experienced research focused lecturer in Construction Management at the University of Limerick, with a demonstrated history of working in both higher education and the construction industry. As a Chartered Construction

Manager, working within the remit of Digital Construction, Sustainability, Dispute Resolution and Confined Site Construction, John is currently working on a number of research projects throughout Ireland and the UK.

John L. Sturges began work in the Foundry Industry in the West Midlands, before going to Aston University, where he obtained a Junior Research Fellowship in the Department of Metallurgy. From there he took up a research post in the Department of Mechanical Engineering at the University of Leeds, pursuing work on the dynamic flow and fracture of materials. He moved to Leeds Beckett University as senior lecturer in Materials Science in the School of Civil Engineering and Construction. While there, he pioneered the teaching of environmental impact and sustainability to final year courses across the school. He presently serves as visiting professor in the Leeds Sustainability Institute.

Ali Murat Tanyer, MSc, PhD, LEED AP BD+C; O+M After graduating from the Department of Architecture of Middle East Technical University (METU), Ankara—Turkey, in 1997, he started his master studies at the same department. He completed his master's degree in 1999 in construction management field. He started his graduate studies at the Salford University, United Kingdom, in 2000 and obtained his PhD in 2005. He worked as a post-doc researcher in European Union (EU) Framework 6 (FP6) funded INTELCITIES research project.

His main areas of expertise are construction information technology and sustainability and how they support built environment. He has been a full-time instructor since 2006 and currently working as a full professor at METU. He has been lecturing in *Construction Management, Professional Practice for Architects*, *Construction Informatics*, and *Sustainability in Construction*. He has several publications in refereed conferences, journals and books.

Didi Thwala is a professor with the university of Johannesburg, and A-rated researcher. He is a SARCHI chair holder, and an HOD for the Department of Construction Management and Quantity Surveying. He has published a number of conference papers and journal articles and a book on Health and Safety. He has a PhD from the University of Johannesburg. He is an Editor in Chief of the Journal of Construction Project Management and Innovation (JCPMI).

Su Taylor is the Dean of Research for the Faculty of Engineering and Physical Sciences, a Professor of Structural Engineering and lead the Intelligent infastructure group at Queen's University Belfast.

Blake Wentz is chair of MSOE's Civil and Architectural Engineering and Construction Management Department. He is vice-president of the Associated Schools of Construction (ASC), the national professional association of educators and industry practitioners working together for the development and advancement of construction education. Wentz joined the MSOE faculty in 2005. He holds a bachelor's degree in finance and master's degree in engineering, both from the

University of Nebraska-Lincoln, and a PhD in technology management from Indiana State University. From 2009 to 2014, he served as MSOE's construction management program director. More recently he has served as owner's representative for MSOE's Grohmann Tower renovation project and for the university's new Dwight and Dian Diercks Computational Science Hall project, which will break ground this spring. He is a LEED Accredited Professional and American Institute of Contractors (AIC) Certified Professional Constructor (CPC).

Stephen Wilkinson has been in higher education for 34 years, having been a principal lecturer at Leeds Beckett University. His interests range from Robotics and Automation to serious VR, including hand operations for carpal tunnel syndrome; refuse recycling autoclaves and WW1 prisoner camps.

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Part I
Sustainable Development and Urban Spaces

The Significance of Social Sustainability

J. L. Sturges

Introduction

Sustainability first emerged as a matter of concern at least five centuries ago when people expressed concern about the impact of mankind's consumption of natural materials and its impact on the environment. These concerns centred on timber, a very visible resource. Some of the earliest literature on silviculture was produced in Germany 500 years ago (Caradona, 2014). In England, the Woodlands Act was passed by parliament in the reign of Henry VIII, as there was widespread concern about the depletion of forests. Timber was being cut for building, for ship-building, for fuel and for charcoal-burning for iron production. In Japan Tokugawa Ieyasu founded the last Shogunate in 1603, and an early measure instituted was one to protect Japan's forests which were rapidly becoming depleted at that time. These concerns show us that sustainability first had an environmental and resource-depletion element, and this is still the case today.

We have come to realise that there are two other equally important dimensions to sustainability, namely the economic and social ones. Elkington (1997), for example, refers to the 'triple bottom line', where economic prosperity, environmental quality and social justice are the three elements. The need for social sustainability is logical, as it is people and their economic activities that impact the world's environment. Elkington points out that conventional economics places no monetary value on natural materials and resources such as air and water, which are assumed to be free and freely available. He makes the point that sustainability cannot be achieved unless social sustainability is also achieved. In describing social sustainability, he quotes from Gladwin (1996), who calls for a paradigm shift in our current attitudes. This will involve a transformation of human values, its political values, and normal behaviour to:

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L. Scott et al. (eds.), *Sustainable Ecological Engineering Design*,
https://doi.org/10.1007/978-3-030-44381-8_1

economic efficiency towards social equity, from individual rights to collective obligations, from selfishness to community, from quantity to quality, from separation to interdependence, from exclusion to equality of opportunity, from men to women, from luxury to necessity, from repression to freedom, from today to tomorrow, and from growth that benefits a few to genuine human development that benefits us all.

These words set out a vision of society moving in the opposite direction from the one we live in at present. We can compare them with the findings from the case studies.

After sharing the Earth with other, earlier hominins, *Homo sapiens* became the dominant species around 30,000–40,000 years ago. Emerging from Africa, *Homo sapiens* spread to Europe, Asia and America by 15,000 BC, eventually even colonising small islands in the Pacific Ocean. Human societies are complex adaptive systems, and form in response to the local conditions where they take root. The earliest societies evolved sustainable lifestyles, generally in harmony with their local conditions. If so, these societies must have achieved Social Sustainability, in a way that has been lost, or at least no longer exists. Today, in 2019, the fact that we no longer live sustainably is a matter of great concern, and the question arises; do we have any evidence of societies that lived sustainably among all the diverse societies in the world? How do these societies relate to the present global situation and what can we learn from them?

Writers on sustainability have recognised the three elements of environment, economy and society, and represented a sustainable situation in the form of a Venn diagram with three overlapping circles as shown in Fig. 1. Our present world is on a non-sustainable trajectory, and this could similarly be represented by a second Venn diagram where the circles do not overlap, as depicted in Fig. 2.

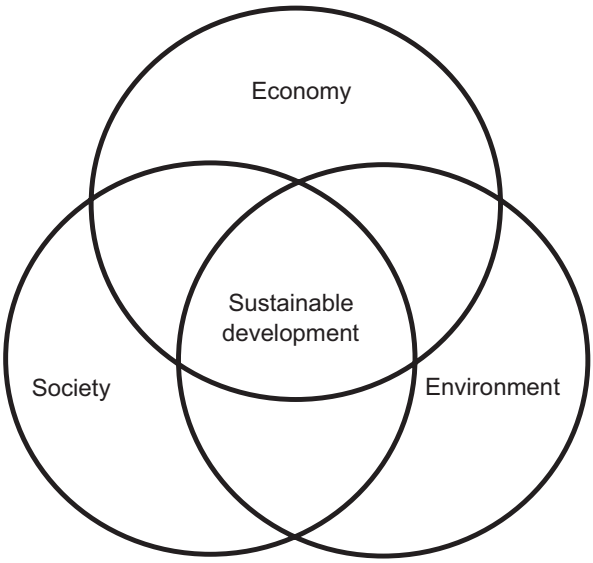

Fig. 1 Idealised picture of sustainability, with the environment, the economy and society being in harmonious relationship

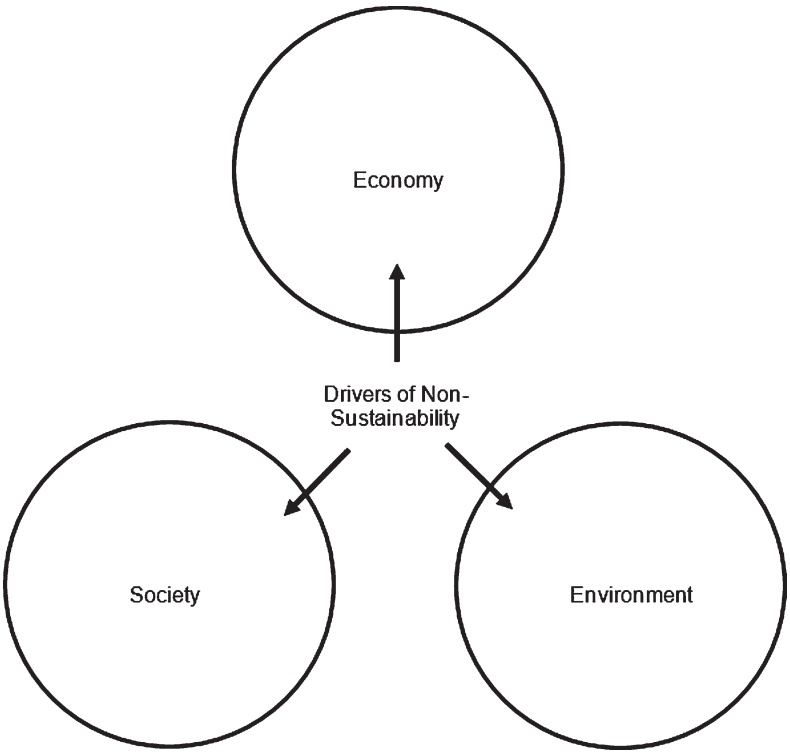

Fig. 2 Picture of our current non-sustainable situation where the environment, the economy and society are seriously out of harmony

Development of Human Society

The evolution of human society has been punctuated by a series of events that have changed its course. When *Homo sapiens* emerged as potentially the dominant life form on Earth around 200,000 years ago, he adopted the role of hunter-gatherer to survive. Then around 10,500 years ago, he began to adopt Agriculture. Just over 500 years ago, Spain and Portugal carved out empires for themselves in Central and South America and in Asia, and adopted the role of mercantile capitalists. Three hundred years later came the Industrial Revolution when industrial capitalism became the human role. Finally, following World War II came the evolution of consumer capitalism. Throughout history, man has always sought to maximise his access to energy, in whatever form. Table 1 below summarises the stages in human development, giving approximate dates, population sizes and *per capita* energy consumption. This table summarises the situation for most, but not all, of the human population of our world. When much of the world had reached the industrial and consumer stage, there were still a few remote societies living in the agricultural and hunter-gatherer modes.

Table 1 Showing transitions in mode of living, including dates, global population and per capita energy consumption

Mode of living	Date	Global population (millions)	Per capita energy consumption (W)
Hunter-gatherer	200,000 years ago	Ancestor group	300
Farmer	10,500 years ago	5	2000
Mercantile capitalist	1500 AD	500	2200
Industrial capitalist	1800 AD	950	4000
Consumer capitalist	1950 AD	2500	8000

Source: Lewis and Maslin (2018)

Each transition from one mode of living to the next is brought about by an increase in the amount of available energy, an increase in information available and an increase in the scope for human action. Although dates are quoted in Table 1, these transitions were not overnight changes, but took some time to become established. In addition, not all peoples and societies made all the transitions; this was determined by their remoteness or proximity to the great centres of population. However, at each stage, the adoption of the next stage gave rise to an increase in population, *per capita* energy consumption and an increase in CO_2 in the atmosphere. The transition from hunter-gatherer to farmer involved forest clearance to make way for fields to grow crops. The total number of trees on Earth at the hunter-gatherer to agriculture transition was around 6 trillion, whereas the number on Earth today is around 3 trillion (Crowther et al., 2015).

Having outlined the development of human society since the dawn of history, it is interesting to examine the scale of human energy and power consumption at various points over the past three millennia. Table 2 below taken from the work of Smil (2017) clearly illustrates the exponential rise in energy use by mankind during this time.

Newcomen's engine is an interesting item in this list as it represented the first time in history that someone had devised a way of converting fossilised sunlight in the form of coal into mechanical power and Lovelock (2019) suggests this event as the start of the industrial revolution. The engine was installed to pump water out of a deep coal mine near Dudley in Worcestershire. This event really should be linked with another development that occurred only about 20 miles away in the Severn gorge at Coalbrookdale when in 1708 Abraham Darby first smelted iron using coke (non-renewable) instead of charcoal (a renewable material). The industrial revolution could not have happened without a plentiful supply of iron, and iron production had been severely restricted by the limits placed on the cutting of timber to make charcoal. The ability to use coke 'liberated' iron-making from dependence on

Table 2 Power ratings from a candle to global power consumption

Examples and dates	Power (W)
Small wax candle burning (800 BCE)	5
Egyptian boy turning Archimedean screw (500 BCE)	25
Dutch Tread-wheel powered by 8 men (1500)	800
Newcomen's atmospheric engine pumping water (1712)	3750
Large Dutch windmill draining a polder (1750)	12,000
Calder Hall nuclear reactor (1956)	202,000,000
Rocket engine launching Saturn C5 rocket (1969)	2,600,000,000
Global commercial energy consumption (2015)	17,530,000,000,000

Source: Smil (2017)

timber and helped stimulate the demand for coal and the need for pumps to keep mines clear of flooding.

We shall now examine various societies that have achieved sustainability and where we have the evidence, what effect contact with western civilisation subsequently had on them.

Examples of Long-Term Sustainability

In finding case studies of sustainable societies, the work of Diamond (2006) and Norberg-Hodge (2000) has been most useful. These authors' treatment of the case studies was quite discursive, and so the main points will be summarised here. These societies were in various ways cut off from the main centres of population (Tikopia, New Guinea, Ladakh) or decided to cut themselves off from external contact (Japan) or never adopted agriculture and reliance on the land at all (NE Pacific Indian tribes of Alaska).

Tikopia

- Small Pacific Island, near Vanuatu and Solomon Islands, area 1.8 square miles.
- Continuously inhabited for 3000 years.
- Population kept at around 1200 by various birth control measures.
- The people lived by agriculture and fishing.
- Society organised on a bottom-up basis.
- They have exercised excellent stewardship of their environment.

New Guinea

- Large island in East Indies, first visited by Europeans four or five centuries ago.
- People have lived there sustainably for around 45,000 years.
- Until 1930s the interior was never explored and was believed to be uninhabited. Interior inhabited for thousands of years, with people living sustainably and independently from the rest of the world.
- Society organised on a bottom-up basis.
- Very sophisticated agricultural techniques developed.
- They have exercised excellent stewardship of their environment.

Japan

- Large island archipelago east of China, completely cut off from the rest of the world during the Tokugawa Shogunate from 1603 until its end in 1868.
- Christian missionaries ejected and foreign traders only allowed access to small island in Nagasaki Bay by order of the Shogun.
- Society organised on a top-down basis, and it enjoyed peace and prosperity for the duration of the Shogunate.
- No external wars were fought during the Shogunate.
- Population very stable during the Shogunate.

Ladakh

- Land-locked area under the Karakoram, in the trans-Himalayan region of Kashmir.
- It is a 2000-year-old kingdom, an area of Tibetan Buddhism, originally of Tartar herders who have adopted agriculture.
- People live in villages, largely organised on a bottom-up basis.
- They have adopted policies to limit and control their population size.
- They have adopted a very collaborative culture.
- They have exercised excellent stewardship of their environment.

Indian Tribes of North East Pacific in Alaska (Studied by Dr. Jago Cooper)

- These tribes are interesting because they never adopted agriculture, rather they have always depended upon fishing.

- They never developed a sense of ownership of land in the way that the previous four peoples mentioned above did, and they survived the impact of Europeans very much better than the Indian tribes living to the South and East in the USA and Canada.
- They have retained their traditional skills, for example, building wooden houses and making boats from tree trunks.
- They have exercised excellent stewardship of their environment.

Discussion

We have examined several societies that have lived sustainably for periods of time ranging from a couple of centuries to many millennia. Some were island communities, some located inland, all living by farming and just one set of coastal communities living by fishing. Because of their remoteness and inaccessibility they remained untouched by western civilisation until well into the twentieth century. The detailed information that we have is a result of prolonged contact made by a few people who took a great interest in them, who lived with them, befriended them and recorded their observations in detail. The work of Firth in Tikopia (1936, 1939) and Norberg-Hodge in Ladakh (2000) typify this approach.

Most of these societies achieved sustainability by a bottom-up approach, i.e. they did it by collective decisions. Tokugawa Japan was the exception, and this was due to the remarkable character of Tokugawa Ieyasu, who combined a certain military genius with an outstanding capacity for wise statesmanship. The leadership that he gave and the decisions that he took ensured that the Japanese enjoyed a good standard of life and freedom from warfare for over two centuries, and Japan benefits from his legacy to this day.

Much of the literature on sustainability and the future of human civilisation today makes frequent reference to the problems posed by the Earth's burgeoning population. It is the multiplier that exacerbates all our problems. Remarkably, all the societies described in this study solved this problem, taking steps to ensure that there were never too many mouths to feed. Furthermore, following contact with western civilisation, these societies became non-sustainable, and they suffered rapid population growth. Norberg-Hodge (2000) describes this process very well. We have seen that human society passed through various historical transitions to reach its present form. Drawing on what we have learned from the case studies outlined above, we can see that the transition from hunter-gatherer to agriculture did not lead to a non-sustainable society though it did give rise to a modest increase in population. The next transition from agriculture to mercantile capitalism did produce a society that was ultimately non-sustainable. It involved an increasingly intensive agriculture and the growing of cash-crops using slave labour. To make way for this, forests were cleared on an increasing scale, leading to an increase in atmospheric CO_2. The initial impact of the Spanish and Portuguese conquest of their American empires was to cause a population crash among the native Indians who succumbed

to the European diseases against which they had no immunity. The number who died is not known but median estimates of around 50 million have been quoted (Lewis & Maslin, 2018). The immediate result of this was that Indian farmland reverted to forest bringing about a reduction in atmospheric CO_2. This may have helped bring about the mini 'ice age' noted in Europe. However, once the Spanish and Portuguese began growing cash-crops with slave labour, the situation was reversed again. These events illustrate just how sensitive our world is to changes that in former years were thought to be insignificant.

The transition to industrial capitalism was enabled by the increasing use of non-renewable sources of materials and energy. Agriculture became increasingly mechanised, leading to migration of redundant farm workers to the towns which became centres of manufacturing industry. The overall social cohesion in the form that could exist in rural village communities was completely lost, and people could no longer take responsibility for their lives. We have now reached the point where over half of the world's population live in cities. Cities are covered in concrete and asphalt, which act as solar-powered storage heaters, leading to the 'heat island' effect. In this age of consumer capitalism, millions of tonnes of manufactured goods are transported around the globe in huge container ships, causing more atmospheric and marine pollution. Each development leads us further down the path of non-sustainability. Globalisation means that most nations around the world are now following the western development model, but the chances of achieving global agreement on steps to reverse global warming are vanishingly small. We have entered a 'development trap' and it is not clear how we can escape.

The work on Ladakh reported by Norberg-Hodge (2000) is in general agreement with the descriptions of Tikopia, New Guinea and Japan reported by Diamond (2006), but it has the advantage of being a primary source. In it, she gives a very balanced and finely nuanced account of the impact of the west, pointing out all the advantages and drawbacks of each society. Both authors refer to the fact that western men automatically assumed a position of cultural superiority to the 'undeveloped' societies they discovered without taking time to study and understand them. This was usually unjustified, and in a few cases fatal. In New Guinea, westerners saw the vertical drainage channels used on the terraces where yams and sweet potatoes were grown. They 'knew' this was wrong and persuaded a few of the islanders to use horizontal channels. These retained water and during the next heavy rainfall the whole terraced system, crops and all were washed down the valley and into the river. Flannery (2019) also reports a conversation with New Guinea islanders. They were observed planting fruit and nut trees which took several decades to produce food, but which were known to attract game animals. The New Guinea people were asked why they did this when they would not live to obtain the benefit, and their reply was that they did it to ensure that their grandchildren had something to eat. This is inter-generational thinking, part of sustainable living. They were wiser than the westerners asking the questions. In 1845, Sir John Franklin led a well-resourced expedition to find the North West passage with 134 men. The crew had some contact with the Inuit whom they looked upon as savages, and they all perished because of this attitude. The Norwegian, Roald Amundsen, the man who succeeded, took the

trouble to live with the Inuit for some months prior to his attempt and learned how to survive the Arctic conditions.

Clearly these apparently primitive societies had developed highly sophisticated agricultural practices. Their techniques were not wasteful and did not rely on huge tonnages of artificial fertilisers as are employed by western farmers. Soil fertility was maintained in a non-polluting way without the degradation produced by western 'industrial agriculture'. Modern, industrial agriculture is thermodynamically less efficient than traditional farming, as illustrated in Table 3 below.

The data is from the USA and relates to the growing of maize, a high-energy food crop. It shows a comparison between the total energy inputs and food energy outputs for the years 1950 and 1970. This is particularly interesting because 1950 was the year that industrial agriculture took off. The first thing to notice is that labour input was halved, while food energy output more than doubled, i.e. productivity has been quadrupled. This is the basis for claiming that this type of farming is more 'efficient' than the traditional methods. However, the figures also show that the ratio of energy input to output is lower than the traditional route (2.82 as against 3.18). This represents lower thermodynamic efficiency. The other factor to notice is the tremendous increase in the use of artificial fertilisers (figures for nitrogen, phosphorus and potassium) and insecticides and weed killers. It must be remembered that these figures relate to 1970, nearly 50 years ago, and industrial agriculture is pursued more intensely today. Another factor is run-off from agricultural land during rainfall. The excess fertilisers end up in streams and water courses, rivers and eventually the seas, where they cause algal blooms and eventually dead zones. The cost in biodiversity loss and loss of fish stocks is never taken into account, because

Table 3 Production of maize

Energy input type	1950 (MJ/acre)	1970 (MJ/acre)	% Change
Labour	41	21	−49
Machinery	1047	1758	+67
Gasoline	2578	3336	+32
Nitrogen	527	3938	+647
Phosphorus	64	197	+208
Potassium	44	285	+548
Seeds	169	264	+56
Irrigation	93	142	+52
Insecticides	5	46	+820
Weed killers	3	46	+1433
Drying	126	502	+298
Electricity	226	1298	+474
Transport	126	293	+132
Total energy input	5049	12,126	+140
Maize—food energy—Output	16,034	34,177	+113
Ratio output:input	**3.18**	**2.82**	

Energy inputs and outputs for the years 1950 and 1970
Data supplied by Prof. D. Bradley (2005), F.R.S., University of Leeds

neither the fertiliser manufacturer nor the farmer sees the results of this type of agriculture. The manufacturer of industrial chemicals just looks at his bottom line. The farmer just looks at the costs of operating his farm. There is no overall oversight, no one can take responsibility for the system, and this illustrates the disconnection between action and results that typifies the western world. This situation did not exist in sustainable societies; we have entered a 'development trap' of global proportions and therefore we do not have social sustainability.

This example is drawn from agriculture and not from construction and building, but it illustrates very clearly the importance of social sustainability. The evolution of mercantile capitalism, industrialisation and the consumer society leading to a human population explosion have combined to drive the economy, society and the environment out of alignment.

Summary of Conclusions

Certain conclusions can be drawn from the case studies of sustainable societies, as follows:

- These societies were free from outside influences.
- They had a finite area of land available to them.
- They knew that there was an upper limit to the amount of food they could produce, and this knowledge placed an effective upper limit on their population size.
- They devised strategies to keep their populations at a stable size.
- They adopted cultural attitudes that emphasised collaboration rather than the exercise and assertion of individual rights to ensure the survival of their societies.
- They exercised good stewardship of the environments in which they lived.

In the western, modern world we have placed too much emphasis on the economic bottom line, over-emphasised individual freedom and rights, and placed no emphasis on responsibilities.

- These societies have adopted a culture based on individual liberty and the exercise and assertion of individual rights.
- Little or no emphasis has been placed upon individual responsibilities or obligations to society.
- People are unable to take responsibility for their own lives. They increasingly rely on what others provide and cannot know where things come from, or whether they are obtained sustainably or in ways damaging to the environment.
- Because of this detachment, blame for the ills of society is often placed on the wrong people and money and resources are devoted to symptoms rather than causes.
- Western societies have exercised 'freedom to pollute' and did not exercise good stewardship of their environments.
- Adoption of western ways of living has always led to a large population increase.

The main conclusion to be drawn from this must be that without the achievement of social sustainability, overall sustainability cannot be achieved. Everyone in society must be involved, and this involvement must ultimately be global. This is often referred to as the age of 'globalisation', but ironically, we have globalised the drivers of non-sustainability, but not the social sustainability which is of such vital importance.

Acknowledgements The author acknowledges the helpful discussions and encouragement given by his colleagues Mike Bates and Chris Gorse.

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Urbanisation and the Built Environment: Exploring How the Built Environment Can Enhance the Health and Wellbeing of the People Living in Urban Slums

Lilian Nwanyisonde Smart, Dilanthi Amaratunga, and Richard Haigh

Introduction

According to the report from UN-Habitat (2015), one in eight people live in slums resulting in a total of 1 billion people living in slums conditions around the world today. Despite the argued progress in improving slums and preventing their formation which led to a decrease from 39% to 30% of urban slum dwellers in developing countries between 2000 and 2014, the absolute numbers have continued to grow. Shockingly, projections also show that this number could rise to about 2 billion over the next 30 years, and 3 billion by 2050 (Moir, Moonen, & Clark, 2014; UN-Habitat, 2003). The UN-Habitat (2015) sees the slum issue as a huge challenge that remains a critical factor for the persistence of poverty in the world. These are crucial revelations on the persistent growth of slums, a growth that has continued to result to an increased health and wellbeing challenges. Unfortunately, the population of the people residing in urban slums increases with the increased rate of urbanisation. According to Krefis, Augustin, Schlünzen, Oßenbrügge, and Augustin (2018), rapid urbanisation itself contributes to making the health and wellbeing of the people an increasingly distinguishable challenge.

The report from the World Health Organisation (WHO, 2017), however, sees high rate of urbanisation as a welcomed development, stating that growing cities play a crucial role in promoting and protecting the health and wellbeing of the people. While Bai, Nath, Capon, Hasan, and Jaron (2012) acknowledge that health and wellbeing status is better in urban areas than the rural areas, they assert that cities contribute hugely to human health and wellbeing challenges instead of promoting and protecting it. Following the review of some studies Bai et al. (2012) argue that most advantages of the cities especially those that have to do with the health and wellbeing of the people can be windswept by the adverse challenges emanating

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L. Scott et al. (eds.), *Sustainable Ecological Engineering Design*,
https://doi.org/10.1007/978-3-030-44381-8_2

from the urban environment. Pineo and Rydin (2018) argue that the most difficult of these challenges facing the world today is how to accommodate the teeming urban population in a way to ensure long-term health and wellbeing of the people and to provide them the opportunity to live a fulfilled life.

With this, Pineo and Rydin (2018) have identified the lack of adequate accommodation as well as the inability to provide the residents with opportunities to live a fulfilled life as part of the factors that escalates the health and wellbeing challenges in the urban centres. It is arguable that some of the immediate effects of this lack of adequate accommodation in these cities could be a high cost of accommodation and an increased population in urban slums environments where the accommodation cost is presumably affordable. Accordingly, the need to conduct detailed research on the health and wellbeing of this increased number of people living in such deplorable environment called slums emerges.

Krefis et al. (2018) note that several disciplines, including public health, urban planning, and natural sciences, have conducted remarkable research on the link between urban areas and health and wellbeing of the people. Different institutions such as World Health Organization (WHO), the London School of Economics and Political Science (LSE), and the Healthy People 2020 Organisation that monitors health-related issues researched the health and wellbeing of the urban residents. Additionally, the International Council for Science (ICSU) came up with plan on facilitating health and wellbeing in the changing urban environment, focusing on the importance for shaping cities for health (ICSU, 2011). Moreover, Krefis et al. (2018), who researched most of these body of literature, point out that the major recommendations from the above institutions basically centre on improving urban health and wellbeing in order to reduce health inequalities and to build capacity on national and regional levels (see also WHO, 2017). These elaborate studies show the importance of providing a health and wellbeing-enabling environment for the people residing in the cities. However, we observed from the review that these studies do not cover issues on the health and wellbeing of people who reside in urban slums built environments, meaning that the researchers seem silent on this crucial aspect of research. Accordingly, this study focuses on the health and wellbeing of the slum dwellers and their built environment. The aim is to demonstrate how to design and structure the urban slum built environments to enhance the health and wellbeing of the residents. The question emanating from the aim of research is: how can an urban built environment be structured and designed to enhance the health and wellbeing of the residents? With this question, we will be able to identify the exact ways the built environment can be restructured and redesigned to enhance the health and wellbeing of the people in urban slums.

Therefore, to be able to answer this question, this study is divided into sections; the section after this introduction is the methodology in brief. Followed by the section on the concept of urbanisation, this will immediately be followed by definitional perspectives on the term urban slums and the concept of the built environment. The section following will be the review of literature centring on the health, wellbeing, and the built environment. This will be followed by the discussion of the characteristics of the health and wellbeing-enhancing built environment. After this, there

will be a section on how to structure the urban slums built environment to enhance the health and wellbeing of the residents. Then the conclusion of the study.

Methodology

This methodology section describes actions taken to investigate the research problem, detailing the processes of data generation. Instead of the use of the qualitative, quantitative, or mixed-method research design, which uses such methods as interviews, focus group discussion, experiments, and surveys, an integrative literature review method was employed in this research. To address the topic which centres on exploring how the built environment can enhance the health and wellbeing of the people living in urban slums, the researcher reviewed various relevant pieces of literature on the topic area, mainly to find out the current debate in this area and identify the research gap. The literature was sort through different search engines. Some of these search engines include the university summons, google scholars, Business Source Premier (EBSCO), Emerald Management e-Journals, and Science Direct (Elsevier) electronic databases.

After searching and gathering the literature materials, about 50 different literature, they were read intensely, analysed, and critiqued, and about 27 of the work that are most relevant to the study were synthesised and used to be able to come up with an argument in this study. The reason for the use of this method is because, first, there is elaborate recent literature on the built environment, urbanisation, urban slums, and other keywords of the research which is capable of providing the researcher with recent on-going debates in the area. This is important because, to be able to find the gap in the literature, there is need to review literature massively to understand the trending arguments around the topic as well as ascertain the areas that are less researched. Secondly, the researcher has no intention to do a fieldwork data collection for the research presently but solely depended on the literature-based data. Moreover, the extensive literature review was able to help the researcher to achieve the research aim and answer the research questions posed, thereby addressing the identified research gap.

The Concept of Urbanisation

There is no stereotype definition of the concept of urbanisation, as some scholars define it from their perspectives. According to McGranahan and Satterthwaite (2014), urbanisation generally involves the shift in population from rural to urban settlements. To make this very clear, McGranahan and Satterthwaite (2014) state that urbanisation does not occur when urban and rural populations grow at the same pace, that for it to take place, the urban population of the cities must outgrow that of the rural areas. This explanation entails that urbanisation can only occur when the

share of a country's population that resides in the cities outweighs its rural counterparts. Based on this, urbanisation is defined as the increased total number of a country's population that resides in the cities as against their rural counterparts.

According to Pineo and Rydin (2018), city residents have access to parks, public transport, healthy food and other amenities that support health and wellbeing, and the concentration of opportunities and services in urban areas is advantageous to the health and wellbeing of urban residents. Pineo and Rydin (2018), however, argue that the densely populated living and working conditions in cities equally create conditions for the spread of pollution and diseases in the cities. The last line of argument shows that the same urban built environment equipped with facilities that can help to improve the health and wellbeing of the occupants can equally generate health and wellbeing challenges especially if the urbanisation is rapid and unplanned. According to Krefis et al. (2018), rapid urbanisation aggravates the already complicated and prevalent health and wellbeing challenges in our urban centres. This scenario implies that as the urban population grows, the urban built environment becomes unconducive for the enhancement of the health and wellbeing of the people due to density and pressure in the built environment. It could be on this basis that Burdett and Taylor (2011) and Krefis et al. (2018) conclude that the urban environment provides some of the best as well as some of the worst environments for health and wellbeing. Perhaps, this is because, according to Pineo and Rydin (2018), there are different life-threatening communicable diseases present in the urban centres which pace of transfer from one person to another increase with the increase in the urban population.

Bai et al. (2012) also identified that apart from the prevalent communicable diseases in fast-growing cities, there is also the rise of other chronic and non-communicable diseases in the cities. The latter diseases result from unhealthy urban lifestyles such as physical inactivity, unhealthy diets, tobacco smoking, and harmful use of alcohol. The physical inactivity and unhealthy diet can be said to be mostly a consequent of the features, designs, and structure of the built environment. According to Bai et al. (2012), other health issues ravage the urban environment, which also increase with the pace of the urban population growth, and they include the following:

- Prevalent infectious diseases resulting from overcrowding in substandard living conditions and urban squalors—this one is very rampant in urban slums built environment.
- Diseases associated with industrial pollution—acute and chronic diseases such as respiratory disease and pulmonary cancer.
- Some injuries that result from motor vehicle collisions, violence, and crime.

From the above, it is clear that rapid urbanisation hugely contributes to most of the health and wellbeing challenges that bedevil both the main cities and the urban slum areas. The argument is that this rapid urbanisation mounts significant pressure on the built environment resulting to such issues like overcrowding, urban congestion, and increased population in urban slums. This pressure on the concerned built environments can be seen as perhaps the most spectacular of the consequences of rapid urbanisation. No wonder Bai et al. (2012) argue that one of the effective ways to resolve these problems can more probably be through addressing

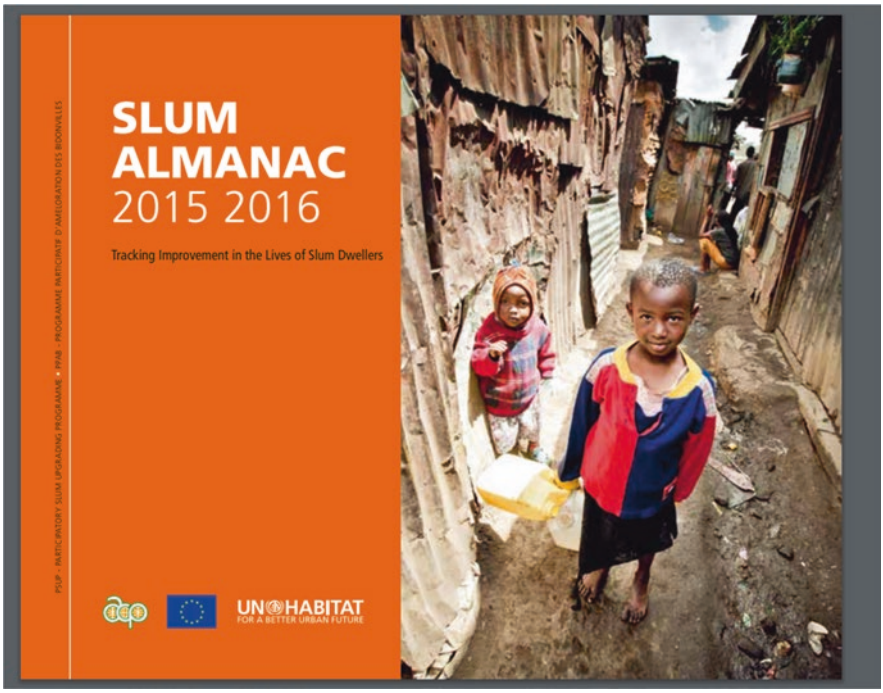
the urban environmental issues rather than focussing narrowly on healthcare facilities. Indeed, this a good suggestion which further justifies the reason why this study focuses on the built environment, the health and wellbeing of the people in urban slums. Therefore, how can we make sense of the concept of urban slums?

What Is Urban Slum?

Ezeh et al. (2017) statistically demonstrates that enormous slums characterise most of the cities in many developing countries today, with the population of slums increased massively in the past 60 years. The United Nations Educational Scientific and Cultural Organisation (UNESCO) defines urban slums as urban spaces characterised with inadequate housing and essential services (UNESCO as quoted in Ezeh et al., 2017). This explanation may mean that any urban area that lacks both adequate housing and basic amenities is classifiable as urban slums. This, however, may not be a sufficient explanation of what an urban slum entails. Ezeh et al. (2017) state that the most used and pertinent definition of slums is the one given by the United Nations Human Settlements Programme (UN-Habitat), a definition based on households. According to UN-Habitat, the slum household is defined as a group of individuals that live under the same roof with the lack of one or more of the following conditions: access to improved water, access to improved sanitation, sufficient living space, the durability of housing, and secure tenure. According to Ezeh et al. (2017), the health of the slum dwellers is mostly jeopardised by such factors as inadequate water supply, sanitation, and drainage and the lack of rubbish collection in a crowded environment which influences obstinate diarrhoea and diseases such as typhoid, hookworm, and cholera that characterises slum settlements.

Ezeh et al. (2017) advance that an unfortunate aspect of the slum settlements is that children are specifically vulnerable because of such factors as low breastfeeding rates, under-nutrition, and poor sanitation, which predispose children to chronic diarrhoea, impaired growth, and cognitive development (please see Ezeh et al., 2017 for more details). According to UN-Habitat (2003), slums are the physical and spatial manifestation of urban poverty and intra-city inequality. Regarding abject poverty in urban slums, Ezeh et al. (2017) state that the health and life of the people in urban slums are usually under threat whenever they get ill because of the lack of extra cash to take care of their health. This is a clear indication of the fact that slums are poverty-stricken places with poverty being one of the primary reasons why people reside there. In fact, Ezeh et al. (2017) raise the unfortunate historical case of the marginalisation and stigmatisation that urban slum dwellers face, and how they experience displacement, expropriation of property, and the denial of access to essential services for a long time.

Arguably, the definition of urban slums provided above is grounded in the condition of the slums built environment and the health and wellbeing challenges of the people resulting from the said environments. However, it is important to state here that urban slums are not to be seen as an informal settlement because even in Sustainable Development Goals (SDGs), informal settlements and slums are treated



Pictorial representation of urban slums. (Adapted from UN-Habitat, 2015)

as two different terms (Ezeh et al., 2017). However, like informal settlements, urban slum increases mostly with an increasingly urban population, which means that as the population in the cities increases, the population in urban slums increases even more rapidly, despite the deplorable conditions of slums.

Indeed, the condition of the slum dwellers is pathetic, and this may be why the UN-Habitat (2003) advised that tackling this situation hugely depends on the rate at which urban policies should continue to aim at using better housing policies to create safer cities for the urban low-income population, especially slum dwellers. Urban planning and management policies should be designed to prevent the emergence of slums, to create cities without slums, and to even resort to slum upgrades with new urban planning strategies. This suggestion is essential considering the longstanding consequences of living in urban slums environment. However, it is worrisome that despite these strong recommendations given in 2003, recent studies still demonstrate that adequate attention has not been paid on creating an urban slum built environment that can facilitate the health and wellbeing of the people (Ezeh et al., 2017). It is worrisome mostly because according to the review, it is detrimental for people to continue to live in urban slum built environments. That gets one wondering why the government, policy makers, and building professionals seem to neglect enacting effective policies that will help to create habitable cities that are also void of any manner of slums. For the sake of clarity, the factors that characterises urban slums built environment are represented in Fig. 1.

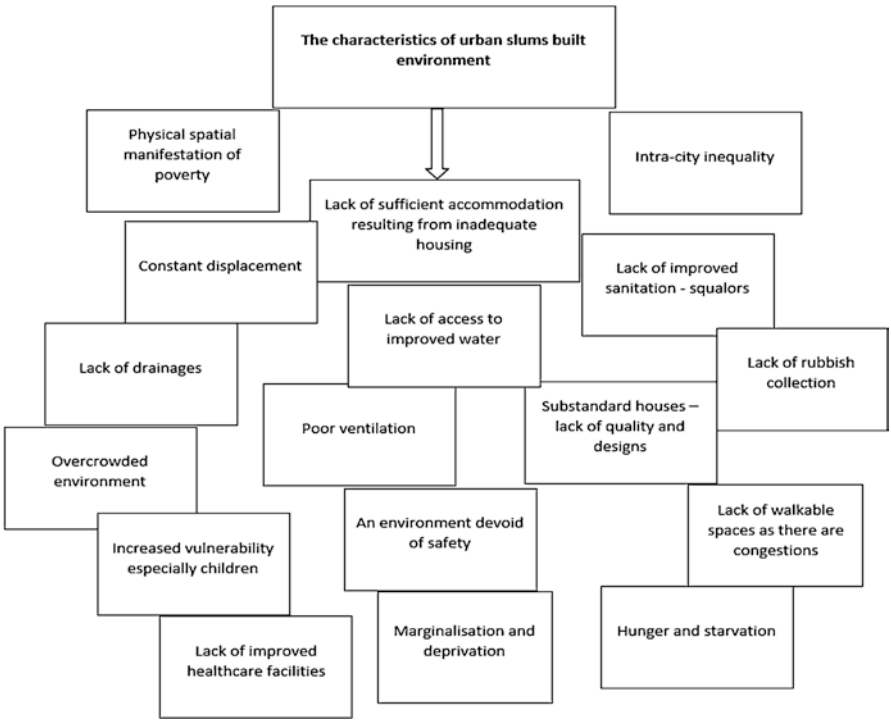


Fig. 1 A framework demonstrating most of the factors characterising the urban slum built environments

A built environment characterised by these factors will continue to be inimical to the health and wellbeing of the people. However, not all built environments have the full blast of these characteristics; it is more prevalent in urban slums. No wonder Ezeh et al. (2017) assert that there is a need to differentiate between the health of the people who reside in a well-built and structured built environment from the health of the people who reside in urban slums. According to them, this distinction should be mainstreamed in the implementation of the Sustainable Development Goals and the New Urban Agenda. In fact, the above framework as well as the pictorial representation of an instance of urban slum is a pointer of the significant differences between the slum and some of the well-designed cities we know of—the major differences is in their built environment. At this point, it becomes important to discuss the concept of the built environment.

The Concept of the Built Environment

According to Barton (2009), a built environment has to do with the planned and structured aspects of our surroundings, which include buildings, transit routes, and parks. Frank and Engelke (2005) define the built environment as an environment

with all the physical structures in which we live, work, travel, and play such as houses, apartments, offices, parks, streets, shopping centres, parking lots, factories, superhighways, transit stations, and so on. To Glasgow Centre for Population Health (2013), the built environment is the physical structures engineered and designed by people to live, play, and socialise. While Williams (2013) acknowledges these definitional perspectives of the built environment which according to him comprises hard infrastructure like houses; he argues that there is no need for the neglect of the role of soft infrastructure like walkable routes in the built environment. According to him, these routes encourage interactions as well as make goods and services accessible. The inference from the assertion of Williams is that there should be a connection between the natural environment and the built environment to create a more conducive environment. Writing about this Glasgow Centre for Population Health (2013) adds that the connection between the built infrastructural spaces and a range of natural features should be an integral part of the built environment. Indeed, the above has called our attention to the fact that the built environment is not just the place we live and work, it is much more than that and should comprise carefully styled hard and soft infrastructure, which is a combination of the built and the natural spaces.

The importance of designing a carefully styled built environment that has the above qualities is paramount because it will positively influence people's lives (Bergman, 2018). Bergman (2018) advance that the built environment, on the whole, plays a vital role in influencing people's lives and their overall performances. Williams (2013) states that the components of the built environment affect our daily decisions and the way we live our lives. Further to this, Frank and Engelke (2005) explains that the technique used to design and build our environments has significant impacts on the decisions we make, our health, and quality of life. Moreover, Williams (2013) confirms that the design and layout of the built environment can significantly contribute to our psychological and physiological health and wellbeing. Thus, these authors have reminded us of the connection between the built environment, the health and wellbeing of the people as well as our daily decisions and possible productivity. From this, one can conclude that most health and wellbeing challenges that people face are traceable to the environment they found themselves.

These scholarly definitions above show that the built environment is supposed to be a well-planned, duly structured, conscientiously engineered, and nicely designed quality environment where people can comfortably live, work, play, socialise/interact, travel, walk, and spend their entire lives. In addition, it is arguable that every built environment is made by the people and for the people's habitations and comforts, and its designs and features have a considerable impact on the health and wellbeing of the occupants. In all, the built environment possesses specific attributes that can either hamper or enhance the health and wellbeing of the people depending on some factors. Moreover, the definitions show that building professionals do have a significant role to play in getting the built environment right because it is more dangerous not to get it right. Getting it right here means ensuring that there are not only places to live, but also places to work, play, socialise/interact,

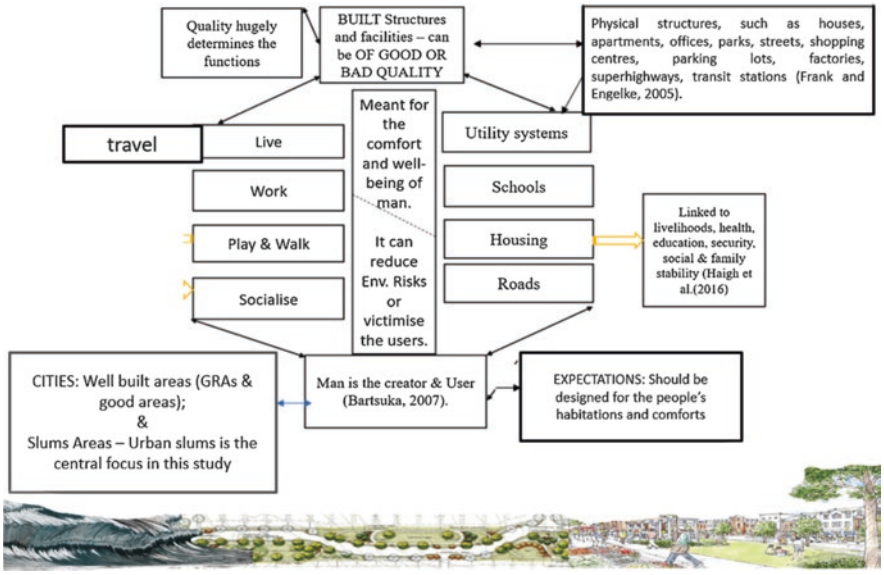


Fig. 2 Framework that demonstrates the meaning of the built environment

walk, and travel as stipulated by the scholars above. Below is a framework demonstrating the meaning of the concept of the built environment (Fig. 2).

Unfortunately, the discussion on urban slums above seems not to reflect the meaning of the built environment spelled out in the above framework, no wonder the health and wellbeing of the slum dwellers remain at stake more than that of the people residing in a more conducive built environment. With these enumerations, it is essential to discuss the health and wellbeing of the people in the context of the built environment. This section will help us to understand correctly the connection that exists between health, wellbeing, and the built environment.

Health, Wellbeing, and the Built Environment

The World Health Organization (WHO) defines health as a state of complete physical, mental, and social wellbeing of the people, not just the absence of disease. According to Barton (2009), this definition explained health in its wholesome perspective, associating it with the social, economic, and the environmental aspect of life. Pineo and Rydin (2018) show that the urban environment has long been recognised as an essential determinant of the health and wellbeing of the residents. A situation where the more significant part of the health and wellbeing of the people hugely depends on their environment. The definitions have shown us that health may be seen as physical, mental, and social completeness, which is associated with the social, economic, and environmental aspects of life. From this, we can conclude

that social, economic, and environmental factors could trigger health and wellbeing-related challenges. However, this study looks at environmentally induced health and wellbeing challenges in urban slums. According to Dodge, Daly, Huyton, and Sanders (2012), the term wellbeing is a growing area of research, and the question of how it should be defined remains unanswered. Notwithstanding, Dodge et al. (2012) propose that wellbeing is the balance point between an individual's resource pool and the challenges they faced. To them, the individual resources that determine his/her wellbeing includes psychological, social, and physical forces. Some other scholars said wellbeing of such factors as happiness, the satisfaction of life, and quality of life explains the wellbeing of an individual (Bai et al., 2012; Kjellstrom et al., 2007).

The above has provided us with some of the vital concepts with which to explain the health and wellbeing of the people. Perhaps the most striking of it all is the fact that what affects the health of an individual may equally affect their wellbeing and vice versa. For instance, people with mental, social, and environmental issues may as well lose their happiness, satisfaction of life, and quality of life and vice versa. With this, it is arguable that the best way to enhance the wellbeing of the people is to equally enhance their health and quality of life and vice versa.

Therefore, wellbeing in this study is defined as a state of mind enveloped with peace, happiness, satisfaction emanating from psychological soundness and impressive social, physical, and or environmental factors. This, in the real sense, means that psychological, social, as well as environmental factors have huge effects on people's wellbeing. Our interest in this study, however, is the effect of the environmental factors (built environment) on the health and wellbeing of the people. The recent research conducted by Pineo and Rydin (2018) demonstrates that chronic health conditions that impose high costs on countries are rising globally, that in the UK alone, these health conditions accounts for about 70% of the spending on health and social care. According to Pineo and Rydin (2018), this alarming rate of chronic health conditions in the UK, which are strongly influenced by the built environment, is preventable. Pineo and Rydin (2018) also suggest that this uncalled-for expenses on health issues is preventable if the built environment is redesigned and reconstructed in such a way it can help facilitate the health and wellbeing of the people. The absence of this may result in the inability to avert this rapid health issues. Indeed, this is a strong recommendation that needs implementation without any form of delay to at least prevent the health and wellbeing challenges associated with the built environment that are preventable according to Pineo and Rydin (2018).

Some scholars are clear on the fact that the built environment has a strong influence on our health and majorly determines the wellbeing of the people (Barton, 2009; Freeman, Thompson, & Jalaludin, 2011). The relationship between the built environment, health, and wellbeing of the people is becoming clear through these various arguments, unlike the argument of Bai et al. (2012), which states that the relationship between wellbeing and health and the urban built environment is unclear and needs detailed explanation. The supportive role of the built environment for human health is a fast-growing area of interdisciplinary research, evidence-based policy development, and other related practices (Kent & Thompson, 2012).

In addition, the increasing link between the built environment, physical, mental, and social wellbeing of residents has caught the attention of public health professionals and land use planners (Majid, Cox, & Wu, n.d.). The reason is not farfetched, and it is perhaps because human beings spend their lives in the built environment, like their houses, offices, and so on. Haigh, Hettige, Sakalasuriya, Vickneswaran, and Weerasena (2016), writing about housing, clearly show that housing is an essential and complex asset linked to livelihoods, health, education, security, and social and family stability. Barakat (2003) equally shows that housing is essential to the well-being and development of societies; that it is a complex asset, which has links to all of those listed by Haigh et al. (2016).

From the preceding, it is clear that there is a link between the built environment, health, and wellbeing of the occupants. It is also clear that the built environment can affect the health and wellbeing of the people positively or negatively. The inference is that in order to enhance the health and wellbeing of the urban residents, the role of built environment is paramount. This is not to pretend that there are no other factors that affect people's health and wellbeing negatively; the focus in this study is on the built environment. While it is crucial to acknowledge the clarity and consensus of these scholars on the impact of the built environment on the health and wellbeing of the people, what seems missing is a clear indication of how the built environments can be designed and structured to enhance the health and wellbeing of the occupants in urban slum environments. Indeed, this should be an essential part of a study of this sort. Thus, it is vital to discuss the possible factors that characterises a health and wellbeing-enhancing built environment before proceeding to discuss how these factors can help to facilitate the health and wellbeing of the people.

The Supposed Characteristics of the Health and Wellbeing-Enhancing Built Environment

It is crucial to start this section by stating that the built environment is everywhere both in the rural areas, main cities, informal settlements, and urban slums. Although there may not be any perfect built environment, its impacts on the health and wellbeing of the occupants depend hugely on how developed the area is and the features, designs, and structure of the built environment. This means that there may be a level of health and wellbeing issues connected to every built environment no matter the location. However, this study does not pretend to cover all these areas. Its focus is on the urban slums built environment. Without a doubt, understanding the impacts of the built environment on the health and wellbeing of the people who reside in urban slums should be of paramount importance to the policymakers, governing authorities, as well as the building professionals. The reason is that there are several conditions in urban slums built environment that can threaten the health and wellbeing of the people, and some of these conditions require urgent eradication (please see above for the description of the conditions in urban slums). Moreover, it is

essential to state here that the conditions in an urban slum built environment can be said to be much more deplorable when compared to the built environment in most of the main cities.

At this point, it is necessary to discuss the possible factors that can be associated with the urban built environment. Majid et al. (n.d.) assert that there are numerous factors in the built environment which can hugely affect the quality of life and well-being of an individual and these factors include pollution—air and water, the natural areas, and public green spaces. Pineo and Rydin (2018) confirm that lack of air pollution, the presence of green, and walkable spaces for increased physical activity are among the factors that should be found in a built environment. Writing on the need for physical activity in a built environment, Williams (2013) suggests that for a built environment to be capable of promoting physical activity it should make provision for safe pedestrian routes, connected street networks, ample street lighting, dynamic land-use mix, and recreational centres.

In confirmation of the need for the provision of spaces for physical activity in the built environment and the need for designing street networks, some other scholars add that there should also be walking and cycling routes (Freeman et al., 2011; Kent & Thompson, 2012). That also, there should be the creation of an environment for social cohesion. Thus, the expression of social cohesion has emerged in this study, and it is vital to explain it before moving forward, albeit in brief. According to Dempsey (2008), the study of social cohesion or 'the social glue of a society' is a long-standing study which centres in examining society and social relations in a variety of social settings. To Mannakkara and Wilkinson (2013), a cohesive society is a society that 'hang together', partly through social interaction. According to them, this integration of individuals can partly be achieved through residents interacting with one another and getting to know neighbours, and the absence of these results in people being stuck in loneliness and living their separate lives in the same area (this is social isolation).

These elaborations have shown that it is good for the built environment to enhance social cohesion instead of social isolation because social isolation can have devastating effects on health and wellbeing. For instance, Kent and Thompson (2012) found out that social isolation and obesity are among the significant risk factors for many of the chronic diseases facing contemporary society. Therefore, instead of social isolation, the built environment must connect to enhance social cohesion amongst communities, to strengthen communities, neighbourhood, social relations, and social networking (Freeman et al., 2011; Kent & Thompson, 2012). Glasgow Centre for Population Health (2013) adds that the designs and the quality of the built environment affects social connections, accessibility, and physical activity levels. Thus, the emphasis on the importance of getting the features, designs, and quality of the built environment right has been laid. Moreover, Pineo and Rydin (2018) state that the urban built environment needs to have reasonable access to healthy food through the reduction of fast-food centres around school environments. There should be the retention of peri-urban agricultural lands to enable the ease assessment of affordable healthy food as well as put measures in place to encourage the establishment of community and farmers gardens. The essence of this is to

ensure that people live in a suitable environment as well as have easy access to the required diet from their environment.

Indeed, the above has provided us with some of the crucial factors that characterises health and wellbeing-enhancing built environment. The review has also shown that a built environment is not only the houses we live, the offices or places we work, or the shopping malls, but it is also an environment where we do such things as play, socialise, walk, and cycle. It is an environment that should have natural areas, greenery areas, walkable spaces, reasonable access to healthy foods, and spaces for social cohesion. It can be added that an urban built environment needs to have an improved water supply, improved sanitation, waste management techniques, and enhanced health care facilities. These factors are fully noted in this study. Accordingly, the next section will be the discussion of how the built environment can help to facilitate the health and wellbeing of the people in urban slums and it will further be represented in a framework (Fig. 3).

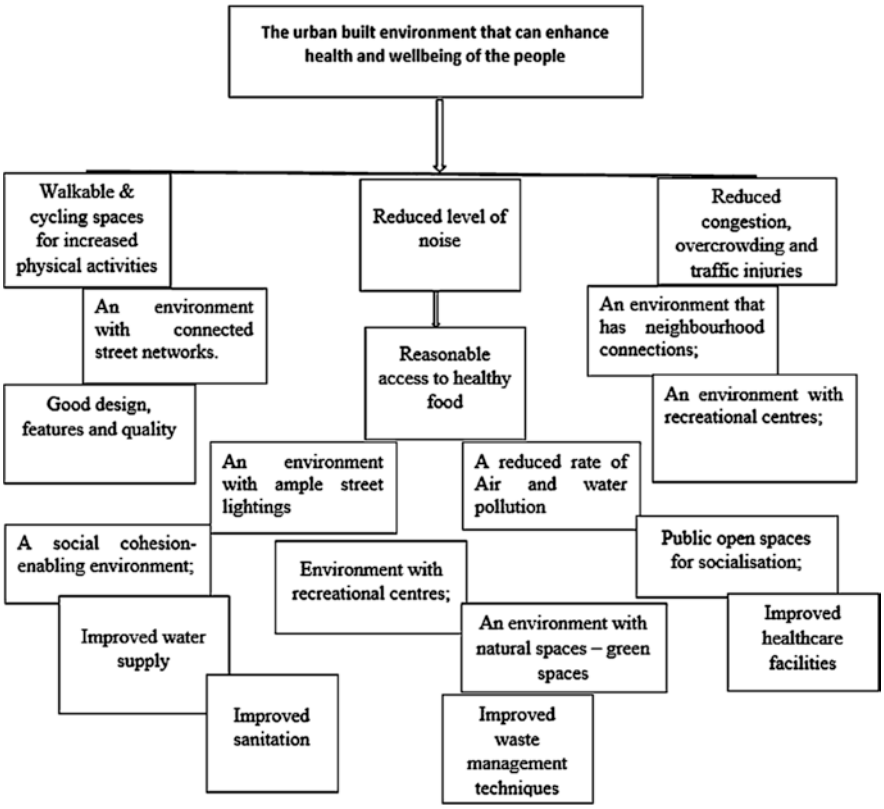


Fig. 3 A framework demonstrating the features of an urban slum health and wellbeing-enhancing built environment

How to Enhance the Health and Wellbeing of Urban Slum Dwellers Using the Built Environment

So far, the literature review has shown the factors that characterise the built environment. Accordingly, this section will centre on how to enhance the health and wellbeing of urban slum dwellers using the built environment. For a smooth line of discussion, most of the points raised in the review above on the characteristics of a built environment will be discussed one after the other, albeit in brief.

Air and Water Pollution

The review above reveals that most urban environments are characterised with air and water pollution, which grossly affects the health and wellbeing of the residents. This situation could even be worse in urban slums characterise by issues such as minimal waste management, poor sanitation, and stagnant water. These pollute the air people breath and the water they drink and as such capable of endangering the health and wellbeing of the people. Therefore, it is strongly recommended that the building professionals and even the government look into the reconstruction, redesigning, and restructuring of the urban slums built environment in such a way that there will be a reduced rate of these high rate of pollution.

The Integration of Natural or Green Spaces to the Built Environment

According to Williams (2013), for a built environment to enhance the health and wellbeing of the people, there is a need to integrate the natural environment to the built environment to make the environment more conducive and stress-reducing instead of a boring and a stress-generating environment. Glasgow Centre for Population Health (2013) adds that the built infrastructural spaces and a range of natural features should be an integral part of the built environment. However, a look at the section that deals with the meaning of urban slums reveals the lack of the integration of the natural spaces to the built environment. The resultant effect is the generation of different health and wellbeing issues. We, therefore, call the attention of the building professionals to revisit the built environment and ensure that it comprises a carefully styled hard and soft infrastructure, built spaces and the natural spaces to produce a habitable environment.