

TRANSFORMATIONAL INFRASTRUCTURE

for Development of a
Wellbeing Economy in Africa



DESTA MEBRATU
MARK SWILLING

EDITORS

TRANSFORMATIONAL
INFRASTRUCTURE
FOR DEVELOPMENT OF
A WELLBEING ECONOMY
IN AFRICA



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SUNPROSS

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ACRONYMS & ABBREVIATIONS

AB3D	Automated Bricklaying 3 Dimensional
ABC	Anchor-Business-Community
AfDB	African Development Bank
AI	artificial intelligence
APP	Africa Progress Panel
ARLI	African Resilient Landscapes Initiative
AU	African Union
BaU	Business as Usual
BCA	benefit-costs analysis
BRICS	Brazil, Russia, India, China and South Africa
BRT	Bus Rapid Transit
CBA	community-based adaptation
CBD	Convention on Biological Diversity
CBNRM	community-based natural resource management
CEA	cost-effective analysis
CED	cumulative energy demand
CLICS	climate change integrated land-use strategies
CP	cleaner production
DEA	Department of Environmental Affairs
DM	distributed manufacturing
DRE	distributed renewable energy
DS	developmental state(s)
EAP	East Asia and Pacific
EAPP	East African Power Pool
EbA	ecosystem-based adaptation
EC	European Commission
ECOSOC	Economic and Social Council
EDP	Economic Development Partnership

EF	ecological footprint
EIA	environmental impact assessment
EIP	eco-industrial park
EKC	environmental Kuznets curve
EMS	environmental management system(s)
EPA	Environmental Protection Agency
EPR	extended producer responsibilities
ESI	environmental sustainability index
ETI	Energy Transition Index
EU	European Union
FAO	Food and Agriculture Organization
FDI	foreign direct investment
GDP	gross domestic product
GEF	Grid Emission Factor
GET FiT	Global Energy Transfer Feed-in Tariff
GGGI	Global Green Growth Institute
GHG	greenhouse gas
GTCO ₂	giga-tonne carbon dioxide
GW	gigawatt
HDI	human development index
IBRD	International Bank for Reconstruction and Development
ICT	information and communication technology
IDB	Inter-American Development Bank
IDCOL	Infrastructure Development Company Limited
IDDA	Industrial Development Decade for Africa
IEA	International Energy Agency
ILO	International Labour Organization
IMF	International Monetary Fund
IO	industrial organisation
IoT	internet of things
IPCC	Internal Panel on Climate Change

IPES-Food	International Panel of Experts on Sustainable Food Systems
IPPs	Independent Power Producers
IRENA	International Renewable Energy Agency
IRP	International Resource Panel
IT	information technology
IUCN	International Union for Conservation of Nature
KPLC	Kenya Power and Lighting Company
kWh	kilowatt hour
LCA	life-cycle assessment
LCC	life-cycle costing
LCM	life-cycle management
LCSA	life-cycle sustainability assessment
LDC REEEI	Least Developed Countries Renewable Energy and Energy Efficiency Initiative
LED	local economic development
MCDA	multicriteria decision analysis
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MFA	material flow analysis
MLP	multi-level perspective
MSWM	municipal solid waste management
MW	megawatt
NCPCs	National Cleaner Production Centres
NDCs	nationally determined commitments
NEPAD	New Partnership for Africa's Development
NGO	non-governmental organisation
NIA	national infrastructure assessment
NIC	National Infrastructure Commission
NMBM	Nelson Mandela Bay Municipal area
OAU	Organization of African Unity
OECD	Organization for Economic Co-operation and Development

PAGE	Partnership for Action on Green Economy
PAYG	pay-as-you-go
PIDA	Programme for Infrastructure Development in Africa
POs	partner organisations
PPA	power purchase agreement
PPP	purchasing power parity
PSILCA	product social impact life-cycle assessment
PV	photo voltaic
PwC	PricewaterhouseCoopers
RA	risk analysis
RE	renewable energy
REIPPP	Renewable Energy Independent Power Producer Procurement Programme
REN21	Renewable Energy 21
SAPs	structural adjustment programmes
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SEA	strategic environmental assessment
SEEA	System of Environmental-Economic Accounting
SEZ	special economic zone
S-LCA	social life-cycle assessment
SMEs	small- and medium-sized enterprises
SPPs	Small Power Producers
SRS	Stockholm Royal Seaport
ST	sustainability transition
STAMP	Sustainability Assessment and Measurement Principles
STIAS	Stellenbosch Institute for Advanced Study
SWMS	solid waste management system
TEA	total energy access
TVET	technical vocational education and training
UN	United Nations

UNCED	United Nations Conference on Environment and Development
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
WB	World Bank
WEF	World Economic Forum
WI	wellbeing index
WRI	World Resources Institute
WWF	World Wide Fund
WWP	Working Wetland Potential



PREFACE

Desta Mebratu and Mark Swilling

Our knowledge and understanding of the natural environment and its interaction with our socio-economic systems have significantly expanded over the last couple of decades. However, we have not been able to go beyond incremental gains, which have limited capacity to contain and reverse the unsustainable trends of development. This is manifested through a deepening socio-economic and social-ecological crisis expressed in the form of growing environmental degradation, persistent economic stagnation, increasing unemployment and growing disparities between and within countries. Recognition of these challenges provided the basis for the development of Agenda 2030 on Sustainable Development Goals at the global level and Agenda 2063 on the Africa We Want by the African Union. Both of these agendas focus on the continuous improvement of human wellbeing while preserving the natural ecosystem as its foundation.

This book project was conceived with the belief that Africa's ability to make any progress towards meeting the Sustainable Development Goals and fulfil its aspiration of Agenda 2063 will largely depend on the kind of infrastructure it develops in

the coming years and decades. We also recognise that emerging technologies and knowledge systems coupled with Africa's early stage of development provide the continent with unique leapfrogging opportunities. To this effect, the book provides a transformational framework for Africa's transition to a wellbeing economy that is inclusive, climate-resilient and resource-efficient.

The core chapters of the book cover the main issues and tools which African countries should consider in developing their ecological, energy, industrial, urban and governance infrastructure. The book is a collective product of African scholars who have extensive academic and development experience on the topics covered in the book. While African policymakers and planners are its primary target audiences, the book can also be used as a source reference for academic education and research work.

The book project was developed and implemented by the Centre for Complex Systems in Transition at Stellenbosch University in collaboration with Stellenbosch Institute for Advanced Study (STIAS). On behalf of the research group, we wish to thank the management of STIAS for the financial and institutional support provided for the book project. We also wish to thank the staff of our publisher, African Sun Media, who provided the required editing and back-up support, and the anonymous reviewers who provided valuable feedback and comments on the book. We particularly wish to thank Dr Christoff Pauw from STIAS and Mr Wikus van Zyl of African Sun Media for their consistent support for the publication of the book. Finally, we wish to thank Ms Davida van Zyl for the excellent formatting and editing support to the book project.



FOREWORD

H.E. Mrs Sahlework Zewde¹

African countries have been collectively making numerous efforts to develop their economies since independence. The Lagos Plan of Action that was developed under the auspices of the Organization of African Unity in 1981 was the first continent-wide initiative that was aimed at heralding the economic independence of Africa in parallel with its political independence. This was followed by the New Partnership for Africa's Development that was endorsed by the African Union at the dawn of the new millennium to promote a comprehensive and integrated sustainable development initiative for the revival of Africa through a constructive partnership. As a continuation of the Pan African drive for self-determination, freedom, progress and collective prosperity, the African Union, at its 50th anniversary, adopted Agenda 2063 as an endogenous, shared strategic framework for inclusive growth and sustainable development for Africa's transformation.

¹ President of the Federal Democratic Republic of Ethiopia.

These three regional development initiatives have their own specificities in terms of their strategic focus. However, they all share and reflect the collective aspirations of Africans to get rid of poverty and achieve a more healthy and secured wellbeing for their people. A more detailed look at the process that led to their development also shows that there has been a progressively growing sense of ownership and endogenisation of the regional initiatives. Agenda 2063 notes that humanity today has the capacities, technology and know-how to ensure a decent standard of living and human security for all inhabitants of our earth. It also recognises the critical importance of having world-class infrastructure and human capital developed through quality education. Understanding existing and emerging knowledge and technology systems with their attendant positive and negative consequences is a critical first step for African countries to make the right policy and planning decisions. In this regard, this book makes a valuable contribution in enhancing our understanding of the key elements of developing transformational infrastructure for sustainable development.

Creating jobs and making development more inclusive are the two prominent challenges that are faced by all countries in the twenty-first century. These challenges are significantly pronounced in Africa, where there is a high level of poverty and unemployment. This book shows that the kind of infrastructure we develop today will determine the number of jobs we create and the economic and environmental wellbeing we provide for the coming decades. More specifically, it advocates for the promotion of distributed renewable energy systems and development of distributed economy networks that create jobs and add value at the local level as a preferred development path for African countries. I believe this path could also be a valuable vehicle for the economic empowerment of women at the local level besides contributing to social inclusivity and environmental sustainability. Shifting the overall focus of development from growth to wellbeing economy resonates well with the needs and aspirations of Africans.

This book, as an intellectual product of African scholars, makes a valuable contribution to the realisation of the objectives of Africa's Agenda 2063 on industrialisation, urbanisation, energy, and the environment. I encourage all African policymakers, planners, and academics to make good use of the knowledge in this book and make Africa the shining star of global sustainability in the twenty-first century.



FOREWORD

Ibrahim Thiaw¹

Africa is a land of incredible complexities and contradictions. It has diverse ecological systems and is rich in natural assets but is battered by weather and poverty. It has enough farmland and water to feed its people but is plagued by malnutrition and drought. And it has massive renewable energy potential, but more than half of its population are powerless to connect with this life-changing resource. This book is a welcome reminder of how we can use ecological, physical and institutional infrastructure to redress that balance and build the foundations for wellbeing and economic development.

Africa certainly has its challenges. However, with Agenda 2063, this extraordinary continent also has a set of ambitious, but achievable, strategic goals to provide a better future for its people; one that will ripple out to generate benefits for the entire world. Achieving those goals depends on the ability of all stakeholders to

¹ Undersecretary General of the United Nations and Executive Secretary of the UN Convention to Combat Desertification.

combine the very best of nature and technology with strong governance and efficient knowledge management. If they succeed, Africa's towns, farms, industries and infrastructure could make enormous strides in the transition towards more sustainable development.

Take the ecosystem services that not only make communities more resilient to threats such as desertification, biodiversity loss and global warming but also reduce those threats in the first place. For example, while cutting trees provides limited energy and fragile farmland in the short term, research in Ethiopia has shown that preserving them sequesters carbon, feeds livestock, pollinates crops, retains soil and protects water systems. Likewise, the falling cost of developing and distributing clean energy and connectivity can not only reduce deforestation, pollution and global warming but also nurtures a healthier, better-educated population that can make the most of emerging trends for dispersed design and production across a range of industries. With affordable pay-as-you-go and off-grid solutions spreading fast, agricultural technology improving yields and reducing waste, and machine learning hubs taking root, there are some real opportunities for the eleven million young Africans entering the workforce every year.

Above all, while there is no single solution to Africa's challenges, there are many individual opportunities that can and must be connected to increase the speed and scale of their impact, particularly through the eradication of poverty and inequality. With so many of those solutions inextricably linked to the natural capital that accounts for up to 50 percent of the continent's wealth, the African Research Group does well to highlight the role of infrastructure and life-cycle planning and development can play in their success and will make a valuable contribution to the work of anyone seeking to improve wellbeing and economic progress.



INTRODUCTION

Mark Swilling and Desta Mebratu

The global economic crisis has generated new literature that draws on long-wave theory to re-imagine present and future landscapes. The writers in this neo-Polanyian tradition include consultant's advisories and popular literature aimed at business audiences (Allianz Global Investors, 2010; Bradfield-Moody & Nogrady, 2010; Rifkin, 2011); the policy-oriented research-based literature generated from a variety of academic, United Nations, and advisory and consulting agencies (McKinsey Global Institute, 2011; United Nations Department of Economic and Social Affairs, 2011; Von Weizsacker, Hargroves, Smith, Desha & Stasinopoulos, 2009); the theory-laden academic literature (Drucker, 1993; Gore, 2010; Mason, 2015; Pearson & Foxon, 2012; Perez, 2009, 2010; Smith, Voss & Grin, 2010; Swilling & Annecke, 2012); and the post-developmental 'transition discourses' (Escobar, 2015). These texts have all to a greater or lesser extent drawn on a tradition (originating in the works of Nikolai Kondratieff and Joseph Schumpeter), which depict economic history in terms of a succession of long-term waves or cycles of economic development lasting between 40 and 60 years.

Karl Polanyi was interested in a ‘double movement’ – the divisive fragmentary nature of laissez-faire capitalism, which emerged in the late nineteenth century and led up to the Second World War, and the integrative dynamics of micro-level pacts and associations – and proposed the coming of a ‘grand transformation’. Social democracy after WWII realised this grand prophecy. The conditions today exhibit the same double movement – crisis, inequality, division and potential collapse, versus the power of global grassroots movements expressing real liveable alternatives.

Nowadays, there is increasing interest in the possibility of some sort of epochal shift, leading to a post-industrial world that is more or less sustainable. This is the ‘transformed world’ referred to in the Preamble to the UN Sustainable Development Goals (SDGs). Schot and Kanger (2018) refer to this as the ‘second deep transition’, while the German Advisory Council on Climate Change (explicitly invoking Polanyi) refer to another ‘great transformation’ similar in significance to the eighteenth century agricultural and industrial revolutions (German Advisory Council on Climate Change, 2011). For Mason, this is a ‘post-capitalist’ epoch, and similarly for Nafeez Ahmed who envisages a ‘civilizational transition’ that will of necessity need to transcend capitalism (Ahmed, 2017). For Mazzucato and Perez, capitalism can be reformed around new developmental and environmentally sustainable imperatives (Mazzucato, 2016; Perez, 2016). It is worth considering Schot and Kanger’s definition of a ‘deep transition’:

A Deep Transition is formally defined as a series of connected and sustained fundamental transformations of a wide range of socio-technical systems in a *similar direction*. Examples of this directionality include (the post-WWII) move towards increased labour productivity, mechanization, reliance on fossil fuels, resource-intensity, energy-intensity, and reliance on global value chains. Our assumption is that this process of building connections between change processes in multiple systems takes on wave-type properties, unfolds through centuries, and is implicated in broader transformations of societies and economies. In this conceptualization each wave is broadening and deepened in the Deep Transition but should not be seen as a Deep Transition in itself. The Deep Transition refers to the overall change process and is thus comparable to what Polanyi (2001 [1944]) called the Great Transformation. (Schot & Kanger, 2018:1 – emphasis added)

This definition of ‘deep transition’ is remarkably similar to Swilling and Annecke’s conception of ‘epochal transition’ from an African perspective (Swilling & Annecke, 2012). When integrated in this way into a deep epochal transition, the following proposition becomes possible: the ‘deep transition’ from industrial modernity to the ‘transformed world’ referred to in the preamble of the SDGs is not merely about the extended survival of industrial modernity (embodied in its current financialised form of global capitalism with its various national manifestations), but

rather it is about catalysing a deep (socio-metabolic) transition to a new sustainable epoch whose directionality and pace will depend on the policy choices made by policymakers. Depending on existing social struggles for change and how, in particular, the renewable energy transition pans out over time, the outcome will be more or less *just*. A *just transition* may well need to be an information-based hybrid with capitalist features (e.g., a socially-embedded market, subordination of finance to the ‘real economy’, continuation of aspects of private ownership and private investment) and post-capitalist features (significantly expanded ‘commons’ where ownership is neither state nor private, socially and/or publicly-owned financial institutions with major investment resources, expanded non-market transactions, burgeoning social entrepreneurship sector, and a non-exploitative non-extractive relationship with natural systems). How exactly this turns out will more than likely be very different to what can be imagined from ‘this side of history’ (Frase, 2016).

Africa, as a developing region, has a unique opportunity to take advantage of this wider deep transition, or it could drown in the complexities and messiness and once again miss out on a major long-term development cycle. Much will depend on how the African policy community deals with the critical transition elements and drivers in the coming decades. This must include a critical reflection on the kind of development narratives that each African country should adopt and uphold as an alternative to the neo-liberal ‘growth economy’ narrative which has resulted in social exclusion and environmental degradation.

Furthermore, the type of infrastructures that are designed and built in the coming years will determine whether African countries have the capacity to manage a long-term commitment to sustainability-oriented inclusive development. The conceptualisation and design of these infrastructures must take into account the longer-term impact of the new advanced information and communication technologies (variously referred to as Web 3.0, Second Machine Age or the Fourth Industrial Revolution (Brynjolfsson & McAfee, 2014; Schwab, 2017) and their potential for catalysing more inclusive commons-based peer-to-peer economies (Murdock, 2018). If African countries want to be active contributors and partners in the twenty-first-century global economy, information-rich sustainability-oriented infrastructure development strategies will be essential. The fact that most of the sub-Saharan African countries are at the early stage of economic development allows them to leapfrog into a more inclusive and sustainable development trajectory.

In relation to the development narrative, the first chapter of this book presents the ‘wellbeing economy’ as an alternative development narrative that enables African countries to transition to inclusive, low-carbon, and resource-efficient economies. It highlights the major technological drivers that are shaping economic

development in the twenty-first century and the specific opportunities and threats related to these technologies. It further underlines the critical importance for African countries of the promotion of transformative leapfrogging that is internally-driven and context-relevant rather than subscribing to incidental leapfrogging that is externally-driven and sub-optimal in its outcome.

The second chapter focuses on demonstrating the critical importance of maintaining the resilience of ecological infrastructures as a foundation for achieving the SDGs with a particular focus on food security. It also presents the major tools which African countries can deploy for ensuring the resilience of their social-ecological systems for the wellbeing of its population which is growing at an alarming rate.

The third chapter presents the critical importance of addressing energy poverty in Africa through the development of sustainable energy systems. It focuses particularly on the development of distributed renewable energy systems that enable African countries to utilise their renewable energy resources for the development of an inclusive and low-carbon local economic development.

While recognising the critical need and aspirations of African countries to industrialise, the fourth chapter argues that attempting to industrialise with the same industrialisation pattern of the twentieth century is not only unsustainable but is also unattainable in the twenty-first century. Hence, Africa's industrialisation efforts should be focused on making the maximum use of the opportunities created by resource-efficient and disruptive technologies while building on its comparative resource advantage.

Unplanned urbanisation leading to urban sprawl characterised by the expansion of slums is another major challenge facing African countries in the coming decades. Chapter five deals with factors that ensure sustainable urban development in Africa, with a particular focus on how to carry out sustainable urban planning and development using resource-efficient urban economic strategies that provide for jobs and livelihood creation.

Life-cycle management of the planning and development of economic infrastructure is one of the most useful tools for building and managing inclusive and resource-efficient regional and local economies. Chapter six presents the major tools and techniques that could be utilised to ensure the development of transformative infrastructure that facilitates the development of a wellbeing economy.

One of the major effects of the disruptive technologies, including information and communication and renewable energy technologies, is the transition from mass production to mass customisation of production systems. Chapter seven provides

some guidance on how African countries can utilise these opportunities and develop distributed economy networks that create jobs and provide livelihoods at the local level.

Governance has been one of the major developmental challenges faced by most African countries over the past decades. Chapter eight reconceptualises what a sustainability-oriented developmental state could mean in the African context. The chapter proposes an alternative to state-centric and market-centric modes of governance. This alternative mode of governance is one that respects the reality of increasing complexity while providing for ways of ensuring directionality over the long term.

The development of an economy that satisfies the requirements for both human and ecosystem wellbeing will require a different set of indicators than gross domestic product, which is a measure of misconceived economic growth. Chapter nine presents some of the key principles and methods used in developing alternative indicators for sustainable development, including key procedures for sustainability assessment and selection criteria for indicators. It also proposes a framework of indicators that could be adapted and used by African countries with a particular focus on measuring progress in developing transformative infrastructures for wellbeing-oriented economic development in Africa.

This publication attempts to tackle the challenges of building wellbeing economies in Africa. We recognise that it is far from complete; nonetheless, we believe that the book provides comprehensive coverage of all the major issues related to building a transformational infrastructure for the transition to an inclusive, low-carbon and resource-efficient economy. The book also provides valuable insights that could be used by African policymakers and planners to develop a new development trajectory that would assist them to meet the SDGs and fulfil the aspiration of Agenda 2063. We sincerely hope that the ideas presented in this book will be further refined and expanded through academic and field research that will be carried out by Africans in the coming years.

References

- Ahmed, N.M. (2017). *Failing states, collapsing systems: Biophysical triggers of political violence*. Cham, Switzerland: Springer. <https://doi.org/10.1007/978-3-319-47816-6>
- Allianz Global Investors. (2010). *The sixth Kondratieff – long waves of prosperity*. Frankfurt: Allianz Global Investors. <https://bit.ly/317YnUs> [Accessed 1 March 2012].
- Bradfield-Moody, J. & Nogrady, B.T. (2010). *The sixth wave: How to succeed in a resource-limited world*. Sydney: Vintage Books.
- Brynjolfsson, E. & McAfee, A. (2014). *The second machine age: Working, progress, and prosperity in a time of brilliant technologies*. New York: W.W. Norton & Co.
- Drucker, P.F. (1993). *Post-capitalist society*. Oxford: Butterworth-Heinemann.
- Escobar, A. (2015). Degrowth, postdevelopment, and transitions: a preliminary conversation. *Sustainability Science* 10(3): 451–462. <https://doi.org/10.1007/s11625-015-0297-5>
- Foxon, T.J. (2011). A coevolutionary framework for analysing a transition to a sustainable low carbon economy. *Ecological Economics* 70(12): 2258–2267. <https://doi.org/10.1016/j.ecolecon.2011.07.014>
- Frase, P. (2016). *Four futures*. London: Verso.
- German Advisory Council on Climate Change. (2011). *World in transition: A social contract for sustainability*. Berlin: German Advisory Council on Global Change.
- Gore, C. (2010). The global recession of 2009 in a long-term development perspective. *Journal of International Development* 22(6): 714–738. <https://doi.org/10.1002/jid.1725>
- Köhler, J. (2012). A comparison of the neo-Schumpeterian theory of Kondratieff waves and the multi-level perspective on transitions. *Environmental Innovation and Societal Transitions* 3: 1–15. <https://doi.org/10.1016/j.eist.2012.04.001>
- Kondratieff, N.D. & Stolper, W.F. (1935). The long waves in economic life. *The Review of Economics and Statistics* 17(6):105–115. <https://doi.org/10.2307/1928486>
- Mason, P. (2015). *Postcapitalism: A guide to our future*. London: Penguin.
- Mazzucato, M. (2016). *Rethinking capitalism: Economics and policy for sustainable and inclusive growth*. West Sussex: John Wiley & Sons.
- McKinsey Global Institute. (2011). *Urban world: Mapping the economic power of cities*. London: McKinsey Global Institute.
- Murdock, G. (2018). Commons manifestos: a reply to Bauwens and Ramos. *Global Discourse* 8(2): 343–347. <https://doi.org/10.1080/23269995.2018.1461443>
- Nelson, R.R. & Winter, S.G. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.
- Pearson, P.J.G. & Foxon, T.J. (2012). A low carbon industrial revolution: insights and challenges from past technological and economics transformations. *Energy Policy* 50: 117–127. <https://doi.org/10.1016/j.enpol.2012.07.061>
- Perez, C. (2009). The double bubble at the turn of the century: technological roots and structural implications. *Cambridge Journal of Economics* 33(4): 779–805. <https://doi.org/10.1093/cje/bep028>
- Perez, C. (2010). *The financial crisis and the future of innovation: A view of technical change with the aid of history*. The Other Cannon Foundation & Tallinn University of Technology Working Papers in Technology Governance and Economic Dynamics, 28, TUT Ragnar Nurkse Department of Innovation and Governance.
- Perez, C. (2016). *Capitalism, technology and a green golden age: The role of history in helping to shape the future*. *The Political Quarterly* 86(S1): 191–217. <https://doi.org/10.1111/1467-923X.12240>

- Rifkin, J. (2011). *The third industrial revolution: How lateral power is transforming energy, the economy and the world*. New York: Palgrave MacMillan.
- Schot, J. & Kanger, L. (2018). Deep transitions: Emergence, acceleration, stabilization and directionality. *Research Policy* 47(6): 1045–1059. <https://doi.org/10.1016/j.respol.2018.03.009>
- Schumpeter, J.A. (2007) [1934]. *The theory of economic development*. New Brunswick, NJ: Transaction Publishers.
- Schwab, K. (2017). *The fourth industrial revolution*. Great Britain: Portfolio Penguin.
- Smith, A., Voss, J.P. & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy* 39(4): 435–448. <https://doi.org/10.1016/j.respol.2010.01.023>
- Standard Chartered. (2010). *The super-cycle report*. <https://bit.ly/325uipX> [Accessed 2 October 2019].
- Swilling, M. & Annecke, E. (2012). *Just transitions: Explorations of sustainability in an unfair World*. Tokyo: United Nations University Press.
- United Nations Department of Economic and Social Affairs. (2011). *World economic and social survey 2011: The great green technological transformation*. New York: UNDESA. <https://doi.org/10.18356/0408b8c4-en>
- von Weizsacker, E., Hargroves, K.C., Smith, M.H., Desha, C. & Stasinopoulos, P. (2009). *Factor five: Transforming the global economy through 80% improvements in resource productivity*. London: Earthscan.



EXECUTIVE SUMMARY

Desta Mebratu and Mark Swilling

African countries face unprecedented challenges of defining a future development pathway in a resource- and carbon-constrained world. This book addresses these challenges, with special reference to the set of infrastructure that most African countries require to meet the Sustainable Development Goals (SDGs) and fulfil the aspirations of Agenda 2063. Infrastructure is a key factor that determines how resource and energy flow and transform through socio-economic systems. Decisions made today by African countries on their infrastructural configuration will determine the inclusivity, resource intensity and climate resilience of their development pathways for decades to come. This book is a product of a two-year research conducted by a group of African scholars who have extensive academic and practical experience on the development of key infrastructure sectors in Africa. This executive summary highlights the key conclusions and recommendations made in each chapter of the book.

Chapter 1: Transformative leapfrogging to a wellbeing economy in Africa

Social transformations of different proportions and scope have shaped human history over millennia. Two of the most significant social transformations are the agricultural and industrial transformations. These transformational processes radically redefined human society and determined the future critical features of socio-economic relationships within communities and across nations. Furthermore, they fundamentally redefined our relationship with the natural environment. The confluence of economic, social and environmental challenges that humanity currently faces require a transformational transition towards an inclusive, climate-resilient, and resource-efficient economy. This is a global transition with significant impact on Africa as a region.

The dominant development narrative of the ‘growth economy’ is driven by the neo-liberal economics of the market. This not only led to environmental destruction on a global scale but also miserably failed in ensuring social justice across the world and within communities. The transformational transition of the twenty-first century requires a new development narrative that ensures environmental sustainability and social inclusivity while promoting economic development. This book proposes the notion of the ‘wellbeing economy’ as an alternative. This approach envisages the continuous fulfilment of human wellbeing, with primary attention on job creation, poverty eradication and gender equality, while maintaining the sustainability of the ecosystems.

The Sustainable Development Goals of Agenda 2030, the Paris Declaration on Climate Change and the emerging possibilities created by the accelerated application of renewable energy and IT-based technologies have created new opportunities for African countries to move to inclusive, low-carbon and resource-efficient economies. This evolution is also characterised by forces of lock-in, which actively work to maintain the status quo. At the same time, the drivers of leapfrogging that continuously develop and introduce new systems and technologies are also acknowledged as equally significant. Managing the tension between the lock-in and leapfrogging factors – and moving beyond incidental leapfrogging that is often externally driven and at best incremental – is the critical challenge that African countries currently face.

The recent developments in disruptive technologies such as information and communication, manufacturing, and renewable energy technologies, which are more distributive, coupled with the early stage of economic development of most African countries, opens-up tremendous leapfrogging opportunities for these countries. However, African countries should actively promote transformative

leapfrogging that is internally driven and responsive to the national context as the critical success factor for the development of a wellbeing economy that is inclusive, climate-resilient and resource-efficient.

One of the critical domains which will determine the development trajectory of African countries for the coming decades is the strategic choice and decisions they make on how to develop their socio-economic infrastructure for the coming decades. Developing a wellbeing economy by capturing and utilising the available opportunities provides a strong basis for fulfilling the aspirations of Agenda 2063 and the 'Africa We Want' campaign. The fundamental basis for this transition process is maintaining its ecological infrastructure, which provides the foundation for the development of a wellbeing economy. Development of the energy, industrial and urban infrastructures from a life-cycle management perspective will also determine the pace of their transition to an inclusive, climate-resilient and resource-efficient economy.

Chapter 2: Ecological infrastructure as a basis for the African wellbeing economy

Sustainable development relies on a balanced relationship between addressing social and economic growth within the boundaries of the environment. The environment not only presents the foundation that creates and sustains life on earth but also provides the assets upon which to build a country's economic development. The production of food, provision of water and natural resources for industrial activities, regulation of climate and purification of air rely on the sustainable management of the natural world. Natural resources, however, are limited and are decreasing rapidly. If they are not sustainably managed, the system in which they are embedded will collapse. Building a wellbeing economy across the continent depends explicitly on the protection and integrity of the natural resources that are critical life-support systems for sustained development. A powerful way of approaching this is to consider that ecological infrastructure needs to be at the forefront when thinking about the wellbeing economy. Ecological infrastructure is the nature-based equivalent of built or hard infrastructure.

According to the United Nations Economic Commission for Africa (UNECA), more than 50 million hectares of forests have been lost in Africa between 1990 and 2000, representing an average deforestation rate of nearly 0.8 percent per year (UNECA, 2011). Land degradation is a severe threat in Africa, with about 500 000 km² of land estimated to be degraded due to soil erosion, salinisation, pollution and desertification (United Nations Environment Programme [UNEP], 2013). This is primarily driven by deforestation, forest fires,

over-cultivation, inefficient irrigation practices, overgrazing, over-exploitation of resources (including mining), and climate (UNECA, 2011). Land degradation reduces agricultural productivity and directly impacts on food availability, nutrition and human health. Land degradation in drylands can result in desertification. The desert lands of the Sahara, Namib and the Kalahari, and the drylands of northern Kenya, southern Ethiopia and Somalia cover around 40 percent of Africa's land surface area (International Soil Reference and Information Centre [ISRIC], 2013).

A significant share of the continent's natural resources is used unsustainably, with some lost through illegal activities. This means that the stream of benefits generated from these resources is being reduced over time. This has serious implications for the long-term wellbeing of the population, as natural capital accounts for between 30 and 50 percent of total wealth. Population growth will also have significant implications for building resilient social-ecological systems. Population growth in Africa is likely to continue to put pressure on food, land and water resources.

While the inherent uncertainty and diversity in potential futures across the continent makes it tenuous for a set of prescriptive policies to be established, policy decisions should aim to minimise environmental and developmental trade-offs and maximise Africa's ability to safeguard its natural capital adequately. Living with such complexity and uncertainty requires resilience-building approaches to the management and governance of social-ecological systems. The social-ecological systems approach emphasises the role that people, communities, economies, societies and cultures play in the natural environment. Ecosystem-based adaptation is a nature-based solution that uses biodiversity and ecosystem services to support communities to adapt and build resilience in the face of disturbance.

Underpinning an economic trajectory that will lead to a continent-wide wellbeing economy comes with significant challenges, not least of which is the need to reduce the region's ecological footprint and safeguard the life-support system provided by healthy land, water, air and biodiversity. Ecosystem-based adaptation is recognised for its ability to offer co-benefits in helping society adapt to changes, including climate change. Agricultural biodiversity is vital to the functioning of agro-ecosystems, to ensure food and nutrition security and to cope with the challenges of climate change. African farming systems can build on a fundamentally different model of agriculture based on diversifying farms and farming landscapes, replacing chemical inputs, optimising biodiversity and stimulating interactions between different species, as part of holistic strategies to build long-term fertility, healthy agro-ecosystems and secure livelihoods.

Chapter 3: Sustainable energy systems in Africa

Africa has the largest share of the population without access to energy and addressing energy poverty is central to the eradication of poverty in Africa. The region has a significant volume of renewable energy resources that are yet to be developed. Almost every country that has achieved universal access has reached this goal with the support of strong leadership that can establish a shared vision of the benefits of enhanced energy systems for equitable wellbeing. Leadership is critical to driving through comprehensive long-term planning in partnership with public, private and civil society stakeholders. Visionary political leadership supported by public energy administration systems that embody long-term visions are critical for a successful transition to sustainable energy.

Costs for new energy options are falling and technologies such as wind turbines and grid-based PV systems are becoming competitive. Feed-in tariffs have been the most widely used government support mechanism for accelerating private investment in renewable energy generation. Competitive tenders or auctions have also emerged in various countries as acceptable instruments. Country-level experience has shown the importance of strong banking, legal and other advisory resources in rolling out effective renewable energy programmes. However, there is much more that must be done, particularly in the area of promoting the development of distributed energy systems that are critical for Africa's development. In this regard, it will be necessary to replicate and scale-up proven policy instruments and financing mechanisms.

It has long been evident that low levels of transformative knowledge and skills across sectors account for Africa's overwhelming dependence on prescriptive solutions imported from abroad. This applies as much to sustainable energy efforts as to other efforts at improving living conditions on the continent. The success of sustainable energy initiatives depends on how well they are aligned with domestic needs and resources. There is, therefore, an urgent need to build domestic capacities for multi-level design and management of sustainable energy transitions. Academic and professional institutions can play fundamental roles in creating and disseminating the necessary knowledge and skills within political, business-entrepreneurial, civil society and the general public.

Domestic social entrepreneurs across Africa can help fill the gaps across the sustainable energy supply and value chains and this needs to be further strengthened by recognising and nurturing domestic sustainable energy enterprises. Private entrepreneurs are successfully deploying innovative business models that are unlocking internal and external investments, creating jobs, catalysing local economic growth, and making measurable impacts on poverty reduction. This effort needs to be scaled up to unlock real social innovations that can sustain action

and transform the energy landscape. Providing systematic support to renewable energy service cooperatives could make a significant contribution to job creation, value addition and women's empowerment at the local level.

Agro-industries, such as tea, coffee and sugar estates, already utilise energy for their processing and, on occasions, supply power to their employees within their estates. In the event of non-access to the grid, scaling up electricity service would have direct economic and social benefits to rural communities in the vicinity of these estates, while it offers the agro-businesses a potentially attractive commercial opportunity for diversifying into the energy market. Supporting agro-industrial co-generation and anchor clients as a local solution could contribute to sustainable energy transitions in the region. In situations where the industry is connected to the grid, it creates the possibility to feed into the grid in times of surplus and drawing from it when supplies are low.

Chapter 4: Inclusive and sustainable industrial development for Africa

The industrial revolution, which started in the eighteenth century in England, has gone through different stages of development. By the middle of the twentieth century, industrial modernity was a global phenomenon. Compared to previous centuries, the twentieth century was a time of unprecedented economic growth driven by accelerated industrialisation and globalisation. However, it was also a century that saw exponential growth in the volume of resources extracted from the natural environment and the related environmental degradation. The *Global Resource Outlook* produced by the International Resource Panel (IRP) stated that the decoupling of natural resource use and environmental impacts from economic activity and human wellbeing is an essential element in the transition to a sustainable future (IRP, 2019). Reducing the emissions of greenhouse gasses has become the major environmental challenge that needs to be addressed to mitigate the adverse effects of climate change.

The Malthusian theory of 'environmental limits' and Schumacher's 'small is beautiful' concept are perhaps the early precursors of sustainable development within the disciplines of economics and political economy. Since the middle of the twentieth century, many concepts and tools that focused on reducing and containing the adverse impacts of industrialisation on the environment have been developed. These range from different sets of end-of-pipe management technologies to technologies aimed at improving the resource efficiency of industries from micro to systemic levels. Different economic development models have also been developed with the purpose of transitioning to more sustainable consumption and production patterns. Africa's industrialisation can benefit from

these technologies and knowledge systems, leading potentially to improvements in industrial efficiency.

African countries have been aspiring to industrialise their economies since their early years of liberation. This has led to the development of numerous regional and national economic development strategies that place significant emphasis on industrialisation. Ironically, despite all the efforts and investment since liberation, most African countries have been through decades of premature de-industrialisation. Industrialisation is still an economic imperative for Africa to meet the needs and aspirations of its people, as outlined in Agenda 2063. However, neither the European model nor the ‘exemplary’ Asian models of industrialisation are appropriate for Africa for the following two main reasons. Firstly, attempting to industrialise through the conventional model of industrialisation is neither feasible nor sustainable within the available regenerative and assimilative capacity of the already constrained planetary ecosystem. Secondly, the industrialisation of the twenty-first century is fundamentally different from previous industrialisation paths both in terms of its technological drivers and the expected socio-economic outcome and impacts.

In the twenty-first century, the traditional top-down organisation of society that characterised much of the economic, social, and political life of the fossil-fuel-based industrial revolution is giving way to a distributed and collaborative relationship in the emerging green industrial era. Furthermore, the new industrialisation path has to utilise the opportunities provided by the so-called ‘machine age’ (often referred to as the ‘fourth industrial revolution’ (Industry 4.0) while withstanding its adverse impacts. This includes employing the potential of distributed manufacturing as a basis for developing distributed economic networks that create jobs, empower women and promote local value addition. The transition from mass production to mass customisation as a result of digitisation of the supply chain also provides new opportunities for industrialisation in Africa.

The development of eco-industrial parks that are seamlessly integrated, both horizontally and vertically, into the local and national economy provides a strong basis for inclusive and sustainable industrialisation. Leveraging and utilising all the available opportunities while containing the related adverse effects will require putting the appropriate institutional, physical and human infrastructure in place. Creating a dynamic innovation space with the right combination of institutional, physical and social infrastructure is an essential prerequisite for being an active player in the global economy of the twenty-first century. In this context, African countries need to give maximum attention and support to university-industry linkages and partnerships as a key institutional pillar for sustainable industrialisation.

Chapter 5: Sustainable urban development in Africa

Urbanisation is among the megatrends shaping Africa's economic, social and environmental transformation. Though countries differ considerably, urban Africa is well below the global average in resource consumption. Even if the average per capita energy consumption and carbon emission of Africa are low in comparison to developed economies, energy intensity level remains significantly higher than the world average. Further, a growing urban population lack access to energy, basic infrastructure and services. African cities, therefore, face triple challenges: meeting the growing demand for resources to drive their economies, expanding access to the urban poor, and improving resource efficiency. African cities and urban system are critical in achieving low-carbon job-rich inclusive growth and accelerating the transition to sustainability. However, this requires a rethink in the way African cities are conceived, designed, built and managed.

With many African countries on a rapid urban and economic growth trajectory, Africa's resource consumption and carbon emissions are likely to increase in the following decades. However, its low stock of capital and existing technology and the promising prospect of environmentally sustainable technologies such as renewable energy gives Africa a 'late-comer' advantage to leverage urbanisation for sustainable development. The system of cities in many African countries is characterised by primacy, missing middle and rapidly growing small towns, weak economic bases and inadequate rates of job creation. The urban system is imbalanced, underperforming and unsustainable. Decongesting and improving principal cities is necessary, but not sufficient. Investment in connectivity infrastructure, decentralised energy systems, and leveraging ICT to promote distributed service and industrial economies should help to accelerate progress to economic de-concentration and a balanced spatial system constituting villages, towns and cities across the human settlements continuum.

There is the opportunity to reap a 'sustainability dividend' by adopting a compact and dense urban form and by shifting to cheaper and cleaner energy. Moving to smart urban infrastructure design and technology can be a game-changer. At a more fundamental level, three issues are critical. Firstly, urban form and design which determine the nature and configuration of urban infrastructures. The built environment of today's cities is the product of urban vision and design implemented generations ago. The 'lock-in effect' of urban form is long-lasting. Secondly, considering severe resource scarcities and the long life-cycle of infrastructure, project prioritisation should be considered within appropriate strategic frameworks. Even within energy or connectivity sectors, there are multiple decision issues that matter, such as choice of technology or energy mix, or scale and location. Thirdly, in the context of sustainability transitions, investment

decisions involve shifting to new technologies or future technologies. Policy inertia and powerful stakeholder interests can constrain these decisions if not effectively countered. This kind of obduracy could hamper the necessary technological shift and increase the stock of 'stranded capital' thus making 'leapfrog' transformation increasingly difficult or costly.

Sustainable infrastructure design and implementation can also facilitate investment in affordable housing. The price-to-income ratio of housing in Africa is much higher than the world average. The prevalence of slums and informality in African cities is to some extent due to the disconnect between planning, infrastructure and housing construction. Studies show that if land is efficiently laid out, housing and service provision can be incrementally improved at much less cost than retrofitting slums. Neither shack formation in the middle of the city, nor mega housing projects on the urban edge disconnected from job and economic opportunities or without access to public transport is sustainable. The anomaly of 'housing without people' and the problem of 'people without housing' observed in many cities around the world is symptomatic of fundamental urban development flaws and resource inefficiencies that Africa should strive to prevent or mitigate. Effective housing solutions require multiple front interventions in, for example, land and housing regulations, housing finance and building technology.

Many African cities had master plans, but by the time the plans were completed, the realities on the ground had utterly changed as the rapid forces of urbanisation took their course. The plans remained static and rigid, while the realities continuously evolved. The dynamism and ingenuity generated in bottom-up approaches and the static and rigid planning and control interventions struggling to cope with old and new challenges coexist with limited interaction on the margin. This all results in chaotic urban development. The solution does not lie in the top-down command and control system nor in the bottom-up self-development. What is needed is light-touch top-down planning to provide guidance and structure while allowing adaptation and innovation to suit diverse needs and bottom-up initiatives that are spontaneous, adaptive and collaborative. In a nutshell, business-as-usual does not work. However, action is needed before the window of opportunity closes.

Chapter 6: Life-cycle management for sustainable infrastructure planning and development in Africa

At the heart of global and national socio-economic development are:

- mobility of people, goods and services;
- information through transport, energy, water and wastewater; and
- information and communication technology infrastructure.

How these people, goods and services, and information are moved from one place to another and how the choice affects economic, social and environmental quality continues to be the subject of inquiry of many fields of research and practice. The type and spread of infrastructure systems in different parts of Africa play a strategic role in influencing its path to sustainable development and will determine whether its diverse national, continental and global commitments, such as Africa's Agenda 2063 and UN's Sustainable Development Goals 2030, will be met. It will also ultimately determine the progress of each country in creating jobs and eradicating poverty.

As indicated in many reports on the continent, Africa's infrastructure gap is enormous. Leaving this infrastructural deficit unaddressed for so long or addressing it in a business-as-usual way will pose significant threats to the region's sustainable economic development. The long lifespan of infrastructure systems and the fact that the bulk of Africa's infrastructure requirements to 2050 is yet to be developed, provides a vast opportunity for planning and laying out the systems sustainably. Africa needs to ensure its new infrastructure systems leapfrog the inefficient, sprawling and polluting systems of the past, and develop systems that are inclusive, resource-efficient, low-carbon and climate-resilient. Sustainable infrastructure systems in the continent will be critical elements of achieving a more sustainable form of economic development adaptable to global changes and the changing needs of its population.

The most significant opportunities for improving the overall outcome of planning for sustainable infrastructure systems could result in higher positive impacts without the negative consequences of sub-optimal solutions that are prone to problem shifting. These opportunities must be exploited during the earlier stages of the planning process and at the very start of each stage. A review of existing evaluation tools shows significant gaps in the coverage of sustainability principles at the upstream planning stage. This is because the focus of sustainability analyses are mainly or entirely on later stages in the value chain ('end of pipe') after important decisions have already been made. By this stage, it is too late to make positive interventions. Emerging knowledge for creating sustainable infrastructures can be found in the procedural and analytical tools of life-cycle management. These tools support the mitigation of problems associated with the conventional 'silo' approach.

As key policy and strategic issues for African countries, there is a need for articulating national strategies and fostering leadership for sustainable infrastructures. It is essential to link urban planning with a higher level of integrated infrastructure planning while working on institutional reforms and capacity building to increase access to life-cycle management skills. There is a need to focus on prioritising

strategic partnerships and implementing knowledge management and community engagement systems that are critical for transforming the conventional planning process to be compatible with the requirements of planning for sustainable infrastructure in African countries. To this end, realigning available resources is as important as creating new resources.

The framework proposed in this book in support of strategic planning of sustainable infrastructure in Africa is structured to show the different levels of planning from the national to the local level. While recognising the whole planning ecosystem as a continuum, the framework identifies where broader qualitative life-cycle management elements and specific quantitative life-cycle management elements can be used to take infrastructure planning to the next level. Broader qualitative aspects, such as life-cycle strategies, programmes, systems, processes and concepts, can be used at the highest level, such as national planning, and at the early stages of subnational planning and decision-making. The specific quantitative life-cycle management elements consisting of analytical tools and techniques supported by quantitative data, information and models are better used at the local level and in planning and decision-making circumstances where a higher resolution of planning outcomes are sought. The conditions for a successful application of the proposed framework include aspects of the planning process, assessment and institutional architecture. There is a need for the implementation of a life-cycle-driven adaptive strategic planning process, a strategic environmental assessment with a life-cycle sustainability assessment content, and life-cycle management-based institutional architecture to support the evaluation and the planning process.

Chapter 7: Distributed renewable economy for Africa as a basis for wellbeing economy development

The unprecedented economic growth registered through the agricultural transformation and the successive stages of the industrial revolution led to new sets of environmental scarcities and crises on a global scale. These scarcities grew exponentially with the fast pace of industrialisation and globalisation that was registered during the second half of the twentieth century. The globalisation of the twentieth century did not only globalise national economies but it also globalised environmental pollution and degradation, which had remained local for millennia. This has resulted in global challenges such as climate change. The exponential increase in inequality between and within countries is another worrying social outcome of unbridled globalisation. As reported in an Oxfam Briefing Paper, the 26 wealthiest people on earth in 2018 had the same net worth as the poorest half of the world's population, some 3.8 billion people (Vázquez Pimentel, Ayma & Lawson, 2018).

The emerging disruptive technologies, which are inherently distributive, provide excellent opportunities for the economic empowerment of people provided that they are utilised innovatively. This includes technologies such as artificial intelligence, robotisation and block-chain technology driven by digitisation, renewable energy technology systems and distributed manufacturing systems. However, the possible impacts and benefits of these disruptive technologies will mostly depend on who controls the use of these technologies. The battle is already on between the corporate establishments that are bent on maximising profit and their market position by exploiting the emerging disruptive technologies and the advocates for the transformational utility of these technologies for the broader and higher benefit of humanity through, for example, open-source knowledge commons-based ‘prosumer’ systems.

Given the major economic, social, environmental and technological factors that are at play, the twenty-first century will be registered as the century of the most significant social transformation in human history. This transformation on a global scale will have significant immediate and long-term impacts on the ability of African countries to develop their respective economies. As was noted earlier, Africa has a unique opportunity to be a significant beneficiary of this transformation. However, for Africa to reduce the adverse impact of this transformation on its people and maximise its benefit, it has to break away from its ‘passive recipient’ status and prepare itself to be an active player of this global transformation by seizing the available opportunities.

‘Distributed economies’ generally promote small-scale, flexible networks of local socio-economic actors using local resources according to local needs, in the spirit of sustainable development. Besides the direct economic and environmental benefits, this approach provides a robust socio-economic basis for job creation, empowerment of women and broad participation of local communities in development management. It also provides fertile ground for socio-technical innovations driven by local needs and conditions. Thus, the promotion of networks of local economies that create more jobs and add more value to local economies need to be at the centre of promoting sustainable development in Africa. This can be driven by distributed renewable energy (DRE) systems, which offer an unprecedented opportunity to address energy poverty and accelerate the transition to modern energy services for rural communities.

Planning for a distributed renewable economy is aimed at creating a local, sustainable economy network as a foundation for developing a wellbeing economy that continuously fulfils the needs and aspirations of its people while ensuring the wellbeing of the natural ecosystem. The crucial first step of the whole process is to identify a natural resource sector and or an economic actor which could be

used as an anchor for the development of the distributed economy network. The next step is to organise an innovation incubation space to identify the specific economic activity that may lead to higher value addition and job creation for the local economy. Development of the first tier of the economic network around the most promising resource and economic actors by ensuring optimal vertical and horizontal integration across the value chain is at the core of planning for a distributed renewable economy. This will be further consolidated by replicating the economic network into a second-tier of economic activities.

Chapter 8: Inclusive governance for sustainable development in Africa

The discourses around developmental states and sustainable transition have gained increasing prominence in development studies over the last couple of decades. Proponents of both developmental states (DS) and sustainability transition (ST) agree on the need for profound structural transformation, but with two different ends in mind. For proponents of developmental states, the end is accelerated economic 'Development' (big 'D') that substantially raises the average gross domestic product (GDP) per capita with a focus on industrialisation and urbanisation. On the other hand, the end state for proponents of sustainability transition is a socio-technical transition that results in a low-carbon and resource-efficient economy. This chapter argues that the synthesis of these two bodies of scholarship needs to open up a space for a more detailed discussion about governance for a just transition, with particular reference to how we deepen our understanding of the dynamics of the polity in African governance systems.

A new kind of political leadership is required that strikes a very delicate balance between regulation of shared norms/values and self-managed implementation. It also needs to recognise that there are emergent properties that stem from dense networks of people, working together across institutional boundaries within well-defined institutional ecosystems, unconstrained by outdated, usually hierarchically organised, norms or an atmosphere of fear and conformity. Furthermore, embeddedness for the twenty-first-century developmental states might mean building a polity that broadens out developmental partnering with networks of civil society formations and smaller entrepreneurs rather than focusing only on the investment strategies of large corporates.

To ensure that the directionality of the transition to more sustainable modes of production and consumption is also oriented towards a just transition will depend on power dynamics within the polity. The rise of governance since the 1970s is primarily about the organisation and outward expansion of the polity to incorporate policy actors that were previously excluded from having any influence on policy. Much of this was to compensate for the weakening of the state as

complexities mounted. However, ‘collibration’ is the counter-trend, referring to the way key actors within the polity seek – with varying degrees of success – to harness and mobilise governance and complexity more generally. It is this kind of ‘governance of governance’ that has the potential to guide and shape long-term structural transformation that would be required in the African context to drive a just transition. The core skill required for this is process facilitation.

It is necessary to move away from a ‘black box’ approach to the African polity. Detailed granular analyses of the inner dynamics of the polity will be required. This will need to include, firstly, an understanding of the underlying power relations at the very heart of the polity. Without this, facilitated collibratory governance to widen stakeholder involvement in the polity will be impossible. Secondly, an understanding of the potential and limitations of the paradigm(s) shared by key actors within the polity will be required. Without this, learning and innovation will be difficult to achieve. Thirdly, how state/government institutions are organised, funded and operated is critical. This is where ‘lock-in’ and path dependency sets in, often conditioning constrained parameters within which policy alternatives are considered. Fourthly, how policies are formulated and the potential futures they express is also critical for success.

To effectively implement the SDGs, the traditional debate about African developmental states must incorporate sustainability transitions and conceptualise sustainability-oriented developmental states. The need for purposive directionality to tackle the tremendous African challenges of inequality and unsustainability has never been greater. Collibratory governance in practice is about building a new generation of meta-governance institutions with a mandate and capabilities to facilitate new modes of partnering within reconfigured more inclusive polities.

Chapter 9: Indicators on transformational infrastructure for a wellbeing economy

The most dominant economic development indicator since the middle of the twentieth century is gross domestic product. This indicator has served well for the promotion of the free-market economy in the twentieth century and subsequently globalisation during the second half of the century. GDP, as a measure of the market value of goods and services produced within an economy in a given period, has been a reasonable indicator to measure the level of economic production in a region or country. The limitation of GDP as a measure for development was well recognised even by its creator back in the 1930s and 1940s. However, since the second half of the twentieth century, it garnered a disproportionate amount of attention and influence from both policymakers and the general public as a measure of human wellbeing and social progress. The mounting evidence from countries

has shown that a narrow focus on GDP is at odds with the broader outcomes of sustainable development, particularly those relating to environmental wellbeing and social equity.

The need for developing alternative indicators to GDP has been recognised for many decades. The most notable challenge came from the global effort to develop sustainable development indicators that address the economic, social and environmental dimension of sustainable development. This effort received a new push since the 1990s and led to the development of different methodologies and hundreds of indicator sets including composite indicators. These include ecological footprint (EF), environmental sustainability index (ESI), wellbeing index (WI), human development index (HDI), global happiness index (GHI), and green economy indicators (GEI).

The various sustainability assessment approaches and development indicators provide valuable insight into how to navigate through development and utilisation of alternative indicators. The key selection criteria African countries are advised to consider in selecting an indicator set are policy relevance, the utility for policy and decision-making, soundness of the methodology, interpretability of generated information and availability of relevant data. While many lessons could be drawn from existing literature and practical experience in developing and utilising sustainability-related indicators, the indicator framework proposed in this book is specifically focused on assessing the leapfrogging possibilities from a transformative infrastructure perspective.

The guiding vision of the indicator framework is that African countries can transition to a wellbeing economy that will enable them to fulfil the basic needs and aspirations of their people while sustaining the wellbeing of the natural ecosystem as a foundation for their development. The scope of the framework is that the investment decisions to be made on essential infrastructure development within the coming five to ten years will determine the leapfrogging opportunity of African countries to a wellbeing economy both in the medium and long term. The framework also recognises that the ability of countries to effectively integrate the above consideration into their policy, planning and budgeting process is a crucial factor in determining their leapfrogging potential.

The proposed set of indicators are clustered under transformative policy formulation, transformative infrastructure development, and transformative governance. The policy component looks at the high-level political commitment for a transformational transition to a wellbeing economy expressed in different forms in national policy and strategy documents. The infrastructure component looks at the level of commitment for transformational infrastructure and the lifecycle consideration in the planning and development of energy, industry and urban

infrastructure as the primary drivers. Finally, the governance component looks at the fulfilment of both distributional and representational justice for communities as fundamental prerequisites for achieving transformational development in the twenty-first century. The proposed framework needs to be further adapted and developed according to the specific context of each country.

References

- International Resource Panel. (2019). *Global resources outlook: Natural resources for the future we want*. Nairobi: UNEP.
- International Soil Reference and Information Centre. (2013). *Soil atlas of Africa*. <https://www.isric.org/projects/soil-atlas-africa> [Accessed 2 October 2019].
- United Nations Economic Commission for Africa. (2011). *Sustainable development report on Africa: Managing land-based resources for sustainable development*. Addis Ababa: UNECA. <https://www.uneca.org/sites/default/files/PublicationFiles/sdra1-full.pdf> [Accessed 20 September 2019].
- United Nations Environment Programme. (2013). *Africa environment outlook 3: Our environment, our health*. <http://www.unep.org/pdf/aeo3.pdf> [Accessed 12 September 2019].
- Vázquez Pimentel, D.A., Ayma, I.M. & Lawson, M. (2018). *Reward work not wealth*. Oxfam Briefing paper, January 2018. Cowley, UK: Oxfam GB. https://www-cdn.oxfam.org/s3fs-public/file_attachments/bp-reward-work-not-wealth-220118-en.pdf [Accessed 13 March 2019].



I

TRANSFORMATIVE LEAPFROGGING TO A WELLBEING ECONOMY IN AFRICA

Desta Mebratu

Introduction

2015 was a year during which a broader global consensus was reached across science, politics and morality on the need for transformational change. The adoption of Agenda 2030 on Sustainable Development Goals (SDGs) and the Paris Declaration on Climate Change together with the Encyclical issued by Pope Francis on climate change, which happened during the same year, represents this development. In essence, all these and other declarations recognised the urgency for the transition to inclusive, low-carbon and resource-efficient economies at the global level. The declarations underline that such a transformation is critical if humanity was to avoid an irreversible natural disaster of a global scale and make progress towards a more inclusive society. The path to be followed by each country and regions could be different from one to the other. This is because each path is dependent on the current level of development and the specific socio-economic and socio-ecological challenges faced by the respective countries and regions. Broadly categorised, countries with developed economies would require to deconstruct

and retrofit their existing infrastructural base while countries that are at an early stage of development have the opportunity to build their infrastructure on a more inclusive, low-carbon and resource-efficient basis. By doing so, they maximise their leapfrogging opportunity into a more sustainable development trajectory.

Besides what has been agreed at a global level, Africa as a region developed its own Agenda 2063 that aims to transform the development visions and aspirations of its people into reality and improve the wellbeing of its people. Many African countries have been developing ambitious development visions and strategies that align with Agenda 2030 and Agenda 2063. However, most of these countries are facing severe challenges in making progress in implementing their visions and strategies. Much of these challenges are associated with the fact that most of these national efforts are locked in the conventional economic development models of the twentieth century that has some fundamental limitations. In light of the early stage of development of most African countries, the region is believed to have the largest leapfrogging potential to an economy that is inclusive, climate-resilient and resource-efficient. Putting Africa on a more sustainable development trajectory is a global opportunity that should not be missed by the international community.

This chapter provides an overall conceptual framework for transformative leapfrogging of African economies and presents the key drivers and elements of such leapfrogging opportunities. The chapter starts with a brief discussion of the conceptual basis for the transition to an inclusive, low-carbon and resource-efficient economy and critical aspects of leapfrogging including the qualitative distinction between incidental and transformative leapfrogging. This is followed by a section that highlights the key drivers that favour transformative leapfrogging in Africa and the related constraints that need to be addressed by African countries.

Environment and economic development

For millennia, the interaction between human society and its natural environment had been primarily governed by adherence to the limits and correcting conditions imposed by the natural systems. This relationship started to change with the onset of the agricultural revolution and subsequently took a new proportion with the industrial revolution. While these changes were initially driven mainly by the Judeo-Christian beliefs of ‘man’s right to master the earth’, it was later given an economic rationale of wealth creation for economic development. This subsection provides an overview of the perceived dichotomy between economic growth and the environment followed by a synoptic review of the concept of sustainability and sustainable development.

Economic growth and environment

One of the major myths that have adversely affected progress in sustainable development policy-making is the perceived dichotomy between the environment and the economy that is dominant in neo-classical economics. This resulted in continuous depletion and degradation of the natural ecosystem as a consequence of externalising all costs associated with environmental inputs and services. The concept of the environmental Kuznets curve (EKC), which became popular in the 1990s, attempted to describe the relationship between economic growth and environmental pollution by applying Kuznets' theory. The Kuznets curve, which is an inverted U-shaped curve, is based on the hypothesis that was first advanced by economist Simon Kuznets stating that as an economy develops, market forces first increase and then decrease economic inequality (Munasinghe, 1999). According to the environmental Kuznets curve hypothesis, economic growth increases environmental pressures at early stages of development, but after a turning point, high per capita income levels enable societies to reduce their ecological impact (Padilla, 2017). In a nutshell, EKC states that indicators of environmental degradation tend to get worse as new economic growth occurs until average income reaches a certain point over the course of development (Shafik, 1994).

The World Bank's World Development Report 1992 (International Bank for Reconstruction and Development [IBRD], 1992) argued that as incomes rise, the demand for improvements in environmental quality will increase resulting in more resources being made available for environmental investment. The assertion is that once countries reach a certain level of growth, they will be in a position to invest in environmental protection measures, which will result in improved environmental quality. This has been a mantra that has been fiercely advocated by some international development organisations and development experts in the last decade of the twentieth century. Even if the overall assertion of the EKC might have been correct for some developed countries concerning limited types of environmental pollution, it cannot work ad infinitum for all countries. Besides the various econometric limitations outlined by Stern (2003), the foundation of EKC became more discredited in the last couple of decades, mainly for the following reasons:

- As was concluded by many international scientific panels, the existing global economic system has already overshoot the carrying and assimilating capacity of the planetary system in several areas. This places an ecological limit to the industrialisation of developing countries' economies following the same old path of industrialisation.

- Significant progress has been made in developing more resource-efficient and environmentally-sound technologies across sectors since the 1990s. This created opportunities for newly industrialising countries to develop their economy in a more economically and ecologically efficient way. These opportunities led to the possibility of tunnelling through the environmental Kuznets curve and achieving economic growth with reduced environmental impacts.
- The long-standing dichotomy between environment and economic development, which has been misleading policy development in most countries, has been debunked in the subsequent decades. This has resulted in global consensus documents aimed at promoting alternative development pathways that meet the multiple economic, social and environmental objectives of a country.

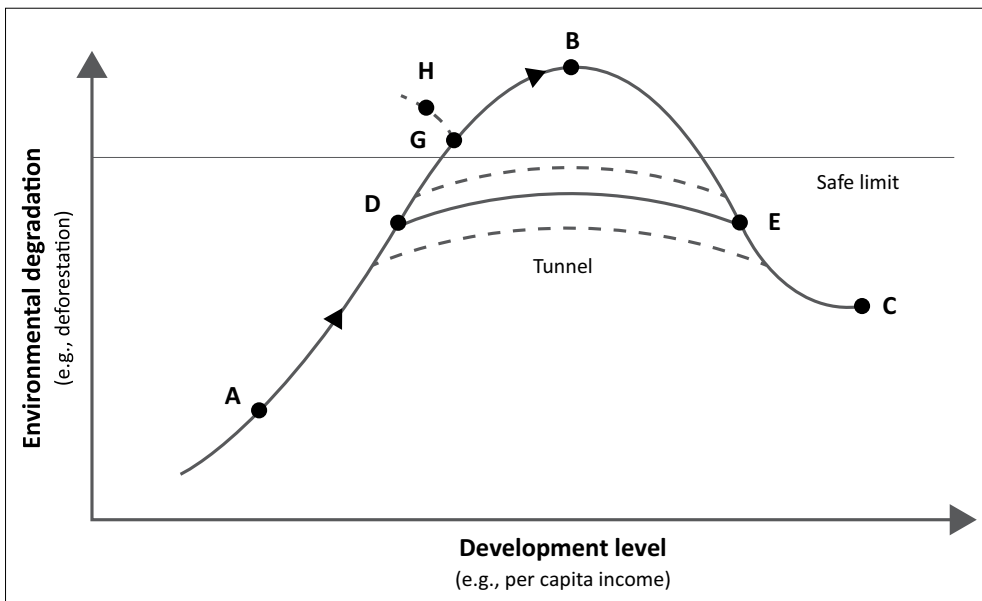


Figure 1.1 Tunnelling through the environmental Kuznets curve using sustainable development strategies (Source: Munasinghe, 1999:95)

All African countries have signed up to the most recent global sustainable development consensus documents including Agenda 2030 on Sustainable Development Goals and the Paris Declaration on Climate Change. Despite their full endorsement of these documents, many African countries are still trapped in the idea of ‘industrialise first and deal with the environment later’. The first major step to getting ready for the opportunities from transformative leapfrogging is to get rid of such an obsolete notion of industrialisation which does not fit well with the reality of the twenty-first century.

Sustainability and sustainable development

Major social transformation processes have shaped human history over millennia. These transformational processes determined the critical features of socio-economic relationships both within communities and across nations. However, they also fundamentally redefined our relationship with the natural environment. Two of the most significant social transformations are the agricultural and industrial transformations, which radically redefined human society. Both of these transitions were driven by confluences of crisis which include the environmental crisis of various dimensions. The dynamic relationship between society and its natural environment had been one of the critical drivers of these social transformations while their outcomes had also redefined it. The agricultural transformation, as a successful response to wildlife scarcity faced by the hunter-gatherer society, resulted in slow population growth from about 10 million to approximately 800 million by 1750 (Meadows, Meadows & Randers, 1992). This created new scarcities and social conflict, especially in land and energy, which led to the industrial revolution that began in England with the substitution of abundant coal for vanishing biomass resulting in the introduction of the steam engine.

Compared to previous centuries, the twentieth century had been a period of unprecedented economic growth and development driven by a faster pace of industrialisation and globalisation. However, it was also a century that saw exponential growth in the volume of resource extracted from the natural environment and the related environmental degradation. The International Resource Panel (IRP) reported that over the past five decades, our global population has doubled, the extraction of materials has tripled and the gross domestic product (GDP) has quadrupled. The report further concluded that the extraction and processing of natural resources have accelerated over the last two decades, and accounts for more than 90 percent of our biodiversity loss and water stress and approximately half of our climate change impacts (IRP, 2019). On the other hand, the International Panel on Climate Change (IPCC) concluded that if humanity is to avoid irreversible change, it has to limit global warming to 2°C relative to the period 1861–1880 and reach carbon neutrality by the second half of this century (IPCC, 2014). French economist Thomas Piketty maintains that on the social front, while social inequality seemed to narrow down in developed countries in the decades immediately after the Second World War, it became significantly wide across the world with the increased globalisation of national economies (Piketty, 2014).

The relationship and interaction between the natural environment and society have been a subject of discourse for thousands of years, be it in philosophy or religion. However, it took a different scope and dimensions since the middle

of the twentieth century due to the global proportion of the environmental impacts that were being faced by humanity. In this context, it has been more than 30 years since the terms 'sustainability' and 'sustainable development' rose to the prominence in international development discourse. Although the terms are more recent terminologies, there are important schools of thoughts that are considered as historical precursors to the current discourse (Mebratu, 1998). This ranges from the traditional conceptualisation of 'living in harmony with nature' adhered to by indigenous communities across the world, to the various religions which represented the 'voice of nature to humanity' by celebrating and consecrating our ties with the non-human world (Gottlieb, 1996). The relative vagueness of the concept coupled with its increasing importance in national and international policies led to the proliferation of definitions and interpretations that emphasise one or the other aspect of sustainability and sustainable development (Mebratu, 1998).

Over the subsequent decades, numerous processes were initiated from global to local levels focussing on different aspects of sustainability and sustainable development. As a result of these initiatives and processes, our knowledge and understanding of the natural environment and its interaction with our socio-economic systems have significantly expanded. Despite the progress made so far, we have not been able to go beyond incremental gains which have limited capacity to contain and reverse the unsustainable momentum that is building up. This is manifested through the deepening socio-economic and social-ecological crisis expressed in the form of growing environmental degradation, persistent economic stagnation, increasing unemployment and growing disparities between and within countries. These and other global and regional developments have brought the transition to inclusive, low-carbon and resource-efficient economies to the centre of national and international development discourse.

Swilling and Annecke (2012) argue that sustainability is a challenge that is difficult to comprehend through disciplinary lenses and the significance of complexity theory lies in the fact that it shows how to make this break from reductionism. Applying principles of systems dynamics based on key principles of systems thinking could help us to better understand sustainability as an organising principle of any system. Mebratu (2000) proposed a planetary sustainability matrix aimed at highlighting the hierarchical relationships and interactions between the different dimensions of the cosmic universe as presented in the sustainability matrix shown in Table 1.1.

Table 1.1 The planetary sustainability matrix

Planetary sphere/hierarchy	Subsidiary process	Measurable flows	Regulating mechanisms	Non-stable scenarios	Default corrections
Abiotic natural system	Geophysical assimilation and accumulation	Mass and energy flow	Geological cycles and processes	Disturbances of cycles and variations	Natural calamities and disasters
Biotic natural system	Reproduction and metabolic processes	Population and consumption	Mobility and succession	Persistent overshoots and migration	Population crash or extinction
Social	Family and social network creation	Resource distribution and wellbeing	Social norms, policies and regulations	Conflicts and social unrest	Revolution and war
Economic	Value addition and surplus exchange	Resource and information flows	Market mechanisms	Economic recession	Economic depression and collapse

(Source: Adapted from Mebratu, 2000:67)

The horizontal axis of the sustainability matrix consists of the subsidiary process, measurable flows, regulating mechanisms, non-stable scenarios and default corrections while the vertical axis represents the hierarchical spheres of our planetary universe. The subsidiary processes are those processes that inherently determine stability within the planetary regimes while the measurable flows are the characteristic flows (of energy, material and information) that help to describe the planetary entity. The regulating mechanisms are the mechanisms which determine its functional stability. The non-stable scenarios are indicators of effects of persistent overshoots of the measurable parameters, while the default corrections are the systemic corrective mechanisms that restore the stability of the system.

In this context, social transformations are systemic responses that are necessitated by the dynamic interaction between the socio-ecological and socio-economic factors of a given society. The specific scope and nature of the transformation process shall be determined by the particular dynamics of the socio-economic and socio-ecological interactions. Such social transformation could happen either through a smart and creative response to non-stable scenarios or as an outcome of the default corrections of the system which will be beyond anybody's control. The stark choice that humanity is faced with today is whether it will act timely and take the necessary action to bring about a desirable social transformation outcome or be at the receiving end of the default corrective action by the system, which would have its undesirable consequences.

As noted by Swilling and Annecke (2012), the evolution of new modes of existences instigated by innovations that partially or provisionally resolved the crisis and destroyed the basis for pre-existing modes of operations, technologies and hierarchies of power were crucial prerequisites for social transformations.

All major socio-economic transformations are characterised by changes that happened in leaps and bounds. The transformational impact we see with the exponential developments in the field of information and communication technology (ICT), including the application of artificial intelligence, and the progress made on renewable energy development are some of the critical factors that determine the nature and pace of the transition in the coming decades. In a nutshell, we live in an era that provides numerous transformative leapfrogging opportunities towards a society that is more inclusive, low-carbon and resource-efficient. This is particularly true for most African countries at the early stage of industrial development since they have a higher opportunity to build their economy on a more sustainable basis.

Leapfrogging and social transformations

Moments of social transformation in human history are mainly characterised by the various tensions between the old and dominant system that strives to maintain the status quo and the new system that emerges as a result of the system dynamics. These tensions are usually resolved with the new techno-economic system taking the upper hand by meeting the required threshold of transformational change. In the next section, we look at the key features of lock-in and leapfrogging followed by the distinction between incidental leapfrogging and transformative leapfrogging supported with some case studies. The last subsection covers some of the key drivers and factors of transformative leapfrogging.

The concept of lock-in and leapfrogging

From a technological progress perspective, the dynamics between lock-in and leapfrogging scenarios has been central to all forms of social transformations, including the agricultural and industrial transformations. These dynamics become even more critical for the transition to inclusive, low-carbon and resource-efficient economies given the dominant role of technology in today's economies. Hence, it will be essential to understanding the relationship and distinction between these two critical factors of technological transition. Corvellec, Campos and Zapata (2012) note that the notion of lock-in originates from historical studies of science and technology. The idea of path-dependence (Corvellec et al., 2012; Liebowitz & Margolis, 1995; Schreyögg & Sydow, 2010) is close to the notion of lock-in. Both ideas underscore that today's solutions are constrained by yesterday's choices and decisions even if these choices have lost their relevance and new alternatives have emerged that are more efficient and effective than the solutions that currently dominate. However, there are some distinctions in the sense that while path-dependence focuses on the constraints that the past puts on present decisions, lock-in describes a current state of things (Corvellec et al., 2012). Once it is set,

it is not easy to break-up a lock-in due to stiff resistance for any change that will be created by the coalitions of interested groups and forces that benefit from the status quo.

However, as suggested by Cowan and Hulten (1996), possibilities of unlocking technologies can emerge from a combination of events, just as the process of lock-in can start with a small historical event or sequence of events. Grabher (1993) identifies three types of lock-in. These are: (i) functional, as in the case of personal ties and joint investment; (ii) cognitive, because of common ways of interpreting or envisioning things; (iii) and political, through associations or coalitions of industrialists or politicians. Corvellec et al. (2012) identified four types of rationales for a given state of infrastructural lock-in, taking the lock-in effect of waste incineration infrastructure as a basis. These are: (i) institutional rationale that are determined by existing policy and institutional frameworks; (ii) technical rationale justified through economic and technological factors that create a stalemate on identifying and accepting a new alternative; (iii) cultural rationale that leads to the establishment of a culture-bound cognitive lock-in; and (iv) material rationale associated with the physical infrastructure and related resource flow which may require a radical redesign of this network.

The concept of leapfrogging was initially used in the context of economic growth theories and industrial-organisation innovation studies with a specific focus on competition among firms. In the field of industrial organisation (IO), the leading work on leapfrogging was developed by Fudenberg, Gilbert, Stiglitz and Tirole (1983) who analysed the conditions under which a new entrant can leapfrog an established firm. However, Joseph Schumpeter's notion of 'gales of creative destruction' (Schumpeter, 1942) provided the conceptual foundation for this and other subsequent works on innovation and leapfrogging. Schumpeter proposed that companies holding monopolies based on incumbent technologies have less incentive to innovate than potential rivals, and therefore they eventually lose their technological leadership role when new radical technological innovations are adopted by new firms which are ready to take risks (Schumpeter, 1942). According to Schumpeter, the gale of creative destruction describes the process of industrial mutation that incessantly revolutionises the economic structure from within, steadily destroying the old one, creating a new one (1942, cited in Tirole, 1988). The concept of creative destruction as defined by Schumpeter became a powerful concept in the field of economic research because it can explain many of the dynamics or kinetics of industrial change: the transition from a competitive to a monopolistic market, and back again (Sidak & Teece, 2009). Nelson and Nelson (2002) noted that it has also been the inspiration of endogenous growth theory and evolutionary economics.

Table 1.2 has been developed building upon the classification of the rationales for lock-in described earlier to further clarify the similarity and distinction between technological and infrastructural lock-in and leapfrogging.

Table 1.2 Comparison of the rationales of lock-in and leapfrogging

The rationale	Lock-in	Leapfrogging
Temporal	Managing the present within the boundaries and constraints of the past	Creating a new future by breaking out of the boundaries and constraints of the present
Institutional	Viability of the status quo under existing policies, regulations and institutional procedures	More economical, social, and environmental benefits could be achieved
Technical	Focus on incremental efficiency gain within a piecemeal and stand-alone operational objective	Drive for systems-wide transformational outcomes by redefining the operational boundaries
Cultural	Cognitive and institutional inertia caused by fear of the unknown	Preparedness to be innovative and disruptive with focus on higher and broader outcomes
Material	Rehabilitating and retrofitting of existing physical infrastructure with an emphasis on optimising resource flow	Deconstructing and replacing existing physical infrastructure with a new infrastructure of a higher metabolic function

As the table shows, concerning the time dimension, a lock-in situation is more focused on managing the present within the boundaries and constraints of the past while the leapfrog scenario focusses on creating a new future by breaking out of the boundaries and constraints of the present. At the institutional level, the lock-in scenario strives to ensure and secure the viability of the status quo under existing policies, regulations and institutional procedures while the leapfrog scenario aims at breaking the dominant institutional framework with a focus on creating multiple economic, social, and environmental benefits.

On the cultural front, the lock-in scenario is characterised by cognitive and institutional inertia driven by fear of the unknown, while the leapfrog scenario is characterised by the drive to be innovative and disruptive with focus on higher and broader outcomes. Finally, on the material front, the lock-in scenario invests on rehabilitating and retrofitting existing physical infrastructure with an emphasis on optimising resource flow, while the leapfrog scenario invests on deconstructing and replacing existing physical infrastructure with a new infrastructure of a higher metabolic function.

Transformational moments are typically characterised by the increasing tension between lock-in and leapfrog scenarios in various forms. A closer look at the current tension between the oil and gas industry, which has been the dominant energy sector for more than a century, and the emerging renewable energy sector provides a clear demonstration of the above comparison at the sectoral level. Until recently, the oil and gas industry has been actively undermining the advancement of renewable energy technologies both through its covert and overt actions. As the

build-up of the facts from climate science on the increasing adverse impact of carbon emission on the environment become indisputable, and the global consensus on climate change became stronger, the oil and gas sector started to invest in becoming a renewable energy company too. In recent years, an increasing number of major financing institutions have decided to disinvest from the use of coal for power generation and shift their investment to renewable energy development. Such moments represent a tipping point from a lock-in to a leapfrog scenario.

Incidental and transformative leapfrogging

The term ‘leapfrogging’ has been used in different contexts in development discourse, particularly in relation to development pathways that need to be followed by developing countries. Munasinghe (1999) and Goldemberg (2011) note that developing countries can either choose to mimic industrialised nations and undergo an economic development that is dirty, wasteful and that creates an enormous legacy of environmental pollution or to leapfrog over some of the steps of development. Some experts tend to confuse leapfrogging with a conventional process of transferring technology. Goldemberg (2011) notes that technological learning and innovation, which lead to lower costs for existing and new products and enhances productivity and competitiveness, are not synonymous with leapfrogging. The World Bank Group (2018) noted that Africa’s massive infrastructure, technology, and policy gaps require disruptive solutions and thinking outside of the box, yet development policies have often been primarily programmatic and mostly incremental.

One of the critical distinctions we need to understand when we talk about leapfrogging is the distinction between an incidental leapfrogging, which is mainly incremental, and transformative leapfrogging. An incidental leapfrogging is the application and utilisation of a new generation of know-how and technology that has become available on the market as a result of externally driven innovation and operational factors. On the other hand, transformative leapfrogging is innovative and need responsive application and utilisation of a new generation of knowledge and technology for broader and transformative impacts. To illustrate with an example, the improvement of access to communication through mobile connectivity without the need to have an elaborate copper-wire based communication infrastructure for landline connectivity is a typical example of incremental leapfrogging. On the other hand, the innovative application and utilisation of the same mobile communication technology for financial inclusivity, agricultural productivity and health services to tens and hundreds of millions of people are examples of transformative leapfrogging.

A more detailed look at the distinction between incidental and transformative leapfrogging (refer to Table 1.3) shows that the focus for incidental leapfrogging is more on acquiring the technology (hardware), while the focus for the transformative leapfrogging is on the development of a socio-technological regime that is more relevant and impactful to the specific context. In terms of the driving factors, incidental leapfrogging is mainly driven by external driving factors, which includes the availability of technology and finance, while transformative leapfrogging is primarily driven by contextually-defined and demand-driven internal factors linked to broad development objectives.

Table 1.3 Comparative analysis between incidental and transformative leapfrogging

Key features	Incidental leapfrogging	Transformative leapfrogging
Dominant mechanism	Diffusion of new technologies	Development of new socio-technological regimes
Driving factors	Mostly supply driven by external push factors	Contextually-defined and demand-driven by internal factors
Level of impact	At best segmented and incremental	Society-wide and transformative impacts
Innovation	Minimal innovation as the technology end-user	Unpacking of technology with a strong dimension of socio-technical innovation
Empowering potential	Higher potential of disempowering people	Provides more empowerment to society

In terms of its ultimate impact, incremental leapfrogging may, at best, result in segments of incremental progress that are of limited impacts, while transformative leapfrogging has high possibility to lead to society-wide and transformative impacts. In terms of innovation, incremental leapfrogging has a minimal element of innovation as it tends to focus on transferring the technology as an end-user while unpacking the technology with a purpose of enhancing the socio-technical innovation is key for transformative leapfrogging. Finally, incremental leapfrogging has high disempowering potential as it promotes dependency on providers and external players, while transformative leapfrogging empowers countries through a continuous build-up and accumulation of knowledge.

One can find a sufficient number of cases to illustrate incidental leapfrogging in all spheres of African socio-economic textures. To start with, there is very strong evidence that our education system is mostly suffering from all the malaise of incidental leapfrogging. This is because our modern education system was designed to either serve the neo-colonial governance agenda of the post-colonial era (in the field of social sciences) or feed the best and the brightest of the region's children to the economies of the developed world (through the fields of science and engineering). Hence, despite decades of effort, African education and research institutions have not been able even to identify the source of the critical development challenges that Africa is facing, let alone provide solutions for its

underdevelopment. Overcoming these challenges would require fundamentally rebooting our knowledge system in such a way that it becomes responsive to the specific needs and demands of the respective countries.

On the technology front, there have been numerous regional and national efforts to transfer technology to African countries since the middle of the twentieth centuries. Most of our technology transfer efforts over the last five to six decades, however, have been mainly determined either by external push factors or misguided ambitions of the ruling elite. As a result, their outcome and developmental impact have been mostly marginal, and in some cases detrimental to the respective countries. As we move to the era of the Fourth Industrial Revolution (Industry 4.0), in which the role of technology is becoming exponential, the success of any country will be determined by the way it manages and utilises the opportunities from these technologies. The examples in the two boxes that follow provide insight into the benefits and damages of transformative and incremental leapfrogging respectively.

Box 1.1: The case of M-Pesa, Kenya

M-Pesa, which was launched in 2007 by Safaricom in Kenya, ignited the mobile money revolution in Africa. The service allows customers to use their mobile phones to, for example, deposit and withdraw funds from banks, make money transfers, pay bills and purchase airtime. M-Pesa's initial innovation was leapfrogging the lack of financial services by exploiting existing telecommunications infrastructure and network subscriptions in Kenya, circumventing the expenses associated with storefronts and in-cash transactions (World Bank Group, 2018). Nearly two-thirds of Kenya's adult population, which comprise a quarter of the country's GNP, use mobile payments and M-Pesa has been a lifeline for the unbanked (Brugmans, Van Dinteren & Hajer, 2016). The service has expanded to include more advanced offerings, including ATM cash withdrawals, savings accounts, on-site retail payments, mobile ticketing for events, and corporate banking accounts. M-Pesa spawned competing mobile money services.

By 2016, 75 percent of the country's adult population had a mobile money account, with transactions amounting to the equivalent of 4.5 percent of annualised GDP per day. M-Pesa is a disruptive innovation that transformed banking in other countries, leading to an explosion of mobile money services across Africa, enhancing financial inclusion. Besides promoting inclusiveness and broader social justice, such transformative innovation makes a significant contribution to the growth of revenue and profitability of private companies. According to the annual report of Safaricom (2017), M-Pesa has become Safaricom's most significant driver of revenue growth in just a decade, contributing to over a quarter of its fiscal year 2017 revenue, with the mobile money service generating KSh 55 billion (US\$103 million). *(Sources: Safaricom, 2017:11; Brugmans, Van Dinteren & Hajer, 2016:33)*

Box 1.2: Reppie Waste-to-Energy facility, Addis Ababa, Ethiopia

Like most of the African urban centres, Addis Ababa, which does not have a single sanitary landfill, is faced with the growing challenge of managing the domestic waste generated by its residents. The city is estimated to create 1 400 tons of household waste every day. The Reppie Waste-to-Energy facility is a plant located at an open-dump site of Addis Ababa city. According to the information released during the inauguration, the plant cost about Birr 2.6 billion (approximately 95 million USD) and can generate 50 MW/year, which could cover about 30 percent of all household electricity consumption of Addis Ababa.

The waste incineration technology that forms the basis for this project is considered to be an obsolete technology since the introduction of the programme of ‘reduce, reuse and recycle’ of waste in the 1990s. Furthermore, for such a facility to be operationally efficient and economically viable, it primarily needs to have a waste volume containing a significant proportion of energy-rich combustible waste. In addition, the city has to have a relatively efficient waste segregation facility, as well as a collection infrastructure that ensures collection and sorting of the waste at a minimal cost. The plant should also have a co-generation possibility that will enable it to make use of the steam/hot water that comes out after driving the turbine.

The situation in Addis Ababa clearly shows that the city does not meet any of the above fundamental prerequisites. Actually, except for a couple of towns in South Africa, none of the urban centres in sub-Saharan Africa would fulfil any of the three operational requirements. Even those cities that may have a higher percentage of combustible waste can make higher values through recycling and re-using rather than incinerating the waste for energy generation. Considering the composition of the domestic waste of African urban centres, which is mostly (60–75 percent) dirt and biodegradable debris, burning of household waste for energy generation is a fundamentally wrong and is a misplaced choice of technology for the region.

The decision to invest in this facility has all the hallmarks for an incremental leapfrogging that is driven by external factors. It is a sunk investment that resulted in an infrastructural lock-in with significant financial consequences for decades to come.

(Source: Adapted from Mebratu, 2018)

The two cases clearly show how Africa can either achieve a more transformative outcome through an innovative application of an emerging technology or get trapped in a detrimental infrastructural lock-in by acquiring an obsolete technology as a result of submitting to external drivers. Ill-informed investment decisions made by African countries on major infrastructure may trap these countries with a significant volume of stranded assets that would have substantial operational and decommissioning costs besides the attendant social and environmental cost. The only way African countries can avoid such unsustainable scenarios is through active and strategic measures that favour transformative leapfrogging, which is needed responsive and internally driven, over incidental leapfrogging, which is supply-oriented and externally driven.

Drivers and factors of transformative leapfrogging

Transformative leapfrogging is part of a broader transformational process that happens within a given socio-economic system. The nature of such a transformational process is mainly defined by some major driving factors that have their own dynamics, while the paths that are to be followed are determined by the specific elements of the socio-economic system under consideration. The unprecedented global economic growth witnessed since the middle of the twentieth century resulted in significant improvement in human wellbeing as seen in key human development indicators. However, it also resulted in a substantial rise of environmental pollution, natural resource degradation and widening income inequality both within and between countries. The ecological and social challenges faced by the global community continued to build up over the last couple of decades leading to an unprecedented confluence of economic, environmental and social challenges. This led to a broader recognition of the need for a transformational process at a global level, which resulted in the adoption of Agenda 2030 on Sustainable Development Goals and the Paris Agreement on Climate Change. The following are some of the critical global drivers that necessitate the transition to an inclusive, low-carbon and resource-efficient economy and provide the basis for transformative leapfrogging:

- **Environmental drivers:** From a systems perspective, the relation between the natural and socio-economic systems is defined by the source function, which includes the provision of required resource inputs, and the sink function, which consists of the regulating function of the natural system (Mebratu, 2000). From a source function perspective, annual extraction of natural resources grew from 7 billion tons in 1900 to 60 billion tons in 2010 and, with the Business as Usual (BaU) scenario, this is projected to reach 140 billion tons by 2050 (United Nations Environment Programme [UNEP], 2012:15). According to IPCC (2014), keeping global warming within 2°C would require limiting global CO₂ emission at 47 GTCO₂e by 2025, which is about the level of CO₂ by 2010, and reduce it to 22 GTCO₂e by 2050. However, according to the *Emissions Gap Report 2014* produced UNEP, greenhouse gas (GHG) emission is expected to grow to an average of 68 GTCO₂e by 2030 and 87 GTCO₂e by 2050 under the current development scenario (UNEP, 2014).
- **Economic drivers:** Based on comprehensive economic data, Picketty (2014) showed that the economic development of the last two centuries has led to wider economic inequalities even in most developed economies. This has demonstrated the complete failure of the trickle-down theory of neo-liberal economists. He further noted that the inimical economic recession faced by almost all of the major OECD countries as a result of the economic and

financial crisis of 2008, which is dubbed as the ‘Great Recession’, indicates the urgent need for transforming the global economy. The failure of neo-classical economics that takes growth in GDP as the primary measure for economic development has been increasingly recognised in the last decade.

- **Social drivers:** The two major factors underlying the social driver are the issue of widening social inequality and job creation. Oxfam (2016) declares that, just 62 individuals had the same wealth as 3.6 billion people in 2015, which is the bottom half of humanity. According to the International Labour Organization (ILO), global unemployment reached 197.1 million, 27 million higher than in 2007 (ILO, 2016). More disturbingly, vulnerable employment reached 1.5 billion people or over 46 percent of the total employment. Coming to the specific case of inequality in resource consumption, the average use of resources in some developed countries is as high as 30 to 40 tonnes/person/year compared to two tonnes/person/year for some developing countries (IRP, 2019). An average citizen in a developed country uses each year nearly 12 times as much energy as one would in a developing country.
- **Technological drivers:** Technological progress made in the last couple of decades has created new opportunities and challenges that may fundamentally reshape the currently dominant global economy. The progress made in ICT has created significant transformational opportunities that empower individuals with information and knowledge. On the other hand, the increasing application of artificial intelligence (AI) in the industrial sector is a source of major threats as much as it is a source of opportunities. Progress made in areas such as materials science and engineering and nanotechnologies have also created new opportunities and challenges.
- **Energy drivers:** Since time immemorial, the provision of energy has been at the centre of all major social transformations. Notable among these were the discovery of fire, bioenergy, coal and petroleum, which were the main drivers for the advent of sedentary settlements, agricultural revolution and industrial revolutions respectively. As noted in the Paris Agreement and Agenda 2030, it is urgent that we move to a low-carbon economy to help reduce the impact of climate change. From a social development perspective, addressing the widespread energy poverty across developing countries is a fundamental prerequisite for achieving poverty eradication. In this regard, the transition to an inclusive, low-carbon and resource-efficient society shall be driven by increasing share of renewable energy resources in national economies. This development would make renewable energy resources the next energy frontiers of this century.

- **Political drivers:** The currently dominant nation-state governance that is based on the principle of electoral democracy together with the global governance structure that emerged after the Second World War have been instrumental for the fastest economic growth witnessed in human history. However, it has also led to systemic governance failure that subjected billions to absolute poverty and created environmental damages of global proportion. This systemic governance failure is expressed in increasing level of public discontent and dissatisfaction that manifest themselves in civil conflicts and political unrests across the world. Addressing this challenge would require a transition towards participatory development governance that empowers people and local communities in determining and shaping their future.

Coming to the specific case of Africa, after decades of decline and stagnation, economies of African countries showed significant turnaround towards positive economic growth around the turn of the twenty-first century. Once written off as a continent uniquely suffering from structural impediments to economic growth and development, there is now widening optimism about the future of the continent (United Nations Economic Commission for Africa [UNECA], 2016). The talk of the ‘doomed continent’ and ‘African growth tragedy’ are now being replaced by metaphors such as the ‘Rising continent’ and the ‘African lions’ respectively. The *African Development Report* concludes that Africa’s growth momentum in the past 25 years has been remarkable by historical standards. The report further states that in at least two-thirds of the African countries with data, per capita income rose for eight consecutive years between 1950-2016 at a rate of 3.5 percent per year or more (African Development Bank [AfDB], 2018:33). According to United Nations Conference on Trade and Development (UNCTAD) 2015 statistics, annual GDP growth in Africa was 4.6 percent on average between 2000 and 2014 (cited in UNECA, 2015) making it one of the fastest-growing regions in the world. As a result of these development trends, the region has been increasingly touted as the next frontier for global economic growth and foreign direct investment (FDI).

While Africa is recognised as a continent that is on the rise, it is also faced with enormous environmental and social challenges that pose significant threats to the livelihood of its population. Despite the low level of development, the ecological footprint of the region increased by 240 percent between 1961 to 2008 and the overall carbon footprint of the region increased by eight-fold during the same four decades (AfDB & World Wide Fund [WWF], 2012). Furthermore, the ecological footprint of most of the African countries is expected to double by 2040 under the business as usual scenario. More than 640 million Africans have no access to energy, giving an electricity access rate for African countries at just over 40 percent, which is the lowest in the world. Africa’s energy potential, especially renewable

energy, is enormous, yet only a fraction is employed. Hydropower provides around a fifth of current capacity, but not even a tenth of its potential is utilised. Similarly, the technical potential of solar, biomass, wind and geothermal energy is huge (AfDB, 2018).

In terms of job creation, between 2000 and 2008, employment in the region grew at an annual average of 2.8 percent, which is roughly half the rate of economic growth (AfDB, 2018). Despite slower economic growth, yearly employment growth increased at an average of 3.1 percent from 2009 to 2014. However, this figure was still 1.4 percentage points below average economic growth. Africa is projected to have the highest population growth of any geographical region by 2050, which will have major implications for the continent's economic development. According to UNCTAD (2018), the population of Africa is projected to increase from 1.2 billion in 2017 to 2.5 billion in 2050, while its rate of urbanisation is expected to increase from 40 percent in 2015 to 56 percent of its population in 2050. Furthermore, its youth population is forecasted to grow from 231 million in 2015 to 461 million in 2050, while its working-age population (15–64 years) is predicted to grow by 2050.

While Africa is equally, if not more, challenged by the emerging global drivers/pressures, including climate change, it has a unique opportunity of leapfrogging to a more inclusive, sustainable and resource-efficient society that eradicates poverty and ensures improved wellbeing to its population. The following are some of the key factors that favour Africa's leapfrogging to an inclusive, low-carbon and resource-efficient society:

- **Resource endowment:** Despite its fragility, Africa is endowed with relatively abundant natural resources that provide a solid ecological foundation for its development. This includes the renewable energy resource of the continent.
- **Low lock-in inertia:** Related to its early stage of development, Africa has a low lock-in inertia from unsustainable physical and institutional infrastructure. This allows the country the opportunity to develop an economic development infrastructure that is climate-resilient and resource-efficient.
- **Technology beneficiary:** Most of the technical and technological solutions that are needed for the transition are already developed and available for use. Through an effective social innovation regime, Africa could be a primary beneficiary of these emerging and resource-efficient technologies and techniques.
- **Affinity to sustainability:** The widely prevalent communal philosophy known as *Ubuntu* in southern and eastern Africa, which is based on the principle of 'I am because of who you are' and the concept of *Ukama*, which represents

African culture of environmental conservation through the relations between nature, society and ancestors, give African communities better affinity to sustainability (Murove, 2009).

Even if Africa has a substantial leapfrogging potential, changing this potential into a transformational opportunity would require various levels of innovations at the countries level. The World Bank Group (2018) noted that embracing and leveraging innovation and building the momentum to leapfrog will be critical for Africa to create the jobs its youth so desperately need. The Africa 2063 Agenda, endorsed by the African Union Summit in 2015, expresses the collective aspiration of African countries to further promote sustainable development of the region. It is now a matter of creating the required innovation space for countries and its people to be active economic players and contributors to the twenty-first century. Africa has mostly missed out on benefiting from the industrial revolution of the twentieth century. It cannot afford to miss out on the economic transformation of the twenty-first century.

Transformative leapfrogging to wellbeing economy

The preceding section highlighted the critical importance of focusing on transformative leapfrogging for African countries not to be left out and to secure their share of benefit from the Fourth Industrial Revolution. This section focuses on describing the macro-economic context that facilitates transformative leapfrogging in Africa and highlights the specific issues that African countries need to consider to have an effective transformative leapfrogging.

The macro-economic argument

Transformational changes happen when the organising principles of an existing system persistently fail to address existing and emerging challenges and an alternative organising principle emerges as a basis for a systemic transition. There has been a growing consensus over the last couple of decades which indicated that the organising principle of the self-regulating market, as dictated by the neo-liberal economic thinking, has persistently failed. This failure has been manifested through the numerous socio-economic and socio-ecological challenges faced across the world that have become increasingly complex both in scope and frequency. American economist Joseph E. Stiglitz writes:

The current situation reminds me of the world some seventy years ago. As the world plummeted into the Great Depression, advocates of the free market said that 'Not to worry; markets are self-regulating, and given time, economic prosperity will resume'. Never mind the misery of those whose lives are destroyed waiting for this so-called eventuality. (Stiglitz, 2002:249)

Piketty concluded:

[A] market economy based on private property, if left for itself, contains powerful forces of convergence, associated in particular with the diffusion of knowledge and skills; but it also contains powerful forces of divergence, which are potentially threatening to democratic societies and to the values of social justice on which they are based. (Piketty, 2014:571)

There have been many attempts made by various groups and institutions over the years to provide alternative organising principles for the global economic system. These attempts can be broadly categorised under the following three groups:

- The first group consists of those schools of thought that consider market forces as the most efficient and effective organising principles for economic growth and prosperity and deploy macro-economic instruments to address environmental externalities. This covers the various schools of environmental economics that attempted to provide market-based solutions to environmental pollution and degradation problems while having neo-liberal economics as its foundation.
- The second group consists of those schools of thought that recognise the exclusion of the inputs and services obtained from the natural ecosystem in the overall economic calculation and attempt to rectify this limitation by putting a market value on natural resources. This covers the various schools of ecological economics that gave rise to multiple shades and colours of economies, including Green Economy, Blue Economy, etc.
- The third group, which is the most recent and still an emerging one, consists of those schools of thought that recognise the fundamental deficiency of the currently dominant organising principle of the neo-liberal schools of thought and advocate the need for a more transformational organising principle. This has given rise to more transformational economic models for continuous fulfilment of human wellbeing, while maintaining a healthy ecosystem as its foundation.

One of the emerging schools of thoughts that are based on recognising the critical importance of a transformational change is the concept of wellbeing economy. For this chapter, we will focus on the concept of wellbeing economy, which is recognised as the more transformational school of thought that belongs to the third group. Fioramonti (2017) notes that societies have adopted a narrow definition of economic growth as the route to development for the past couple of centuries thereby making the economy the most fundamental decision-making system in contemporary societies. He further notes that the transition from a growth economy that overemphasises the primary importance of large corporations

to wellbeing economy that emphasises the critical role of distributed economy networks at the local level is imperative.

Table 1.4 shows some of the major distinctions between growth and wellbeing economies based on a comparison of some of the key features.

Table 1.4 Comparison between a growth economy and a wellbeing economy

Key features	Growth economy	Wellbeing economy
Organising principle	Linear, extractive and isolated	Circular, adaptable and integrated
Primary drivers	Large corporations	Distributed economy networks
Natural ecosystems	Unlimited Providers of input	Provider of ecosystem services as the foundation for the economy
Primary measurement	Gross domestic product	Wellbeing improvement/gross happiness
Distributional outcome	Concentration of wealth under a few corporate companies	Inclusive economic opportunity across communities

To start with the major organising principles, the growth economy is organised as a linear economic system that is primarily based on the extraction of inputs, production, consumption and disposal structure that concentrates economic power. Conversely, a wellbeing economy strives to develop a circular economy that is adaptable and integrated with the local community and the natural ecosystems. Similarly, a growth economy takes large corporations as the major driver of development and prosperity, while a wellbeing economy considers distributed economy networks as the primary drivers. Concerning natural ecosystems, a growth economy is the unlimited provider of inputs and services, while a wellbeing economy takes the wellbeing of the ecosystem as the essential foundation for economic development and prosperity.

The most important distinction between growth and wellbeing economies is their position on the role of gross domestic product in measuring economic progress. One of the major successes of neo-liberal economics during the second half of the twentieth century was their success in elevating growth in GDP as the ultimate measurement of economic development by countries. While recognising the specific role of GDP as a measure for economic productivity, wellbeing economics recognises the limitation of GDP as the primary measurement for development and advocates for alternative indicators that measure the wellbeing of people and the natural ecosystem. Finally, from a distributional justice perspective, a growth economy primarily results in the concentration of wealth in the hands of the few as a result of its exclusionary structure, while wellbeing economy aims at creating an inclusive economic opportunity to all members of the community.

In a nutshell, a wellbeing economy is an economy that strives for continuous fulfilment of basic human needs and aspirations of its people within the limits

and possibilities of its resource and available external opportunities. As noted by Swilling and Annecke (2012), a sustainable society must be both equitable in social terms and more respectful of the fact that human survival depends on the natural systems that have emerged from the evolutionary process. This would require deploying a national development strategy that is home-grown and organic but at the same time adaptive to the global dynamics. It also involves governance mechanisms that are equipped with transformative leadership based on adaptive learning and inclusivity. A wellbeing economy addresses both distributive and participatory justice of its people through their active involvement in the planning and management of the development process. Progress towards a wellbeing economy is measured by an actual and perceived improvement in the wellbeing of its people rather than solely relying on growth rate in GDP and FDI.

For most developing countries, progress towards a wellbeing economy requires the development of distributed local economy networks in combination with low-carbon and resource-efficient national backbone industries. The primary operational objectives of the distributed economy would be the creation of jobs and adding of value at the local level, which are extremely crucial for African countries. Such an economy also recognises the critical importance of maintaining the wellbeing of the natural ecosystem as the foundation for the fulfilment of its developmental objectives on a sustainable basis. In essence, a wellbeing economy provides a fundamentally new vehicle for the effective implementation of Agenda 2030 on sustainable development goals with a qualitatively higher outcome.

The foundations for transformative leapfrogging

Tan, Ng and Jiang (2018) concluded that the process of technology Leapfrogging is analogous to the mechanics of a physical leapfrog and traverses across four stages: psyching, planting, propelling, and perpetuating. The psyching stage primarily covers the broad institutional framework that is required for a transformative leapfrogging. The planting stage focuses on establishing the foundation upon which the leapfrogging will be grounded. The propelling stage is the stage at which the technological leapfrogging is actualised, while the perpetuating stage is the stage at which the transformative impact of the leapfrogging process results in a new trajectory of development with multiple benefits. Taking the four stages of leapfrogging as a basis, Table 1.5 presents the key features and related outcomes of actions taken at the different stages of leapfrogging.

Table 1.5 Cycles of transformative leapfrogging

Stages	Focus	Mechanisms	Outcomes
Psyching	Developing a strategic framework aligned with national development goals	<ul style="list-style-type: none"> ▪ Defining clear strategic objectives ▪ Translating it into concrete action plans 	<ul style="list-style-type: none"> ▪ Clarity of vision and commitment ▪ Platform for collaborative actions
Planting	Building the foundation for leapfrogging	<ul style="list-style-type: none"> ▪ Defining the partnership modality with external partners ▪ Developing the required local skillsets 	<ul style="list-style-type: none"> ▪ Repurposing of existing capacity and creating new ones ▪ Establishment of an organisational anchor for the leapfrogging process
Propelling	Actualising the leapfrogging process	<ul style="list-style-type: none"> ▪ Choosing the right set of technologies ▪ Contextualization of technologies to local needs 	<ul style="list-style-type: none"> ▪ Innovative application of acquired technologies ▪ Effective assimilation of transferred technologies
Perpetuating	Consolidating the trajectory for transformative change	<ul style="list-style-type: none"> ▪ Leveraging the symbiotic impact ▪ Consolidating the path-dependent gains 	<ul style="list-style-type: none"> ▪ Optimising the transformative impact ▪ Setting the scene for the next leapfrogging

The first stage of the transformative leapfrogging cycle is the psyching stage, which involves developing a strategic technology framework aligned with national development goals that provide clarity on the vision and commitment of the government and create the platform for collaborative actions between the key stakeholders. This has to be followed by definition of the partnership modality both within and outside the country and development of the required skillsets. This may include repurposing of existing capacity and building new ability to cover for the gaps and could also lead to the emergence of organisational anchors for the leapfrogging process. The propelling stage, which is about actualising the leapfrogging process, involves choosing the right set of technologies and contextualising them to local conditions and needs. This will, in turn, lead to the innovative application of acquired technologies and effective assimilation of transferred technologies. The final stage of perpetuating is about consolidating the trajectory for transformative change by leveraging the symbiotic impact of the transferred technology and enhancing the path-dependent gains. Moreover, the process at this stage sets the scene for the next phase of leapfrogging.

Strategic considerations

For Africa to realise its leapfrogging potential and benefit effectively from the global transition, it needs to be more innovative and follow an alternative economic development path that takes into account the global drivers of change and the specific leapfrogging opportunity of the region. The critical factor that determines the ability of African countries to gain the maximum benefit from the existing leapfrogging opportunity is the strategic choice and decisions they make in building their socio-economic infrastructure for the coming decades.

Figure 1.2 shows the key features of transformative infrastructure.

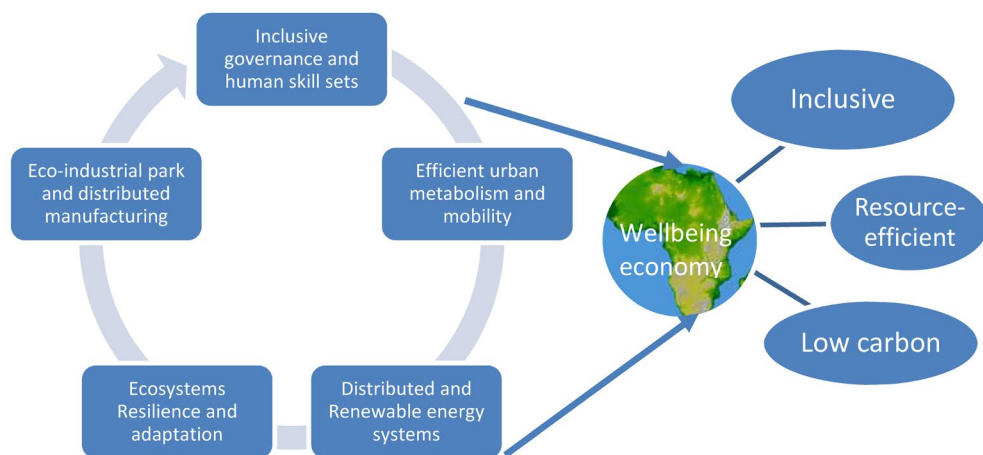


Figure 1.2 Key features of transformative infrastructure

The following are the key strategic areas that need to be given primary attention by all African countries to lay the foundation for the transition to a more inclusive, low-carbon and resource-efficient society:

- **Ecological infrastructure:** Africa’s possibility for its development on a sustainable basis and the future of its people for the coming decade depends mainly on its ability to manage and effectively utilise its natural resource base as the foundation for its economic development. Building the adaptive capacity of local communities and enhancing the resilience of the natural ecosystem is particularly critical in light of the growing threat from climate change and the pressure from a high rate of population growth.
- **Energy infrastructure:** The transition in energy systems is one of the critical determinants of the progress towards an inclusive, low-carbon and resource-efficient economy. According to the African Progress Panel (APP), the first step that needs to be taken by each African country in this regard is ensuring the transition to sustainable energy systems in which renewable energy resources shall form the core of the energy infrastructure (APP, 2016). Besides the resource mix, the smart combination between grid and off-grid distributed energy systems will be a crucial factor for ensuring the distributive impact of the energy system. The latter aspect is particularly critical for most countries in Africa as it plays a key role in promoting energy access and poverty eradication through inclusive socio-economic development at the local level.

- **Industrial infrastructure:** An efficient transformation of finite natural resources through industrial processing is a fundamental prerequisite to meet the basic needs of a growing global population. However, such efficient conversion requires replacing the predominantly linear mode of industrial production with an industrial infrastructure that promotes a circular economy. The United Nations Industrial Development Organization (UNIDO) maintains that a key component of such infrastructure is the development of eco-industrial parks as the backbone of industrialisation (UNIDO, 2016). Furthermore, concerted planning efforts should be made to enhance the productive capacity of local communities as part of a sustainable value chain by effectively linking the development of distributive energy systems with value addition at the local level.
- **Urban infrastructure:** The development of urban infrastructure to facilitate effective and efficient flow and movement of resources and promote the development of socio-economically productive urban centres is another crucial factor of leapfrogging in Africa. Besides developing multi-modal urbanisation strategy that effectively manages the push and pull factors of urbanisation, countries need to utilise the transformational contribution of progress in ICT and renewable energy development to facilitate productive empowerment of local communities.
- **Human resource:** Realising all the opportunities that are highlighted earlier and utilising the full potential of the region can only happen if countries have a working force that is equipped with the right set of skills and capability. This would require re-orienting existing education and training programmes by incorporating a new set of knowledge and skills that are necessary for the transformational change. The new set of skills and knowledge needs to be channelled towards promoting innovation at all levels of the society with a particular emphasis given to social innovation on which there is a significant gap.

In general, the global community is faced with a moment of another major social transformation in human history and Africa is uniquely positioned to lead this transformational process provided that it seizes the emerging leapfrogging opportunity. This requires effectively utilising the development possibilities that are created by key transformation drivers such as recent developments in renewable energy development and the changes driven by the development of information and communication technology. The progress to be made by African countries in this leapfrogging process will largely be determined by their success in creating the required physical and knowledge infrastructures for the transition to an inclusive, low-carbon and resource-efficient economies.

Conclusion

The Sustainable Development Goals of Agenda 2030 and the Paris Declaration on Climate Change coupled with the emerging possibilities from the development in renewable energy and IT-based technologies have created new opportunities for African countries to transition to inclusive, low-carbon and resource-efficient economies. Capturing and utilising these opportunities will largely depend on the ability of countries to develop transformational infrastructure that promotes the development of a wellbeing economy, which provides a strong basis for fulfilling the aspirations of Agenda 2063: The Africa We Want. The following are the key issues that need to be considered by national governments, development financing institutions and international development partners as the primary drivers of infrastructure development in African countries:

1. National governments: need to strategically focus on transformative leapfrogging that is contextually relevant and internally driven rather than being passive recipients of incidental leapfrogging that is driven by external interest and influence. This will provide them with a strong basis to make the right investment decisions and technology selections that result in transformational infrastructure that promotes the wellbeing of their people on a sustainable basis.
2. Development financing institutions need to desist from pushing and promoting conventional infrastructure development that is unsustainable and economically and socially inefficient in the name of development financing. Instead, they need to assist and support African countries to leapfrog into transformational infrastructure that is low-carbon and resource-efficient while at the same time promote socially inclusive development that benefits current and future generation.
3. International development partners, including the United Nations system and bilateral development organisation, need to support building the capacity of African countries in managing the transition to inclusive, climate-resilient and resource-efficient economies. It is essential to recognise that getting Africa on a more sustainable development trajectory will significantly determine the success of the global effort on mitigating the effect of climate change and the progress towards global sustainability.

In this opening chapter to the book, a modest attempt is made to lay down the basis for a new development narrative with emphasis on transformational infrastructure development. It is hoped that this will be further enriched through lessons to be gained from the concrete actions that African countries will take in the coming years and decades.

References

- Africa Progress Panel. (2016). *Power, people and planet: Seizing Africa's energy and climate opportunity*. Geneva: APP.
- African Development Bank. (2018). *African economic outlook 2018*. Abidjan: AfDB.
- African Development Bank & World Wide Fund for Nature. (2012). *African ecological footprint: Greening Africa's ecological infrastructure*. Geneva: AfDB and WWF.
- Brugmans, G., van Dinteren, J.V. & Hajer, M. (Eds). (2016). *The next economy: LABR 2016*. IABR exhibition catalogue. Rotterdam: The International Architecture Biennale Rotterdam.
- Corvellec, H., Campos, M.J. & Zapata, P. (2012). Infrastructures, lock-in, and sustainable urban development: The case of waste incineration in the Göteborg Metropolitan Area. *Journal of Cleaner Production* 50(1): 32–39. <https://doi.org/10.1016/j.jclepro.2012.12.009>
- Cowan, R. & Hulten, S. (1996). Escaping lock-in: The case of the electric vehicle. *Technological Forecasting and Social Changes* 53(1): 61–79. [https://doi.org/10.1016/0040-1625\(96\)00059-5](https://doi.org/10.1016/0040-1625(96)00059-5)
- Fioramonti, L. (2017). *Wellbeing economy: Success in a world without growth*. Johannesburg: Macmillan.
- Fudenberg, D., Gilbert, R., Stiglitz, J. & Tirole, J. (1983). Preemption, leapfrogging, and competition in patent races. *European Economic Review* 22(1): 3–31. [https://doi.org/10.1016/0014-2921\(83\)90087-9](https://doi.org/10.1016/0014-2921(83)90087-9)
- Goldemberg, J. (2011). Technological leapfrogging in the developing world. *Georgetown Journal of International Affairs* 12(1) (Winter/Spring 2011): 135–141. <https://doi.org/10.1524/9783486709612.135>
- Gottlieb R.S. (Ed.). (1996). *This sacred earth: Religion, nature and environment*. New York: Routledge.
- Grabher, G. (Ed.). (1993). *The embedded firm: On the socioeconomics of industrial networks*. London: Routledge.
- International Bank for Reconstruction and Development. (1992). *World development report 1992*. Washington, DC: World Bank
- International Labour organization. (2016). *World employment social outlook: Trends in 2016*. Geneva: ILO. <https://doi.org/10.1002/wow3.76>
- International Panel on Climate Change. (2014). *Climate change synthesis report*. Geneva: IPCC. <https://doi.org/10.1017/CBO9781107415416>
- International Resource Panel. (2019). *Global resource outlook: Natural resources for the future we want*. Nairobi: UNEP.
- Liebowitz, S.J. & Margolis, S.E. (1995). Path-dependence, lock-in, and history. *Journal of Law, Economics and Organization* 11(1): 205–226. <https://doi.org/10.2139/ssrn.1706450>
- Meadows, D., Meadows, D. & Randers, J. (1992). *Beyond the limits*. London: Earthscan Publications.
- Mebratu, D. (1998). Sustainability and sustainable development: Historical and conceptual review. *Environmental Impact Assessment Review* 18(6): 493–520. [https://doi.org/10.1016/S0195-9255\(98\)00019-5](https://doi.org/10.1016/S0195-9255(98)00019-5)
- Mebratu, D. (2000). Strategies for sustainable industrial development in sub-Saharan Africa. PhD dissertation, Lund University.
- Mebratu, D. (2018). Repi waste-to-energy plant: Sunk, misguided. <https://bit.ly/2ODitn4> [Accessed 12 September 2019].
- Munasinghe, M. (1999). Is environmental degradation an inevitable consequence of economic growth: Tunneling through the Kuznets curve. *Ecological Economics* 29(1): 89–109. [https://doi.org/10.1016/S0921-8009\(98\)00062-7](https://doi.org/10.1016/S0921-8009(98)00062-7)

- Murove, M.F. (Ed.). (2009). *African ethics: An anthology of comparative and applied ethics*. Pietermaritzburg, South Africa: University of KwaZulu-Natal Press.
- Nelson, R. & Nelson, K. (2002). Technology, institutions, and innovation systems. *Research Policy* 31(2): 265–272. [https://doi.org/10.1016/S0048-7333\(01\)00140-8](https://doi.org/10.1016/S0048-7333(01)00140-8)
- Oxfam. (2016). *An economy for 1%: How privilege and power in the economy drive extreme inequality and how this can be stopped*. London: Oxfam.
- Padilla, E. (2017). What can developing countries gain from a green transformation? In: T. Altenburg & C. Assmann (Eds), *Green industrial policy. Concept, policies, country experiences*. Geneva, Bonn: UN Environment; German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE).
- Piketty, T. (2014). *Capital in the twenty-first century*. Cambridge, MA: The Belknap Press of Harvard University Press. <https://doi.org/10.4159/9780674369542>
- Safaricom. (2017). *Safaricom annual report and financial statements 2017*. <https://bit.ly/2VBC0Wp> [Accessed 18 May 2018].
- Schreyögg, G. & Sydow, J. (Eds). (2010). *The hidden dynamics of path dependence: Institutions and Organizations*. Basingstoke, UK: Palgrave Macmillan. <https://doi.org/10.1057/9780230274075>
- Schumpeter, J. (1942). *Capitalism, socialism and democracy*. New York: Harper.
- Shafik, N. (1994). Economic development and environmental quality: An econometric analysis. *Oxford Economic Papers* 46 (October): 757–773. https://doi.org/10.1093/oep/46.Supplement_1.757
- Sidak, J.G. & Teece, D.J. (2009). Dynamic competition in antitrust law. *Journal of Competition Law & Economics* 5(4): 581–631. <https://doi.org/10.1093/joclec/nhp024>
- Stern, D. (2003). The environmental Kuznets curve. *International Society for Ecological Economics Internet Encyclopedia of Ecological Economics*. <https://bit.ly/2OJcBbQ> [Accessed 12 September 2019].
- Stiglitz, J. (2002). *Globalisation and it's discontent*. London: Penguin Books.
- Swilling, M. & Annecke, E. (2012). *Just transitions: Explorations of sustainability in an unfair world*. Tokyo: United Nations University.
- Tan, B., Ng, E. & Jiang, J. (2018). The process of technology leapfrogging: Case analysis of the national ICT infrastructure development journey of Azerbaijan. *International Journal of Information Management* 38(1): 311–316.
- Tirole, J. (1988). *The theory of industrial organization*. Cambridge: MA: MIT Press.
- United Nations Economic Commission for Africa. (2016). *Transformative industrial policy for Africa*. Addis Ababa: United Nations Economic Commission for Africa.
- United Nations Environment Programme. (2012). *Responsible resource management for a sustainable world: Findings from the International Resource Panel*. Nairobi: UNEP.
- United Nations Environment Programme. (2014). *The emissions gap report 2014*. Nairobi: UNEP. <https://doi.org/10.18356/988ece44-en>
- United Nations Industrial Development Organization. (2016). *Global assessment of eco-industrial parks in developing and emerging countries*. Vienna: UNIDO.
- World Bank Group. (2018). *Leapfrogging: The key for Africa's development*. Washington, DC: World Bank.



2

ECOLOGICAL INFRASTRUCTURE AS A BASIS FOR THE AFRICAN WELLBEING ECONOMY

Kristi Maciejewski and Scott Drimie

Introduction

Sustainable development relies on a balanced relationship between addressing social and economic growth within the boundaries of the environment. The environment not only presents the foundation that creates and sustains life on earth but also provides the assets upon which to build a country's economic development. The production of food, provision of water and natural resources, regulation of climate and purification of air rely on the sustainable management of the natural world we live in.

Natural resources, however, are limited and decreasing rapidly. If they are not sustainably managed, the system in which they are embedded will collapse. The commercial agriculture sector, for example, which forms part of the food system, contributes nearly one-third of all anthropogenic greenhouse gas emissions, causing rapid deforestation, soil degradation, and massive biodiversity loss. These affect the Earth system functioning to a degree that threatens the long-term sustainability

of the system. Development decision-makers need to take cognisance of the ecological system, ecological functions and processes and treat these common resources sustainably.

Put simply, environmental resources are required to support economies to grow, while also meeting the needs of society. The imperative, therefore, is for sustainable development that is not only economically and socially sustainable, but also environmentally sustainable. It is useful to consider this through the lens of human wellbeing: if society collapses, the wellbeing of countless individuals will be reduced, if the economy collapses that society will be significantly weakened, and if the environment collapses, the economy will be massively damaged. For human wellbeing to be maximised, environment, economy and society must be in the best possible state without compromising each other.

A powerful way of approaching this is to consider that ecological infrastructure needs to be at the forefront when thinking about the wellbeing economy. Ecological infrastructure is the nature-based equivalent of built or hard infrastructure. For example, instead of using conventional engineering solutions, such as water infiltration and drainage systems, rather restore the wetlands and mangrove forests that naturally provide these services. Nature-based solutions offer a more sustainable way of living, reducing the impact on the environment, and provide multifunctional solutions to several challenges which are also more cost-effective (Nesshöver et al., 2017).

In Africa, economic growth remains heavily dependent on natural resources. Yet the significant degradation of the natural environment coupled with the impacts of climate change continue to impede sustainable human development. Achieving pro-poor environmentally sustainable economic growth will require an enhanced understanding of how sustainable use of natural resources can help reduce poverty and support economic growth. In this chapter, we illustrate the importance of maintaining and strengthening a resilient social-ecological system approach as the foundation of wellbeing in Africa.

A social-ecological systems approach to development

The ecological infrastructures underpinning sustainable development are comprised of threatened ecosystems and limited natural resources and, therefore, need to be managed as common-pool resources. The sustainable use of ecosystems relies on cooperation and trust between stakeholders. Understanding that resources need to be harvested sustainably, overharvesting by one actor means there is less of the resource available for others. In a social-ecological system, two social actors sharing one ecological resource implies competition that can lead to

overharvesting (Ostrom, 1990). Social-ecological systems are systems that include social, economic, and ecological elements as well as interactions between them (Cumming et al., 2015). The concept of a social-ecological system is useful because it explicitly implies that stakeholders and related institutions are part of a cohesive whole, the system.

Many ecosystems and the services they provide are perceived as public goods and are not recognised in planning processes. For example, building infrastructure to provide people with water for irrigation is crucial for economic growth, for alleviating poverty and attaining many of the Sustainable Development Goals (SDGs). However, this infrastructure, especially dams, has impacts on aquatic ecosystems, and by altering the flow of water, sediment and nutrients can weaken the ecosystem services on which the communities depend (McCartney et al., 2005).

It is sometimes necessary to modify ecosystems to facilitate socio-economic development. However, this does not have to mean the degradation of ecosystems. In considering the value of ecosystems, the intent is to identify interventions that offer people long-term sustainable solutions to improve their livelihoods. For instance, by focusing more on ecosystem services, development decisions can incorporate human perceptions – the values people place on different parts of the landscape that tend to go unrecognised. Ecosystem services are the benefits people receive from nature. Tangible benefits include supplies of food and fresh water, flood mitigation and improvements to water quality. Less tangible benefits include contributions to cultures. This concept (ecosystem services) also offers a useful link between ecological and economic perspectives; by achieving a compromise between different approaches (valuation and markets versus biodiversity and system functioning), it helps ecologists and economists to communicate (Daily et al., 2000).

As an example, the Working Wetland Potential (WWP) is a pragmatic social-ecological systems approach that contextualises the provisioning ecosystem services of a wetland in terms of agriculture, without undermining the ecological infrastructure (McCartney et al., 2005). WWP uses a multi-criteria analysis that integrates the biophysical and socio-economic aspects of wetland use to provide an initial assessment of the suitability of a wetland for agriculture. This assessment can then be used to identify, organise and analyse complex factors, which in this case links people, agriculture and wetlands to develop wetlands sustainably.

Africa faces enormous challenges in relation to environmental management, and equally huge opportunities for 'doing things better' (United Nations Environment Programme [UNEP], 2016b). Building a wellbeing economy across the continent depends explicitly on the protection and integrity of the natural resources that are critical life-support systems for sustained human wellbeing. Without the

understanding that clean and healthy air, water, land and biodiversity are necessary to support a transformation to a wellbeing economy, an integrated, prosperous and peaceful region, resilient to future shocks, will likely remain a pipe dream.

The current state and trends in Africa

According to the sixth edition of the *Global Environment Outlook* (GEO-6), Africa has the potential to significantly contribute to the world economy and ensure healthy living conditions for all its denizens (UNEP, 2016b). Africa, the second largest continent in the world, has a landmass of 30 million km². Twenty-two percent of this land area consists of forests and woodlands, 43 percent is classified as desert, and 21 percent is suitable for cultivation. According to the United Nations Economic Commission for Africa (UNECA), by 1999, it was estimated that about 32 percent (200 million ha) had already been cultivated (UNECA, 2011). At the same time, about 30 percent of the total land area (892 million ha) was being used as permanent pasture. This significant loss in biodiversity does not necessarily result in poverty alleviation or an increase in human wellbeing; in fact, the opposite has occurred. Even though the continent has abundant agricultural resources, according to the *Africa Human Development Report 2012*, millions of people remain hungry and malnourished (United Nations Development Programme [UNDP], 2012). This was reiterated in the *Africa Regional Overview of Food Security and Nutrition* (Food and Agriculture Organization of the United Nations [FAO], (2017). This is largely a result of uneven local food production and distribution and chronically deficient diet. The UNDP mentions that 'Africans have been trapped by hunger for decades, with millions consuming staple foods deficient in the micronutrients needed to sustain child growth and adult productivity. Hunger also eviscerates society by increasing disease, mortality and disability' (UNDP, 2012:15).

The majority of people in Africa (approximately 85 percent) live in rural areas and are engaged in agricultural activities, with farming making up the main source of their livelihoods (World Bank, 2009). Agriculture plays a major role in the continent's economy, employing nearly 70 percent of Africa's population and generating 30 percent of gross domestic product (GDP) (UNEP, 2016b). Farming productivity, however, is largely driven by precipitation, which has been decreasing over the African continent. Over the past few decades, the northern regions of North Africa have experienced a strong decrease in the amount of precipitation in winter and early spring. The Sahel has experienced an overall reduction in precipitation over the course of the twentieth century. The same is found in eastern Africa where rainfall has decreased over the past three decades, potentially due to an increase in convection and precipitation over the tropical Indian Ocean (Funk et al., 2008). Over southern Africa, a reduction in late summer precipitation

has been reported over the western parts, extending from Namibia, through Angola, and towards the Congo, associated with an upward trend in tropical Indian Ocean sea surface temperatures. Changes in the distribution and magnitude of extreme rainfall events observed in parts of Africa are associated with both climate and variability (Williams, Kniveton & Layberry, 2010), where Africa's near-surface temperatures have increased by 0.5°C over the past 50 to 100 years.

Land cover and land-use changes in Africa are largely driven by population growth, urbanisation and investments in large-scale commercial agriculture. Large tracts of natural land, including forests, are continuously being cleared for agriculture. For example, the Mwekera forest in Zambia has undergone significant deforestation over time with estimates ranging from 250 000 to 900 000 ha per year (Shawa, 2010) with the increase in demand for firewood and cultivable land (UNEP, 2016b). The trend of decreasing forest cover has also been recorded throughout north, west, central, east and southern Africa between 1950 and 2015 (FAO, 2018). These forests are projected to continue shrinking, declining to less than 600 million ha by 2050 due to the rising population and growing demand for firewood. More than 50 million ha of forests have been lost in Africa between 1990 and 2000, representing an average deforestation rate of nearly 0.8 percent per year (UNECA, 2011). Forests play an important role in the carbon cycle. When forests are cut down, not only does carbon absorption cease, but the carbon stored in the trees is released into the atmosphere, increasing carbon dioxide concentration levels.

Land degradation is a serious threat in Africa, with about 500 000 km² of land estimated to be degraded due to soil erosion, salinisation, pollution and desertification (UNEP, 2013). This is largely driven by deforestation, forest fires, over-cultivation, inefficient irrigation practices, overgrazing, overexploitation of resources, including mining, as well as climate change (UNEP, 2016b). Land degradation reduces agricultural productivity, directly impacting on food availability, nutrition and human health. Land degradation in drylands can result in desertification. The desert lands of the Sahara, Namib, Kalahari, and the drylands of northern Kenya, southern Ethiopia and Somalia cover around 40 percent of Africa's land surface area (Jones et al., 2013).

The unreliable rainfall patterns in Africa coupled with the decrease in precipitation over time also affects the availability of freshwater. Most countries in the arid and semi-arid north and southern Africa sub-regions have lower per person internal renewable freshwater levels than the rest of the continent. With an average annual per-person consumption of 31 m³, Africa uses much less water than regions such as North America, which consumes 221 m³ per person per year (UNEP, 2010).

The quantity of water available in Africa is variable, depending on the climatic and geological setting. Africa's main water consumer is agriculture, which often results in unwanted wastage through evaporation and runoff.

There are 63 transboundary river basins in Africa, covering 64 percent of the continent's land area containing 93 percent of its total surface water resource (UNEP, 2010). River basin commissions are responsible for managing these shared resources and the erection of large dams on both local and international rivers, which are used for irrigation and to supply water to big cities. Africa also has transboundary aquifers, mainly found in zones of high-water demand. Some transboundary aquifers, such as the Nubian Sandstone Aquifer System, contain non-renewable water that has been stored for a long time. The water demand that results from population increase and stress induced by climate change may increase aquifer users and rates of depletion (UNEP, 2016b).

A wide range of wetlands types is found in Africa, including natural and constructed freshwater marshes, river floodplains, swamps and peatlands, as well as estuaries and coastal lagoons. Constructed wetlands are designed for the treatment of wastewater from settlements and mining, while natural wetlands are under immense pressure from human activities, including wastewater discharge from agriculture, settlements and industry. In South Africa, for example, wetlands are used for the treatment of mine-water pollution in the gold-mining areas of Witwatersrand (UNEP, 2016b).

Mangrove forests, another threatened land-use type, inhabit many of the saline and brackish coastal and marine areas of the continent's coastline. In East Africa, stretching from the coastal cities of Kismayu in Somalia to Maputo in Mozambique; on the West African coastline stretching from northern Angola to the northern limit of Tidra Island in Mauritania. Altogether, the mangrove forests cover an area of 1.7 million ha. Mangroves are threatened by overharvesting for fuelwood, timber and charcoal, conversion of land including agriculture, aquaculture, infrastructure development, tourism and salt production, pollution, increased sedimentation and changing hydrology (UNEP, 2016b).

Standing back from these figures, UNEP concludes that a significant share of the continent's natural resources are used unsustainably with some lost through illegal activities, which implies that the stream of benefits generated from these resources is being reduced over time (UNEP, 2016b). This has serious implications for the long-term wellbeing of the population, as natural capital accounts for between 30 percent and 50 percent of total wealth. The *GEO-6 Regional Assessment for Africa* sums up the current state of these issues: the environment is deteriorating faster than previously thought, emphasising that African governments must act faster to reverse the worst trends (UNEP, 2016b). Africa's natural capital is integral to the

economic growth of the continent, which hinges on its sustainable management. This is key to the transition to a wellbeing economy that will benefit all of Africa's population and its ecological underpinning.

Applying a social-ecological systems approach to sustainable food

The Africa Regional Overview of Food Security and Nutrition stated that the number of undernourished people on the continent had increased mainly due to the impact of climate change and conflict requiring an urgent need to build affected communities' resilience and to find peaceful solutions that strengthen food security (FAO, 2017). The impact of adverse climatic conditions, such as repeated droughts (often linked to the El Niño phenomenon) resulting in poor harvests and the loss of livestock, was of particular concern in the context of ecosystem services and building adaptive strategies in the face of rapid change. This was confirmed by the recent multi-agency publication, *The State of Food Security and Nutrition in the World*. This publication argues that 'the number of people who suffer from hunger has been growing over the past three years, returning to levels from a decade ago' (FAO et al., 2018:xiii). The situation is worsening in most regions of Africa with climate variability and extremes are a key driver of severe food crises.

Beyond climate and conflict, food and nutrition security are strongly predicated upon ecological resilience (International Panel of Experts on Sustainable Food Systems [IPES-Food], 2016; UNEP, 2016a). Natural resources are heavily impacted by changes in population numbers, wealth, urbanisation and associated changes in human behaviour toward food consumption. The ultimate causes of habitat loss in Africa are human population growth and the resulting demand for space, food and other resources; widespread poverty; dependence on natural resources; and economic pressures to increase exports, especially agricultural produce, timber and minerals (UNECA, 2011:51). Population and income growth will drive food demand in the coming decades; nearly 80 percent more meat, almost 60 percent more cereals, and one-third as many roots and tubers will be required by 2050, at significantly higher food prices and with adverse consequences for the world's poor and vulnerable populations (Rosegrant et al., 2008).

Population growth will also have significant implications for building resilient social-ecological systems. Population growth in Africa is likely to continue to put pressure on food, land and water resources. The global population estimated at 7.6 billion by mid-2017, 1.3 billion African, is anticipated to grow with 2.2 billion people by 2050. It is estimated that 1.3 billion, more than half the global growth, will be added in Africa (UN, 2017). The geography and demography of Africa are, therefore, likely to change considerably in the next few decades. The so-called 'youth bulge', expected to reach over 830 million in Africa by 2050, will add to this

pressure (Chatterjee & Mahama, 2017). Not only will the number of mouths to feed increase, but many will also migrate to urban centres in search of employment and opportunities. This will change the dynamics of rural areas, particularly concerning the supply of labour and the ratio of producers to consumers.

With such change, shifts in consumer preference will occur, leading to a demand for convenience and ready-prepared foods that require little or no energy for preparation. There is now a trend towards the homogenisation of diets and the greater intake of calories, animal protein and fat, and ultra-processed foods that are high in sugar, salt and fat (Cook, 2018). Urban living associated with changes in activity and dietary patterns is part of a nutrition transition – a simultaneous emergence of challenge in rising levels of overweight, obesity and related non-communicable diseases along with continuous problems of undernutrition and micronutrient deficiencies (Bray & Popkin, 1998).

As the African population continues to grow and natural resources become scarcer, the need to shift towards an environmentally responsible, socially accountable, more equitable, and ‘greener’ economy becomes increasingly necessary. This is exemplified in the relationship of the social-ecological system that is the African food system. The International Panel of Experts on Sustainable Food Systems (IPES-Food) argued in a 2016 report, *From Uniformity to Diversity*, that we need a fundamentally different model of agriculture and to shift the centre of gravity. They stressed the need to transition to agroecological production systems stating, ‘This transition is viable and necessary whether the starting point is highly specialized industrial agriculture or forms of subsistence farming in poor, developing countries.’ Similarly, Biodiversity maintained that ‘food systems need to be reformed so that they nourish people while nurturing the environment’ (Frison; IPES-Food, 2016). They argue that agricultural biodiversity is a source of nutritious and culturally acceptable foods often adapted to local and low-input agricultural systems and a source of important traits for breeding resilient, nutritious crops and animal breeds.

UNEP’s 2016 *Food Systems and Natural Resources* called for ‘A fundamental transformation of our food systems ... if we are to meet future demands of food and quality of life for present and future generations’ (UNEP, 2016a:14). Echoing this, the FAO 2017 report on the future of food and agriculture declares:

High-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. [We need] innovative systems that protect and enhance the natural resource base, while increasing productivity. [We need] a transformative process towards ‘holistic’ approaches, such as agroecology, agro-forestry ... and conservation agriculture, which also build upon indigenous and traditional knowledge. (FAO, 2017:xi)

A recent IPES-Food report, *Unravelling the Food–Health Nexus*, stressed the urgency of reforming food and farming systems on the grounds of protecting human health: ‘The health impacts of food systems are interconnected, self-reinforcing, and complex – but we know enough to act (IPES-Food, 2017:1).

A key question emerging from these reports is how can Africa practically move towards these stated solutions for a sustainable food system as an example of a resilient social-ecological system? An important opportunity lies in the application of social-ecological systems theory. Social-ecological resilience is the capacity to adapt or transform in the face of change, particularly unexpected change, in social-ecological systems in ways that continue to support human wellbeing (Chapin et al., 2010). Social-ecological systems theory draws on systems ecology and complexity theory – the study of how large-scale complex, organised, and adaptive behaviour can emerge from relatively simple interactions among individuals. Complex behaviours are embedded in social-ecological systems, such as non-linearities, feedbacks, the existence of thresholds, the potential for alternative stable states and self-organisation (Norberg & Cumming, 2008). Complex adaptive systems can be distinguished from other complex systems by their capacity to respond to their environment through self-organisation, learning and reasoning. These (social and ecological) agents often interact in unplanned and unpredictable ways which underlie the emergence of broad-scale patterns that feedback on the system and influence the interactions of the agents (Levin et al., 2013). The study of complex adaptive systems is, therefore, directly relevant to understanding the environment in which society is embedded and the problems that may arise.

Living with such complexity and uncertainty requires resilience-building approaches to management and governance of social-ecological systems. Echoing the first section of this chapter, this approach relies on realising that people and nature are interdependent systems, conceptualising this coupling and relating it to human wellbeing and sustainability. The field of development research traditionally treated the environment as a factor contributing to human wellbeing, which meant that natural resources were focused on one at a time to minimise impacts on the environment (Folke, Biggs, Norström, Reyers & Rockström, 2016). This way of relating humans to the environment was reflected in the Millennium Development Goals. However, a need for a deeper integration with the social science featuring the social dynamics and features linked to the environmental challenges led to the Millennium Ecosystem Assessment (MEA), which represents a paradigm shift in the human-nature relationship: from protecting the environment and conserving biodiversity to the challenge of stewardship of ecosystems and diversity and their services for human wellbeing (MEA, 2005).

Emerging knowledge, techniques and best practices in sustainable development

The nature-based solutions concept emerged in the late 2000s when international organisations searched for solutions to use nature to address societal challenges while protecting natural ecosystems and biodiversity and improving sustainable livelihoods. This concept is increasingly used by the International Union for Conservation of Nature (IUCN), the European Commission (EC) and other international organisations as well as in the scientific literature. Ecosystem-based adaptation (EbA), which involves the conservation, sustainable management and restoration of ecosystems to help people adapt to the impacts of climate change, is a nature-based solution that harnesses biodiversity and ecosystem services to build resilience to climate change. It has become increasingly more popular to construct wetlands, urban lakes and restore natural streams to recreate natural drainage and filter systems and restore and recover development conditions (Jato-Espino, Sañudo-Fontaneda & Andrés Valeri, 2019)

For us to understand the ecological resilience of a system we need to understand and consider various ecological components as well as human influences. Natural environment means climate, natural resources, plant and animal life, topography, and natural phenomenon. The biotic and abiotic components not only provide us with the water we drink, the food we eat, but also regulate important cycles in nature. These ecological components are closely linked and intertwined with the social components, the human dimension in its diverse facets, including the economic, political, technological and cultural. Together they form a social-ecological system, a complex adaptive system (Levin et al., 2013), a concept that emphasizes the human-in-nature perspective.

The social-ecological systems approach emphasizes the role that people, communities, economies, societies, and cultures play in the natural environment. These social components interact with and are inhabitants of the environment in which they depend on and are shaped by. Social-ecological system analysis presents a new way of thinking about the relationships between people and nature. This is based on the metaphor of resilience, defined by Folke et al. (2016), as the potential of a system to absorb disturbance and re-organise. Resilience is increasingly conceptualised not only as a property of social-ecological systems but also as an approach for managing these systems to ensure they continue to sustain human wellbeing amidst ongoing change and disturbance.

Ecosystem-based adaptation

Ecosystem-based adaptation is a nature-based solution that uses biodiversity and ecosystem services to support communities to adapt and build resilience in the face of disturbance. Ecosystem-based adaptation uses the range of opportunities for sustainable management, conservation, and restoration of ecosystems to increase the resilience and reduce the vulnerability of ecosystems and people. According to the Convention on Biological Diversity (CBD), EbA is an approach to sustainable development that contributes to three outcomes: socio-economic benefits, climate change adaptation and biodiversity conservation (Midgley, Marais, Barnett & Wågsæther, 2012). The intersection between these three spheres is what separates EbA from other approaches, such as community-based adaptation (CBA), climate change integrated land-use strategies (CLICS) or community-based natural resource management (CBNRM). EbA has a range of co-benefits including conservation of threatened species, livelihood benefits, sustainable utilisation of natural resources and the maintenance of ecosystem services such as water and food security (Convention on Biological Diversity [CBD], 2009).

South Africa's biodiversity and climate change policy provides clear support for the development of a coordinated programme of work on EbA, as part of an overall adaptation strategy envisaged in the *National Climate Change Response White Paper* (Department of Environmental Affairs [DEA], 2012). In response to the white paper, the 2013 Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) highlights the 'potential for ecological infrastructure to provide ecological benefits and assist in achieving development aspirations across sectors, building resilience of South Africa's natural systems, working landscapes and open spaces to support economic sectors and local livelihoods under future climate conditions' (DEA, 2013:17). EbA projects are being implemented in many provinces of South Africa. These are documented in the NCCR database, hosted by the DEA.

Ecosystem-based adaptation projects are also well underway in other African countries, including Zambia where small-scale farmers are offered economic incentives for improved land management and are assisted in high-end organic food markets (Midgely et al., 2012). This EbA project maintains ecosystem services essential for agriculture, reducing pressure on natural systems and supporting diverse rural livelihood strategies.

Key policy and strategic issues for African countries

Underpinning an economic trajectory that will lead to a continent-wide wellbeing economy comes with important challenges, not least of which is the need to reduce

the region's ecological footprint and safeguard the life-support system provided by healthy land, water, air and biodiversity.

Ecosystem-based adaptation is strongly promoted in the international policy arena. It is recognised under several multilateral environmental agreements for its ability to offer co-benefits in helping society adapt to changes, including climate change. The CBD has provided specific direction on EbA to support the United Nations Framework Convention on Climate Change (UNFCCC). The CBD's Strategic Plan for Biodiversity (2011–2020) and the Aichi Targets offer further support for EbA under Strategic Goal D which is to 'enhance the benefits to all from biodiversity and ecosystem services' (CBD, 2010:9). The UNFCCC similarly recognise the role of healthy, intact ecosystems in providing valuable services such as food, clean water, flood and erosion control. It provides national action plans and national adaptation programmes of action for least developed countries.

Similarly, the African Resilient Landscapes Initiative (ARLI) facilitated by the New Partnership for Africa's Development (NEPAD) emphasises forest and ecosystem restoration, biodiversity conservation, climate-smart agriculture, and rangeland management as key approaches towards nature-based solutions (NEPAD, 2017). Endorsed by the AU in October 2015, the ARLI and its supporting initiatives are contributing to improved soil fertility and food security, improve access to clean water, combat desertification, increase biodiversity and habitat, create green jobs, bolster economic growth and livelihood diversification, and increase the capacity for climate change resilience and adaptation (World Bank, 2015). The resilience of ecosystems thus cascades downwards to underpinning human wellbeing. A key example of this is the agri-food system.

Agricultural biodiversity is vital to the functioning of agroecosystems, to ensure food and nutrition security and to cope with the challenges of climate change. Yet the agricultural biodiversity of Africa is currently at risk as agricultural landscapes become increasingly simplified and the number of crops, crop varieties and animal breeds on farms decline (Rockström et al., 2009). The heavy reliance on this narrow range of food brings long-term risks for agricultural production, biodiversity, livelihoods and nutrition while undermining the ability of agriculture to adapt to climate change (Zimmerer, 2010). African farming systems can avoid exacerbating this through building on a fundamentally different model of agriculture based on diversifying farms and farming landscapes, replacing chemical inputs, optimising biodiversity and stimulating interactions between different species, as part of holistic strategies to build long-term fertility, healthy agro-ecosystems and secure livelihoods (IPES-Food, 2016).

Diversified agro-ecological systems can also pave the way for diverse diets and improved health as recent evidence from across countries in Africa and South Asia including rural Ethiopia, Mozambique, Tanzania, Uganda and Zambia reveals (Carletto, Ruel, Winters & Zezza, 2015; Kumar, Harris & Rawat, 2015; Shively & Sununtnasik, 2015). Agricultural diversity has been linked specifically to increased consumption of a range of key nutritional elements often missing in diets and based around staple cereal crops. The consumption of legumes, fruits and vegetables was found to be strongly associated with greater farm diversity in Malawi (Jones, Shrinivas & Bezner-Kerr, 2014), and data from Zambia indicates that there was a strong positive association between production diversity and dietary diversity (Kumar et al., 2015).

These findings have profound implications across national boundaries, underlining the need for holistic, innovative, and collaborative solutions, policies and strategies that promote agro-biodiversity. Key to this is recognition of the local crop varieties, animal breeds and underutilised crops in Africa that could be promoted and maintained, adjusting extension services and fostering synergies between scientific and local knowledge. Indeed, biocultural heritage and traditional knowledge underpin much of the remaining agricultural biodiversity in Africa and should be nurtured, including by protecting the rights of women.

The box that follows presents four case studies illustrating the building of social-ecological resilience in Africa.

Box 2.1: Case studies illustrating the building of social-ecological resilience in Africa

Livelihood diversity and redundancy in coastal communities in East Africa

An important example of social-ecological resilience emerges from the coast of East Africa where households often engage in small-scale fisheries as part of a diverse livelihood portfolio including working in tourism, agriculture or casual labour. Households who have a portfolio of options tend to be more resilient, particularly if different livelihood activities are not affected by the same disturbances. For example, in households with diverse livelihood portfolios, fishing activities can continue when the tourism sector suffers low numbers of tourists due to global perceptions of security. It has been shown in Kenya, Tanzania, the Seychelles, Mauritius and Madagascar that coastal fishers are more likely to leave a fishery in response to declining catches if they come from households with more diverse livelihood portfolios.

Avoiding poverty traps in Tanzania

While feedbacks can help keep a system in a desirable regime, they can also lock a system into an undesirable configuration. In drought-prone areas of Tanzania, population growth has increased the demand for crop production and reduced fallow times. This has led to the depletion of organic matter in the soil and a decrease in soil fertility. This, in turn, means that crop harvests are low, and that farmers have little or no surplus to sell, and therefore no money to buy fertilisers to restore or increase soil fertility. As a result, they become trapped in a vicious cycle of poverty. In these cases, it may be necessary to disrupt or weaken the feedbacks that lock the systems in an undesired configuration. In Tanzania, rainwater harvesting, and conservation tillage help restore soil fertility and reduce the impacts of drought.

Foster complex adaptive systems thinking

There are several examples of how complex adaptive systems thinking contributes to enhances the resilience of a system. In the Kruger National Park in South Africa, management has moved away from strategies to keep ecosystem conditions, such as elephant populations and fire frequencies, at a fixed level and instead allows them to fluctuate between specified boundaries. The use of threshold indicators provides managers with warning signals when a component of the system is approaching a critical point. The overall intention is to reduce human intervention (and investment) and increase the variety of ecosystems and habitat types.

Polycentric governance

Polycentric governance is well suited for the governance of social- ecological systems and ecosystem services because traditional and local knowledge stand a much better chance of being considered. This, in turn, improves sharing of knowledge and learning across cultures and scales. This is particularly evident in local and regional water governance, as in watershed management groups in Botswana, where polycentric approaches have facilitated participation by a broad range of actors and incorporation of local, traditional and scientific knowledge.

(Source: Biggs et al., 2012)

Conclusion

In summary, sustainable development cannot be achieved without grounding on an ecological foundation, but one that is not separated from the human element. Nature no longer simply sets the context in which social interaction takes place. Similarly, the human enterprise is not an external disturbance acting upon an ecosystem (Schoon & Van der Leeuw, 2015). The environment that underpins human wellbeing both responds to and influences a wide range of social, political and economic elements as well as the interactions between them. These interactions are intertwined with and ultimately framed by the capacity of the biosphere as part of the complex dynamics of the Earth system to sustain progress and development (Odum, 1989; Steffen, Broadgate, Deutsch, Gaffney & Ludwig, 2015). In sum, human development cannot be decoupled from the environment.

Whilst the inherent uncertainty and diversity in potential futures across the continent makes it tenuous for a set of prescriptive policies to be established, policy decisions should aim to minimise environmental and developmental trade-offs and maximise Africa's ability to safeguard its natural capital effectively (UNEP, 2016b). To achieve sustainable development and reach global biodiversity targets, nature-based solutions, in particular, should be treated as integral to adaptation strategies at global, national and local levels. Indeed, as is made explicit throughout the chapters of this book, the low-carbon, climate-resilient choices in infrastructure, energy and food production, coupled with effective and sustainable natural resource governance are key to protecting the continent's ecological assets that underpin a continent-wide wellbeing economy.

References

- Biggs, R., Schlüter, M., Biggs, D., Bohensky, E., BurnSilver, S.B. et al. (2012). Towards principles for enhancing the resilience of ecosystem services. *Annual Review of Environment and Resources* 37: 421–448. <https://doi.org/10.1146/annurev-environ-051211-123836>
- Bray, G.A. & Popkin, B.M. (1998). Dietary fat intake does affect obesity! *The American Journal of Clinical Nutrition* 68(6): 1157–1173. <https://doi.org/10.1093/ajcn/68.6.1157>
- Carletto, G., Ruel, M., Winters, P. & Zezza, A. (2015). Farm-level pathways to improved nutritional status: Introduction to the special issue. *The Journal of Development Studies* 51(8): 945–957. <https://doi.org/10.1080/00220388.2015.1018908>
- Chapin III, F.S., Carpenter, S.R., Kofinas, G.P., Folke, C., Abel, N. et al. (2010). Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. *Trends in Ecology and Evolution* 25:241–249. <https://doi.org/10.1016/j.tree.2009.10.008>
- Chatterjee, S. & Mahama, J.D. (2017). Promise or peril? Africa's 830 million young people by 2050. [Web log post]. <https://bit.ly/2CKXzIZ> [Accessed 10 September 2019].
- Convention on Biological Diversity. (2009). *Connecting biodiversity and climate change mitigation and adaptation: Report of the second ad hoc technical expert group on biodiversity and climate change*. CBD Technical Series No. 41. Montreal Secretariat of the CBD.
- Convention on Biological Diversity. (2010). *The strategic plan for biodiversity 2011–2020 and the Aichi biodiversity targets*. <https://www.cbd.int/kb/record/decision/12268> [Accessed 26 March 2019].
- Cook, S. (2018). *The spice of life: The fundamental role of diversity on the farm and on the plate*. Discussion Paper. IIED and Hivos, London and The Hague. <https://bit.ly/2IFzgCd> [Accessed 12 September 2019].
- Cumming, G.S., Allen, C.R., Ban, N.C., Biggs, D., Biggs, H.C. et al. (2015). Understanding protected area resilience: A multi-scale, social-ecological approach. *Ecological Applications* 25(2): 299–319. <https://doi.org/10.1890/13-2113.1>
- Daily, G.C., Soderqvist, T., Aniyar, S., Arrow, K., Dasgupta, P. et al. (2000). Ecology. The value of nature and the nature of value. *Science* 289 (5478): 395–396. <https://doi.org/10.1126/science.289.5478.395>
- Department of Environmental Affairs. (2012). *National climate change response white paper*. <https://www.gov.za/documents/national-climate-change-response-white-paper> [Accessed 25 March 2019].
- Department of Environmental Affairs. (2013). *Long-term adaptation scenarios flagship research programme (LTAS) for South Africa*. Pretoria, South Africa: DEA.
- Folke, C., Biggs, R., Norström, A.V., Reyers, B. & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society* 21(3): 41. <https://doi.org/10.5751/ES-08748-210341>
- Food and Agriculture Organization of the United Nations. (2017). *Regional overview of food security and nutrition in Africa 2017. The food security and nutrition–conflict nexus: Building resilience for food security, nutrition and peace*. Accra: FAO. <http://www.fao.org/3/a-i7967e.pdf> [Accessed 4 April 2019].
- Food and Agriculture Organization of the United Nations. (2017). *The future of food and agriculture: Trends and challenges*. Rome: FAO.
- Food and Agriculture Organization of the United Nations. (2018). *The state of the world's forests 2018 – Forest pathways to sustainable development*. Rome. Licence: CC BY-NC-SA 3.0 IGO.

- Food and Agriculture Organization of the United Nations, United Nations International Children's Emergency Fund, World Health Organization, World Food Programme, International Fund for Agriculture Development et al. (2018). *The state of food security and nutrition in the World 2018. Building climate resilience for food security and nutrition*. Rome, FAO
- Frison, A.; IPES-Food. (2016). *From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems*. Louvain-la-Neuve, Belgium: IPES. <https://doi.org/10.5958/0976-1926.2016.00033.4>
- Funk, C.C., Dettinger M.D., Michaelsen, J.C., Verdin, J.P., Brown, M.E. et al. (2008). Warming of the Indian Ocean threatens eastern and southern African food security but could be mitigated by agricultural development. *Proceedings of the National Academy of Sciences* 105(32): 11081–11086. <https://doi.org/10.1073/pnas.0708196105>
- International Panel of Experts on Sustainable Food Systems. (2017). *Unravelling the food–health nexus: Addressing practices, political economy, and power relations to build healthier food systems*. The Global Alliance for the Future of Food and IPES-Food.
- Jato-Espino, D., Sañudo-Fontaneda, L.A. & Andrés Valeri, V.C. (2019). Green infrastructure: Cost-effective nature-based solutions for safeguarding the environment and protecting human health and well-being. In: C.M. Hussain (Ed.), *Handbook of environmental materials management*. Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-319-73645-7_46
- Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J. et al. (Eds). (2013). *Soil atlas of Africa*. Luxembourg: European Commission Publication Office of the European Union.
- Jones, A.D., Shrinivas, A. & Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. *Food Policy* 46: 1–12. <https://doi.org/10.1016/j.foodpol.2014.02.001>
- Kumar, N., Harris, J. & Rawat, R. (2015). If they grow it, will they eat and grow? Evidence from Zambia on agricultural diversity and child undernutrition. *The Journal of Development Studies* 51(8): 1060–1077. <https://doi.org/10.1080/00220388.2015.1018901>
- Levin, S., Xepapadeas, T., Crepin, A-S., Norberg, J., de Zeeuw, A. et al. (2013). Social-ecological systems as complex adaptive systems: Modeling and policy implications? *Environment and Development Economics* 18(2): 111–132. <https://doi.org/10.1017/S1355770X12000460>
- McCartney, M.P., Masiyandima, M. & Houghton-Carr, H.A. (2005). *Working wetlands: Classifying wetland potential for agriculture*. Research Report 90. Colombo, Sri Lanka: International Water Management Institute (IWMI).
- Midgley, G., Marais, S., Barnett, M. & Wågsæther, K. (2012). *Biodiversity, climate change and sustainable development – harnessing synergies and celebrating successes*. Final Technical report, January 2012. South African National Biodiversity Institute, Conservation South Africa, Indigo Development and Change, with funding from the World Bank. <https://bit.ly/2Vw3PiT> [Accessed 15 September 2019].
- Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being* (Vol. 5). Washington, DC: Island Press.
- Nesshöver, C., Assmuth, T., Irvine K.N., Rusch, G.M., Waylen, K. et al. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. *Science of the Total Environment* 579: 1215–1227. <https://doi.org/10.1016/j.scitotenv.2016.11.106>

- New Partnership for Africa Development. (2017). *2017 NEPAD annual report*. <https://www.growafrica.com/resources/2017-nepad-annual-report> [Accessed 12 September 2019].
- Norberg, J. & Cumming, G.S. (Eds). (2008). *Complexity theory for a sustainable future*. New York: Columbia University Press.
- Odum, E.P. (1989). *Ecology and our endangered life-support systems*. Sunderland, MA: Sinauer Associates.
- Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge, UK: Cambridge University Press. <https://doi.org/10.1017/CBO9780511807763>
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S. et al. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society* 14(2): Art. 32. <https://doi.org/10.5751/ES-03180-140232>
- Rosegrant, M.W., Ringler, C., Msangi, S., Sulser, T.B., Zhu, T. et al. (2008). *International model for policy analysis of agricultural commodities and trade (IMPACT): Model description*. Washington, DC: International Food Policy Research Institute. <https://bit.ly/35me7Xp> [Accessed 23 April 2018].
- Schoon, M. & van der Leeuw, S. (2015). The shift toward social-ecological systems perspectives: insights into the human-nature relationship. *Natures Sciences Sociétés* 23(2): 166–174. <https://doi.org/10.1051/nss/2015034>
- Shawa, P. (2010). Deforestation in Mwekera National Forest No. 6: An ethical evaluation. Master's dissertation, University of Zambia, Lusaka.
- Shively, G. & Sununtnasik, C. (2015). Agricultural diversity and child stunting in Nepal. *The Journal of Development Studies* 51(8): 1078–1096. <https://doi.org/10.1080/00220388.2015.1018900>
- Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O. & Ludwig, C. (2015). The trajectory of the Anthropocene: The great acceleration. *The Anthropocene Review* 2:81–98. <https://doi.org/10.1177/2053019614564785>
- United Nations. (2017). *The sustainable development goals report 2017*. New York: UN. <https://bit.ly/2tyb1vg> [Accessed 15 September 2019]. <https://doi.org/10.18356/3cff8bc0-en>
- United Nations Development Programme. (2012). *Africa human development report 2012: Towards a food secure future*. Geneva: UNDP. <http://www.afhdr.org/the-report/> [Accessed 18 September 2019].
- United Nations Environment Programme. (2010). *Africa water atlas*. Nairobi, Kenya: Division of Early Warning and Assessment (DEWA), UNEP. <https://doi.org/10.18356/caf6f03c-en>
- United Nations Environment Programme. (2013). *Africa environment outlook 3: Our environment, our health*. <http://www.unep.org/pdf/aeo3.pdf> [Accessed 12 September 2019].
- United Nations Environment Programme. (2016a). *Food systems and natural resources*. A Report of the Working Group on Food Systems of the International Resource Panel. Westhoek, H, Ingram J., van Berkum, S., Özyay, L. & Hajer, M.
- United Nations Environment Programme. (2016b). *GEO-6 regional assessment for Africa*. Nairobi, Kenya: UNEP.
- Williams, C.J.R., Kniveton, D.R. & Layberry, R. (2010). Assessment of a climate model to reproduce rainfall variability and extremes over southern Africa. *Theoretical and Applied Climatology* 99(1/2): 9–27. <https://doi.org/10.1007/s00704-009-0124-y>
- World Bank. (2009, 16 June). World day to combat desertification 2009. [Web log post]. <https://bit.ly/2pej97x> [Accessed 18 September 2019].

World Bank. (2015). NEPAD launches initiative for the resilience and restoration of African landscapes. Press release, 6 December 2015. <https://bit.ly/35nhLA6> [Accessed 23 March 2019].

Zimmerer, K.S. (2010). Biological diversity in agricultural and global change. *Annual Review of Environment and Resources* 35(1): 137–166. <https://doi.org/10.1146/annurev-environ-040309-113840>



3

SUSTAINABLE ENERGY SYSTEMS IN AFRICA

Yacob Mulugetta and Lawrence Agbemabiese

Introduction

Ever since they attained political independence from colonial rule in the post-war years of the twentieth century, an ‘energy imperative’ has been at the core of the development agenda of African governments and their international development partners. Yet, despite more than 50 years of effort, energy systems on the continent remain largely ‘under powered, inefficient, unequal’ and ultimately unsustainable (Africa Progress Panel [APP], 2015). These failures account largely for the inability of most African countries to realise long-cherished goals of economic growth acceleration, the reduction and eventual elimination of poverty, and overall transitions to equitable improvements in standards of living. The few countries that have successfully transitioned from low- to middle-income status have done so by embarking on the well-beaten path that has been followed by the high-income, high-energy countries of the world: the build-up of centralised large-scale energy systems reliant on fossil and large hydro plants and associated infrastructure.

Such conventional systems have fuelled rapid growth in recent years in several African countries while catalysing their integration into a global energy economy dominated by oil and gas. But, as explained in this chapter, energy systems of this sort are often not consistent with local needs, primarily because their design and construction have been directed (and continue to be governed) by a conventional paradigm of energy-environment-society relations that has proven problematic.

Africa thus confronts a dilemma; the resolution of which should be informed by recognising contemporary energy systems as themes of a complex energy story. One narrative presents the continent as undergoing transformation, with several countries following conventional development models that support a strategy of energising their agricultural and manufacturing sectors as part of an economic growth agenda, the creation of high-quality jobs on a path to achieving multiple SDGs. This story, however, has failed so far to provide viable explanations of, and solutions for, the persistent failure of most African countries to establish energy systems capable of delivering energy access and improved living conditions for all.

There is another largely marginalised side of the African energy story; one that exposes the realities of life in a larger world beyond the affluent enclaves of large cities. This is the world beyond the grid; a rural world inhabited by millions of people with the lowest per capita use of electricity in the world. People in such areas rely heavily on solid biomass as a main source of household energy for cooking. These areas are often represented by poor access to communication systems, underdeveloped transport networks, and inadequate educational and health systems. The areas also suffer from poor income generation, largely because of their inability to add value through agricultural processing. The lack of energy access due to the combined lack of skills, finance, institutions and policies is one of the key reasons for these poor development outcomes.

African governments and their development partners find themselves in a contradiction – between the critical nature of energy problems demanding quick solutions and interventions, and the complex energy system with so many dimensions. This requires careful planning and time-consuming studies that lead to concrete interventions with positive livelihood outcomes. The good news is that there are reasons to be optimistic about the future. Firstly, if stable enabling conditions are created there is a growing domestic economic wealth that can be unlocked and mobilised for energy investment. The growing demand for energy and the high tariffs that consumers already face (in addition to a frequent reliance on expensive electricity from back-up systems) creates opportunities for investment. Secondly, sub-Saharan Africa is rich in energy resources, even if it remains poor in energy supply. The region has significant and diverse primary energy resources, with sufficient coal, gas, geothermal, hydro, solar and wind resources to deliver

more than 11 terawatts (TW) of capacity (Castellano, Kendall, Nikomarov & Swemmer, 2015). Thirdly, the cost of energy technologies, especially renewable energy (RE) technologies, has come down rapidly over the past few years. In relation to this, the large capacity gaps in Africa's energy system creates openings for technological leap-frogging through policy innovation and experimentation. Here, the contribution that distributed energy systems can make needs to be explored further.

This chapter reviews the opportunities and constraints that African countries and communities face as they explore different energy options and delivery models, focusing on bottom-up and distributed energy systems.

Africa's energy system

Nowhere is the critical nature of energy for development more pressing than in Africa. Part of the urgency is because the continent is under transformation, featuring favourable gross domestic product (GDP) growth rates over the past decade. According to International Monetary Fund (IMF) figures, overall, GDP grew at 4.6 percent in 2014, but slowed down to 3 percent in 2018 as commodity prices fell sharply and financing conditions became more difficult. It is expected rise to 3.6 percent in 2019 before stabilising at around 4 percent over the medium term (IMF, 2019). However, within this difficult picture, there is a considerable variation across the region, with growth in some countries holding steady at 7 percent or more in 2015 and 2016 supported by ongoing infrastructure investment and consumer spending. Several countries are also looking to boost their manufacturing sector as part of a programme of structural transformation by moving labour from low-productivity to high-productivity sectors. However, structural transformation is a double-edged sword. While it lays the foundation for high and sustained economic growth, it also requires increased energy use to maintain productivity necessitating significant investment in energy infrastructure.

Africa has significant resources. According to the United Nations Environment Programme (UNEP) publication *Atlas of Africa Energy Resources*, Africa has 7.5 percent of the world's proved gas reserves, 7.6 percent of its proved oil reserves and 3.6 percent of global coal reserves (of which South Africa alone accounts for 3.4 percent). The region's renewable energy resources are diverse, consisting of almost unlimited solar potential (10 TW), significant hydropower potential (350 GW), wind (110 GW), as well as geothermal resources (15 GW) (UNEP, 2017:2). The challenge African countries face is how to develop the capability to harness sustainably their significant resources to meet their development objectives. At the moment, only a fraction of these resources are developed.

The practice of widening access to modern energy services across sub-Saharan Africa is complex, largely due to the dual nature of the energy system itself where traditional and modern energy systems and practices co-exist (Sokona, Mulugetta & Gujba, 2012). The total power generation capacity of the 48 sub-Saharan African countries, excluding the Republic of South Africa, stands at roughly 45 gigawatts (GW) (less than that of Turkey or Spain), and about a quarter of this capacity is not currently available, mainly due to ageing power plants and lack of maintenance. This case of crippling underinvestment means that more than 620 million people, amounting to nearly 70 percent of the total population, live without access to electricity. Only seven sub-Saharan countries, mostly concentrated in the west and southern African regions, now have electricity access rates exceeding 50 percent. With rapid population outpacing the rate of electrification, it is also the only region in the world where the number of people living without electricity is increasing. The International Energy Agency (IEA) calculates that between 2000 and 2014, the number of people without access to electricity increased in 37 countries, highlighting that any effort in widening energy access must take into account demographic as well as lifestyle changes. Furthermore, nearly 80 percent of those lacking access to electricity live in rural areas, which adds to the complexity of possible interventions, strategies and potential technical solutions (IEA, 2014). However, with the expected population growth of 1.5 billion by 2030, future growth will be almost entirely urban, implying that the number of rural households for which access needs to be created will stabilise (World Bank, 2017c).

The history of electrification across Africa informs us that early electricity development across Africa came about for three major reasons: as a symbol of modernity for non-African settlers, as a source of power for mines and industry, or a stimulus for industrial development (Showers, 2011). As in Europe, electrification began with isolated, small-scale generators supplying farms, industries and municipalities, mostly built by the colonial powers and their associated private enterprises (Showers, 2011). These entities and industries were supported by the local supply of labour and skills, while most of its population remained dependent on subsistence agriculture. Today, African policymakers talk with confidence about the need for structural transformation. In some cases, deliberate policies are or are currently being implemented to support smallholder farmers to increase their energy use per unit of cultivated land by utilising better technologies, inputs and approaches. The lesson to take from history is that the electricity system in sub-Saharan Africa was designed as part of the integration of the continent into a global economic order, leaving the large rural, informal and subsistence production system with limited technological input from outside. The provision of modern energy services today has to be seen against this backdrop and contemporary presence of this historical legacy.

According to the World Bank and partners, some gains are being recorded with an expansion of electricity in poorer countries, even the rate of electrification overtaking population growth for the first time in 2016 (World Bank, 2018). As shown in Figure 3.1, the reason behind this is the high and continued improvement in electricity access in East Africa, namely Kenya, Tanzania and Ethiopia. Helped by the rapidly declining cost of renewables, availability of targeted grants and the emergence of new business models, these countries have invested significantly in their electrification programmes as a means to support their ambitious economic transformation and social wellbeing goals.

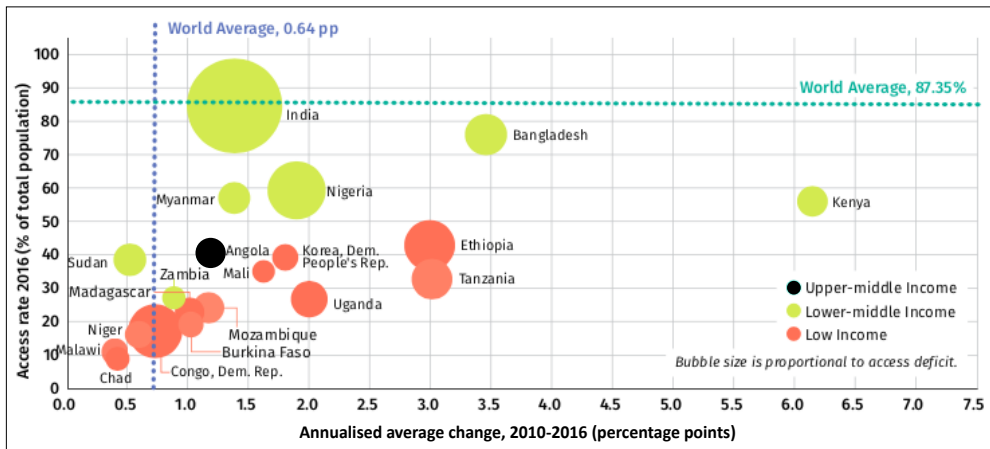


Figure 3.1 The 20 countries with the largest electricity access-deficit over the 2010–2016 period (Source: World Bank, 2018:23)

The UN Sustainable Development Goal 7 (SDG7) focuses on a concerted global effort to ensure access to affordable, reliable, sustainable and modern energy for all. The other ‘branches’ of SDG7, namely, improvements in efficiency and increased implementation of renewables have also seen progress. Energy efficiency also continues to improve, driven by advances in the industrial sector and household appliances, which could have transformative results in doing more with less. Growth in renewable energy expansion across Africa also made gains in the electricity sector in both grid-based and off-grid systems, though much of this growth is concentrated in a handful of eastern and southern African countries. However, despite the huge attention on Africa from potential investors as a new clean energy frontier, the region is still struggling to shed the perception of being high-risk area for energy investment as well as the fact that the utility infrastructure necessary for large-scale renewable power plants is not fit for purpose in many African countries.

Beyond electricity, solid biomass – including wood, charcoal, animal dung and crop waste – is the primary cooking and heating energy source for nearly 730 million

people in sub-Saharan Africa. The high level of reliance on traditional use of solid biomass, typically with inefficient stoves in poorly ventilated space, imposes immense health, environmental and social costs for households. Currently, over 600 000 women and children die annually from indoor air pollution associated with the use of firewood for cooking (APP, 2015). Furthermore, energy production from unsustainable biomass harvesting in Africa as fuelwood and for charcoal production is significant. This exacerbates the strains on the forestry stock and contributes to rises in greenhouse gas (GHG) emissions (Bruckner et al., 2014). A transition to cleaner cooking fuels and appliances faces numerous obstacles, not least because people who have access to modern fuels, such as low-pressure gas, natural gas, biogas or electricity, may also continue to use solid biomass for cultural, cooking or cost reasons – a phenomenon known as ‘fuel stacking’.

Theorising Africa’s sustainable energy system, innovation and development

During the early post-independence years, the conventional development narrative described the continent as a new frontier of Western-style economic growth based on agricultural modernisation and expansion of the manufacturing sector, powered by large-scale power plants reliant on a mix of fossil and large hydro fuels. The model promised that such energy investments would drive the creation of high-quality jobs, increase incomes, and facilitate access to education, health, and other benefits consistent with a relentless economic growth agenda. The ‘Conventional energy systems’ column of Table 3.1 summarises some of the key components of the paradigm that, as noted earlier, has governed post-independence African energy initiatives. Amory Lovins provides a detailed critique of such systems, referring to the collection of policy, market and technology choices as constituents of a ‘hard energy path’ (Lovins, 1977). A recurring fact about the energy-development history of Africa features a succession of large-scale energy projects bearing the unmistakable stamp of hard energy ‘cookie cutters.’

Having been swayed to accept for decades by the premises and promises of hard energy path advocates and technocrats, African governments and their development partners today find themselves caught in a cycle of continually allocating disproportionate shares of national resources for energy and other infrastructure projects serving the minority in urban centres. Rather than build needs-oriented energy solutions for all, governments and their development partners have not been able to think outside the box of centralised and complex energy systems. Years of institutionalised, elite-led energy planning and policy have produced not the benedictions of universal energy access but the maledictions of deepening energy poverty and inequity.

Table 3.1 Conventional versus sustainable energy systems

Conventional energy systems	Sustainable energy systems
Energy policy	
Fossil, large-hydro, nuclear promotion Production incentives Reliability-focused regulation Removal of most market barriers Expansion of demand Local adaptation to national choices Standardisation of delivery systems	Renewables dominant Efficiency incentives Focused on end-use regulation Creation of efficiency institutions Expansion of end-use efficiency Local choices and responsibility Diversification of delivery systems
Energy market	
Supply-oriented Capital-intensive investment pattern Fuel-based prices Emphasis on near-term costing Supply-demand balance of quantity Fuel competition Maximisation of consumption	Efficiency oriented Diversified capital investment pattern Social/environmental cost-based prices Emphasis on life-cycle costing Supply-demand balance of services End-use competition Maximisation of conservation
Energy technology	
Large-scale/technology intensive Central/interconnected systems Industry-driven technology choice Limited technology options Production/economic cost-based	Small-to-moderate scale dominant Decentralised/locally responsive User-driven technology choice Diverse technology options Social/environmental costs-based

(Source: Adapted from Wang, 2001:3)

A radically different story of energy challenges and prospects in Africa has gained traction in recent years. Far from perceiving the unserved hinterlands of the continent as virgin territory ready for fossil-powered corporate profit-maximising energisation, the new narrative tells the truth about impoverished landscapes of unmet needs, lost human freedoms and the progressive decline in capacities to seize opportunities – the underbelly of failed national energy regimes. New and more accurate analyses are exposing the scourge of energy poverty, inequality and injustice beyond affluent urban enclaves – a world beyond the grid, inhabited by millions of people living in rural settlements with the lowest per capita use of electricity in the world. People in such areas rely heavily on inefficient biomass converters as their main source of household energy for cooking and other basic services. The multi-dimensional scope of the new narrative captures the deprivations suffered by Africa’s energy-poor, such as unreliable communication systems, weak or non-existent transport infrastructure, and inadequate educational and health systems, especially for women and children. Studies by scholar-practitioners associated with a ‘bottom-up’ energy planning school of thought are providing a clearer picture of persistently low levels of productivity in primary, secondary and tertiary sectors; the anaemic livelihood systems; and the erosion of income and wealth-creating opportunities (Practical Action, 2010). Inadequate

energy access – itself a function of severe deficits in knowledge, financing, enabling institutions and policies – is at the root of these negative development outcomes of the hard energy path.

These conditions have accelerated the emergence over the past several decades of novel schools of thought around an alternative paradigm of energy for sustainable development. At its most general, the new framework ‘emphasises the process of changing the interlocking nature of energy, economy, environment and equity (E4) to conform with sustainability’ (Wang, 2001:2. Branching out from the ‘seed’ idea of sustainable development (World Commission on Environment and Development [WCED], 1987) the major strands of this emergent paradigm include ‘soft energy paths (Lovins, 1977), Pezzey’s proposition that sustainability be understood as being distinct from optimality and survivability (Pezzey, 1992), and Daly’s definition of ‘development’ as a transformation that makes something qualitatively better, not simply bigger in size (Daly, 1993). From this standpoint, a sustainable energy system is not merely designed to drive economic growth and quantitative proxies of quality of life improvements. Rather, it aims to transform and re-orient the E4 relations in ways that increase wellbeing within the regenerative and assimilative capacities of the environment. As illustrated in Figure 3.2, the strong interplay amongst the elements making up E4 can gather momentum over time to produce higher levels of wellbeing in a manner that these interactions can become self-organising and self-reinforcing. Of course, in order for the multiple benefits to be felt, policies would need to be integrated, and sectoral boundaries loosened. The sustain energy model thus entails properties and ‘rules of the game’ that have little, if anything, in common with those of the conventional (hard) energy paradigm (see the ‘Sustainable energy systems’ column of Table 3.1).

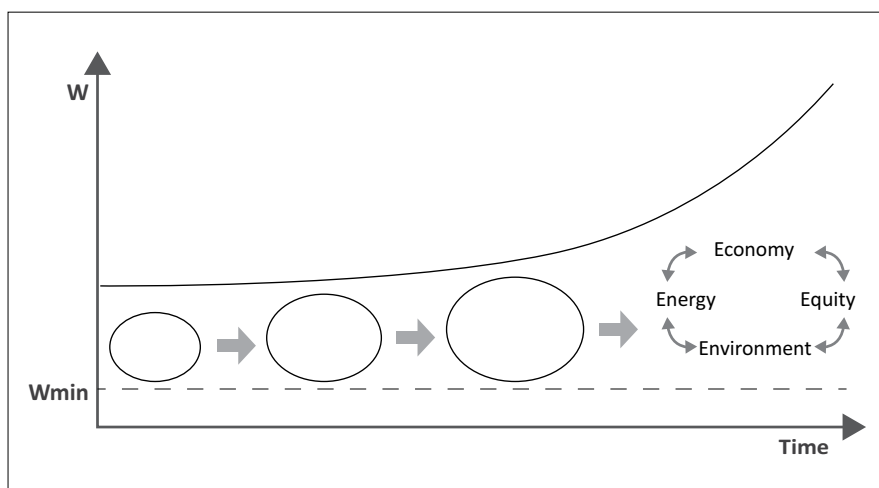


Figure 3.2 E4-Wellbeing relations (Source: Wang, 2001:2)

As part of the newly invigorated discourse on energy-development relations in Africa, attention has largely shifted from theoretical endeavours aimed at defining sustainable energy systems to action-oriented efforts seeking to operationalise the concepts in specific contexts. There is a growing consensus that however it might be defined, the common denominator of any sustainable energy transition agenda is to respect fundamental truths, principles, criteria and indicators that are different from the governing conventions of the day. Energy system transformation processes should diverge from the current unsustainable path. The time to operationalise a transition agenda is now.

A recent contribution to the energy transition literature is the Energy Transition Index (ETI), an empirical tool for measuring energy system performance and thereby ‘identify imperatives and align policy and market enablers accordingly’ (World Economic Forum [WEF], 2019). It emphasises the importance of simultaneously pursuing an energy transition on three broad variables, namely: Access and Security, Economic Development, and Environmental Sustainability (WEF, 2019). The ETI thus offers a flexible framework for elaborating context-sensitive criteria to guide transition strategy and policy in Africa. However, when we consider Africa’s historical experience with authoritarian energy regimes, it becomes obvious that the ETI is missing a critical variable – freedom. This point of view is well supported by Armatya Sen’s seminal theory of ‘development-as-freedom’ (Sen, 2000).

The ETI has also been used to evaluate an economy’s readiness to implement the necessary conditions for a sustainability transition. Transition management theory suggests that an important measure of readiness be defined by the capacity of ‘societal networks of innovation’ to generate ‘sustainability visions’ based on which transition paths and a common transition agenda may be drawn up to guide planning and policy (Kemp & Loorbach, 2006). Loorbach (2010) has defined such networks as ‘transition arenas’ comprising small networks of frontrunners who, among other capabilities: (i) are able to consider complex problems at a high level of abstraction, (ii) are transdisciplinary thinkers, (iii) enjoy a level of authority within various network, (iv) are skilled communicators in explaining visions of sustainable energy and development to key stakeholders, (v) are willing to engage in group thought processes, and (vi) are open to innovative thoughts and solutions other than what they might have in mind.

Although particulars will vary according to context, it is difficult to exclude the following as the key arenas of interacting frontrunners in any assessment of an African country’s energy transition readiness: (i) energy-system structure transformation, (ii) building political commitment (regulatory policies), (iii) stimulating capital and impact investment, (iv) establishing enabling institutions and governance,

(v) mobilising human capital and stakeholder participation, and (vi) innovation system and infrastructure build-up.

Development of this framework is continuing to benefit from applied policy research and country case studies of multi-level transition management. There is an emerging strand of ideas from system innovation studies including the notion of inclusive innovation (Falcone, 2014; Foster & Heeks, 2015; Geels, 2005; Geels et al., 2016; Raven, Van den Bosch & Weterings, 2010). Attempts to apply these concepts in studies of green industrialisation in Africa have appeared in the literature (Okereke et al., 2019).

While casting much-needed light on energy realities beyond the purview of the conventional narrative, the sustainable energy paradigm also presents a more optimistic view of Africa's energy future as well as practical ways of getting there. Highlighted already in the introduction of this chapter, some of these include: (i) the rising demand for energy, creating investment opportunities; (ii) a rapidly growing domestic economic wealth that is yet to be unlocked for energy investment; (iii) Africa's significant primary energy resources, especially in renewable energy resources, raising the attention of investors for both domestic demand and export, even beyond the region; and (iv) the rapid reduction in the cost of renewables, making them competitive against conventional fossil fuels and also increasing the viability of off-grid systems to meet energy needs in rural areas.

The energy, climate and development dilemma in Africa

Today, discussions about energy often take place in the shadows of climate change and development discourses. Scarcely a day passes without climate change being raised as an issue in energy policy debates. Sometimes the concern is with the implications of rising GHG emissions from fossil fuel on human and ecosystems or future generations. Sometimes it is directed at the financial cost of certain decarbonisation actions in energy development and who should pay or of innovations that lead to desirable outcomes. Other times, it is about what happens to economies under conditions of deep decarbonisation (e.g., oil producers) or how lifestyles would need to change to ensure consumption levels are under control to avoid punching through the 2°C or the 1.5°C ceiling (Mulugetta & Castan-Broto, 2018). In this regard, policymakers across Africa now recognise that while Africa's historic responsibility for current climate change is minimal (2–3 percent GHG and 18 percent population), this position takes a static perspective about Africa and assumes that the continent will remain too poor to take up a higher share of the global GHG footprint. Africa's energy demands are increasing, and its energy mix is changing, but there is still plenty of headroom for managing the transition given that the region's energy system is yet to be built, and decisions made

today will have repercussions for many years to come. This section explores the connections between climate change and Africa's energy system and sketches out the opportunities for investment that would help to upgrade energy infrastructures.

Equity considerations are crucial

The Paris Agreement confirmed the need to strengthen the global response to keep a global temperature rise this century well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5°C. According to the United Nations Framework Convention on Climate Change (UNFCCC), the voluntary pledges in nationally determined contributions are currently tracking toward a warming of 3–4°C above pre-industrial temperatures (UNFCCC, 2016). Without a profound transformation of economic and of energy systems at all levels, the current efforts are not sufficient to keep temperature changes under safe levels. The transformations required for deep decarbonisation may also have co-benefits for energy poverty and improving energy access, and hence, they could have a direct impact on enhancing wellbeing and livelihoods in many countries (Ribera et al., 2015). The need for a realignment of current systems of production and consumption within ecological limits is also endorsed by the SDGs at the UN, emphasising the importance of 'access to affordable, reliable, sustainable and modern energy for all', and the recognition that none of the other SDGs can be achieved without adequate access to energy services. That access to modern energy services has gained ever greater attention globally in recent years partly reflects its critical importance to all three pillars of sustainable development.

While the need for decarbonisation is essential for addressing climate challenges, there is a disjuncture between responsibility and consequence in the way the costs and benefits of climate actions are distributed across space and social groups. Questions of justice and fairness are central to the issue of climate change and response efforts across geographies and generations. Several authors outline four key points of connection between climate change and justice from the international regime (UNFCCC) perspective (Harlan et al., 2015; Okereke, 2010; Shue, 2013). This issue was covered well in the latest IPCC report on the 1.5°C warming (Allen et al., 2018). The first is the huge asymmetry in contributions to the problem of climate change in that the benefits of progress and development have been unevenly distributed and those who have benefited the most historically have contributed the most to the climate challenge. The second is the asymmetry in facing the impact of climate change – a problem which is exacerbated because the worst impact tends to be felt most by people and communities least responsible for the problem. The third is the asymmetry in power to decide solutions and response strategies in that the more powerful actors can use their greater influence to

define positions and agendas that suit them. Fourth is an asymmetry in the capacity of future-response whereby some states and places are at risk of being locked out in terms of solutions as the world progresses to a low-carbon economy (Fleurbaey et al., 2014; Humphreys, 2017).

In this context, it is worth asking what are the justice implications for Africa in either volunteering or being pressured to take a low-carbon development route? Arguably, investments in low-carbon technologies offer some opportunities to tackle poverty while increasing mitigating or adapting to climate change. A classic example is the distributed renewable energies for off-grid communities, which in addition to being climate-friendly can increase socio-economic development and enhance adaptive capacity (Sokona et al., 2012). However, it is also possible that some low-carbon pathways may require more upfront investment than conventional pathways, and so there may be complex trade-offs between cost per unit of energy, biodiversity loss, climate change and localised air pollution (Fuso-Nerini et al., 2018). Equally, it is important to recognise that realising greater welfare and wellbeing cannot be achieved without peaceful societies and equal access to justice (SDG16).

In relation to the above, placing the climate discussion in its historical (and political) context has two important functions. Firstly, it helps us to appreciate the genesis of the problem and the possible effect of global warming on present and future generations, hence situating local impacts firmly into global politics and economics, as well as discussing inequality in a concrete way. Secondly, history helps us to explain the evolution of social and environmental systems, with explicit consideration of relations of power thereby providing the platform to challenge 'dominant accounts of environmental change' (Robbins, 2004:12). The argument here is that environmental change and ecological conditions are fundamentally tied to larger issues of economic, social and political processes within which the 'triple inequality' of vulnerability, responsibility and mitigation are embedded (Roberts & Parks, 2006).

Energy and climate dilemma

Globally, the key issue in energy and sustainable development is climate change. However, countries in Africa have very low CO₂ emissions from electricity generation and industrial fossil-fuel use. They account for 42 of the 50 countries with the lowest such emissions in per capita terms in 2014, with median per capita emissions less than one-fiftieth of some developed countries and major oil exporters (Boden, Andres & Marland, 2017). Leaving aside South Africa and the North Africa region, emissions are low across Africa, mainly because economic activities are lower than other regions, and much of the population still lacks adequate and clean energy services (Pachauri et al., 2013). According to the World Resources Institute

(WRI), Africa's per capita emissions of CO₂ amounts to about 2.7 to 3.9 tonnes per person (tCO₂/pp) per year depending on whether land-use change and forestry are included in the calculations (WRI, 2014). Still, these figures compare favourably against an annual Asian average of about 5–5.3 tCO₂/pp, 9.7–10.3 tCO₂/pp for Europe and over 20 tCO₂/pp for North America. To limit global temperatures to 2° C, the atmospheric concentration must not exceed 450 ppm (parts/million) CO₂ equivalent (IPCC, 2013). This means the annual average per capita emissions will need to converge at 2.1–2.6 tCO₂/pp, and of course, staying within the 1.5° C global temperature limit means an even smaller 'carbon budget' to play with.

Three key trends are likely to change this picture. Firstly, Africa's population is growing significantly and is estimated to amount to 25 percent of the global population by 2100 (United Nations Department of Economic and Social Affairs [UNDESA], 2015). Secondly, Africa has the fastest-growing urban population, driven by internal growth and migration from rural areas, and often cities tend to be associated with higher levels of per capita consumption of energy. Thirdly, the economies of Africa have plenty of headroom to grow, which will require more energy to sustain growth. In short, the African emissions will rise in aggregate, and Africa's share in global energy-related CO₂ emissions is projected to increase markedly. The only questions are the size of this increase and which regions, or countries will experience concentrated growth. The answers to the questions depend on the development pathways countries choose or compelled to pursue. According to Lucas et al. (2015) without a climate policy that is underpinned by a robust strategy for sustainable energy, this increase in demand for energy services will most likely be supplied by fossil energy sources, which will mean that Africa's energy-related CO₂ emissions are expected to increase by a factor 7 to 50 between 2010 and 2100.

Whilst action concerning climate adaptation is critical for Africa, it is equally important to implement mitigation efforts to avoid a high carbon lock-in that other countries had experienced in their development journey. Furthermore, actions, such as the widespread adoption of renewable energy in power generation and cooking, would bring multiple benefits in health, education and energy security. According to the IEA (2014), the total consumption of biomass in sub-Saharan Africa burned directly and to produce charcoal amounted to 658 million tonnes in 2012. The region also represents the world's highest regional per capita wood energy consumption, amounting to an average consumption of 0.69 m³ per year (or 1.66 tonnes/year) in 2011, compared to a global average of 0.27 m³ or 0.65 tonnes per year (Iiyama et al., 2014). This demonstrates the dependence on biomass for household energy but may also indicate that the unsustainable harvesting of biomass (although there are large geographic variations) exists. For example, Bailis,

Drigo, Ghilardi and Masera (2015) estimate that 27 to 34 percent of woodfuel harvested across the developing world is unsustainable, which contributes to the concentration of woodfuel depletion ‘hotspots’ in South Asia and East Africa. Hence, it would appear that large efficiency gains can be achieved along the entire woodfuel and charcoal value chain, helping to reduce GHG emissions significantly.

Industry accounted for half of the electricity consumption, with services using about 20 percent, and the rest distributed across household energy and agriculture (Hogart, Haywood & Whitley, 2015). Most power systems in Africa experience major challenges associated with power outages, which has a major knock-on effect on the economy and performance of health and education systems. In terms of GHG emissions, the power sector accounted for about 63 million tCO₂eq, about 2 percent of the region’s total GHG emissions. This seemingly low share of the total indicates the low consumption of electricity on a per capita basis; and the low levels of access to electricity in several countries.

To illustrate the CO₂ emissions embedded in the electricity supply system of some individual countries and the regional power pool systems, a rough Grid Emission Factor (GEF) was assembled using data provided by the International Renewable Energy Agency (IRENA) to illustrate (see Figure 3.3) over the 2015–2025 period. To serve for comparison purposes, Figure 3.3 also consists of national GEF from a range of countries from the region and other regions. The GEF serves to quantify the amount of carbon dioxide (equivalent) emissions associated with each unit of electricity from different sources of power generation fed into the grid and provides a single figure reflecting the composite carbon value.

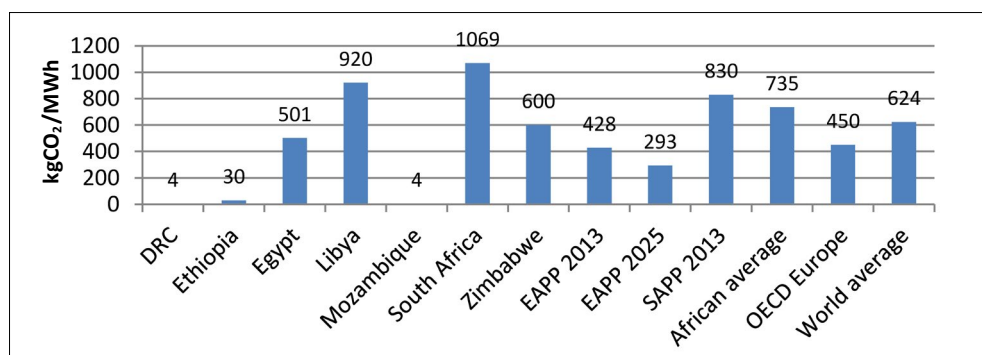


Figure 3.3 Grid Emission Factor for various electricity generation systems
(Source: Calculated from IRENA data in Brander, Sood, Wylie, Haughton and Lovel, 2011:4–6)

Figure 3.3 also shows the range of decarbonisation opportunities and challenges that countries and power pools will face. Several East African countries show considerable room for the development of low-carbon energy systems through a

variety of renewable energy and low-emissions options, which is also reflected in the GEF for the East African Power Pool (EAPP). The story for the southern and northern African regions is different. The transition from fossil-based power system is not as straightforward since there is a considerable sunk cost in fossil-based power systems that would need to be phased out as part of the decarbonisation pathway. In the future, these two regions offer the largest decarbonisation potential in terms of reduction of carbon intensity per unit energy as a result of a comprehensive strategy of energy efficiency and renewable energy developments. Specifically looking at South Africa, one of the major climate change mitigation issues it faces is the need to reduce GHG emissions from the power sector, primarily reducing its heavy dependence on coal.

As governments across the region are looking at their progress in reducing their emissions, their interventions would need to be compatible with local developments and people's aspirations regarding their wellbeing. This means that energy systems would need to be integrated into the fabric of local economies and embrace radical notions of modernity. The SDGs offer a useful framework for integrating energy across the range of goals, thereby identifying potential energy interventions that have multiple benefits.

Distributed energy as a sustainable energy pathway

The past few years have seen the coming of age of distributed generation and smart energy systems. There are a number of characteristics that smaller and locally embedded systems bring to local development in Africa, for example, unlike traditional centralised systems, these locally embedded systems can be tailored to local contexts in terms of household needs and socio-economic circumstances. As such, a more diversified ownership base can be implemented. This base involves large number of households, communities, cooperatives, small- and medium-sized enterprises, as well as larger companies, which become both producers and consumers of electricity. This could allow small and locally-based systems to become innovators of grassroots systems where social learning and experimentation can take place, creating the evidence for scaling up. This section will explore a variety of cases and innovations where bottom-up energy systems have been deployed to address concrete needs.

The section will explore questions concerning the efficiency of resource use, social justice as well as economic resilience, and the role that needs-focused systems can contribute towards such goals.

Synergies between access, energy efficiency and renewable energy

Depending on population density and income levels, in many parts of the world it is cost-effective to extend the grid where the distance to the transmission and distribution (T&D) lines is within a specific range. This range usually includes urban and peri-urban areas where human settlement is of sufficient density to justify the infrastructure cost. However, this condition does not apply to many rural areas. Indeed, human settlement across Africa is highly dispersed, which has contributed to a limited dispersion of T&D grids. The current pattern of sparse settlements, coupled with low per capita energy consumption levels, at 590 kWh in 2012 compared to the world average of 2 970 kWh/capita, make it costly to extend the grid to most households in the foreseeable future. Power utilities have lacked the finance to improve the situation, while most people have had too little money to pay for connections and the electricity that they would consume. This does not only apply to households, but also to enterprises in rural areas that continue to operate their productive activities at low energy throughput or are heavily constrained by the poor reliability of incumbent energy systems. In recent years, the emergence of new technologies and the lowering of their cost has made it possible for distributed renewable energy systems to be considered as viable alternatives in terms of cost, convenience, speed and impact on the natural environment. This section discusses the various benefits and costs associated with distributed energy production, distribution and use in Africa as critical for meeting sustainability goals. Three important points justify the distributed energy thesis.

Firstly, as discussed in earlier parts of this chapter, widening energy access to modern energy for rural transformation has been gaining momentum over the past ten years, and is now seen as crucial to meeting many of the SDGs (Fuso-Nerini et al., 2018). Almost all development partners now have an energy access programme of some nature, and most countries across Africa have universal access to modern energy targets.

Secondly, energy efficiency is now seen as an increasingly important consideration in delivering modern and affordable energy services. Improvements in efficiency can be considered an additional resource, and so there are benefits in making improvements in demand-side efficiency as well as minimising transmission and distribution losses for investments in renewables to deliver higher impact for each unit investment. A sustainable energy economy requires major commitments to energy efficiency before looking at investing in renewable energy development.

Thirdly, as renewable energy continues to gather momentum, more renewables are being accommodated in the grid, and off-grid using renewables are becoming

cost-effective and reliable options for electrifying rural areas. The flexibility they offer in terms of their modularity makes renewables ideal for tailoring to specific end-use situations. Innovations that lead to cost reductions in storage systems will make them even more attractive than fossil-fuel alternatives in the future.

Looking closely at the off-grid options, stand-alone renewable energy (RE) home systems are simpler to deploy than mini-grids and have been deployed successfully in large numbers with support from governments and donors and governments. There are over 500 000 solar home systems (SHS) across Africa, mostly in East Africa and South Africa (IRENA, 2015). Although there has been an upward trend in recent years, the off-grid SHS market is still quite small compared to other regions. For example, Bangladesh has significantly more SHS than the whole of Africa. As of 2016, over 4 million SHS had been installed, due to a very successful, long-running implementation programme impacting more than 12 percent of the population in Bangladesh (IRENA, 2016). The pico-scale solar product is another stand-alone system that has made a significant impact on the African energy landscape. This system addresses lighting and small load end-uses and is driven by an increasing number of private firms on a commercial basis (Nygard, Hansen & Larsen, 2016).

The pico and SHS systems have been hugely beneficial for households and businesses in addressing their lighting needs. However, they support limited services and are not suitable for multiple appliances, especially those with higher wattage, such as refrigerators. In the off-grid category, mini-grids are being increasingly used to supporting larger loads and higher load variance and these systems meet the needs of over 5 million people worldwide (IRENA, 2015). Mini-grids offer considerable advantages over both grid-based and stand-alone systems where grid extension is not economically attractive but where communities live in a core village with houses nearby (see Figure 3.4). This avoids the cost of transmission infrastructure, which can amount to a significant share of the total electricity bill of a power system. According to Bardouille et al. (2012), the average capital cost for providing a new connection to a household with a mini-grid starts at \$50, whereas the cost of providing a new connection by extending the main grid to a household that is sufficiently close to it can start at \$500. New connection charges in sub-Saharan Africa are among the highest in the world, resulting in low rates of electrification in many countries. Smaller independent grids offer more practical alternatives in many rural situations, and if operated well, they can scale up and become attractive for connecting with the main grid as the local economy grows (Mitra & Buluswar, 2015). There are plenty of such experiences across Europe and North America.

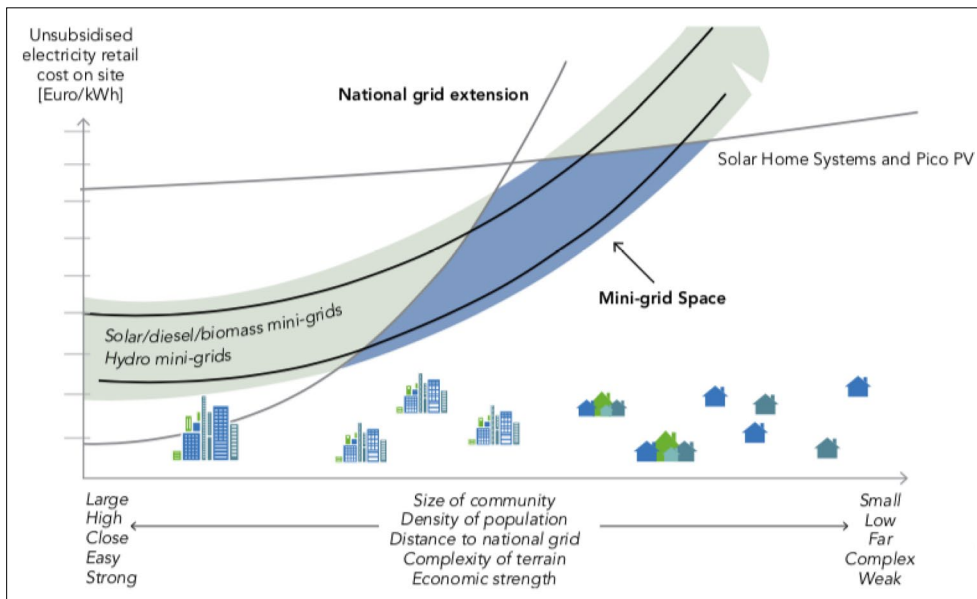


Figure 3.4 The role of mini-grids in an electrification programme
 (Source: Franz, Peterschmidt, Rohrer and Kondev, 2014:20)

Mini-grids offer more transformational potential than stand-alone systems and other advantages over grid systems, however they, these systems face significant technical, economic and institutional barriers. They involve large up-front costs, tariffs that are often higher than those charges to on-grid consumers, and they need on board site-specific conditions on resources and institutional arrangements (Least Developed Countries Renewable Energy and Energy Efficiency Initiative [LDC REEEI], 2018). This is especially important for countries in Africa where the institutional concerns around cost calculations,¹ regulatory uncertainties, potential conflict among actors and operation and maintenance arrangements could create major obstacles due to the limited experience in the development of mini-grids.

The key is that careful planning and a forward-looking approach to widening electricity access wherein mini-grids can be integrated into local livelihoods and economies is important. This would need those involved to deal with the potential complementarity of grid and off-grid solutions where in the event the grid reaches the mini-grid service area, policies and agreements are in place to transform the mini-grids into distribution utilities. Such forward planning would give investors' confidence to develop mini-grids in rural and remote areas, knowing

1 Cost calculation of mini-grids tend to be more complicated. Unlike the entrepreneurial drive that stimulates the growth of stand-alone systems and highly institutionalised top-down pricing of grid-based systems, cost calculations of mini-grids depend on technology and geographical location and require more planning and institutional development.

that their investment will be compensated or allowed to convert their operation into an interconnected mini-grid ‘when the big grid connects with the small grid’ (Tenenbaum, Greacen, Siyambalapitiya & Knuckles, 2014).

Some African countries, such as Nigeria, Rwanda and Tanzania, have developed rules or regulations that allow mini-grids to become small power distributors or sell exclusively to the grid, along with compensation rules should they wish to exit the mini-grid business. It is too early to say whether these regulatory rules will be implemented or not. Experience from Asia, especially from Cambodia, has been quite impressive where the country’s regulatory and subsidy policies enabled hundreds of privately-owned diesel mini-grids to make the transition toward grid-connected small power distributors. According to the World Bank (2017a), the conversion has allowed private operators to provide their customers with longer hours of service at significantly lower prices – a good sign that mini-grids have come of age.

Needs-based planning: From household to community energy

The chapter has highlighted that the energy system in sub-Saharan African countries is inherently complex given its dual nature where the traditional and modern energy systems and practices co-exist (Sokona et al., 2012). The provision of services through centralised and interconnected infrastructures has its place, particularly in the more densely settled urban areas. However, there are large parts of countries, often rural and remote, where this approach/model has failed to deliver basic services such as sanitation, water and energy services to communities. The high dispersal of settlement patterns, the rapid reduction in the cost of renewables, and the new policy and regulatory attention devoted to the energy access agenda creates ideal conditions for off-grid energy systems to meet local development needs in Africa.

Policymakers also recognise that ‘failing to plan is planning to fail’, and so planning the future direction of the energy system needs to embrace all options and scales (Mulugetta, Ben Hagen & Kammen, 2019). Often those engaged in energy planning start with numbers – numbers of people without access to modern energy, the proportion of people who rely on electricity from renewables or the cost of per unit electricity. This is then followed by the importance of bringing electricity or some other fuel to meet needs. This somewhat linear construction is often at odds with a needs-based approach focused on determining citizens’ needs, and planning based on people’s lived experiences, needs and aspirations. Over the years, several researchers have recommended a bottom-up approach to planning where users are placed at the heart of the decisions on technology options for planning to be accountable and representative (Goldemberg, Johansson, Reddy & Williams, 1985; Hiremath, Shikha & Ravindranath, 2007).

Following the long tradition of rural energy planning that emerged following the oil crisis of 1970s, organisations such as Practical Action have been developing bottom-up energy planning approaches for over a decade. Their total energy access (TEA) approach, built on the back of several decades of field experience, helps communities to identify the combination of energy access technologies that address development and poverty goals (Practical Action, 2016).

The TEA approach encompasses:

- all spheres of energy access: households, productive uses and community facilities, differentiated by gender;
- all forms of energy access: electricity, cooking, heating and mechanical power; and
- all feasible and appropriate means of energy provision: grid-connected, mini-grid, and stand-alone.

The World Resources Institute (WRI) proposes another bottom-up approach, known as ‘bottom-up demand forecasting’ (Odarno, Sawe, Swai, Katyega & Lee, 2017). Like the TEA approach, this approach is complementary to the SE4ALL’s² Multi-tier Framework for electricity access as it focuses on different levels of access based on differentiated energy needs. Access at different tiers can be satisfied by numerous options, and the tiers can vary over time and space. For instance, some remote rural communities need only lower-tier levels of electricity service in the early stages of access and development. This means that bottom-up demand forecasting approach will need to take account of changing consumption patterns over time; and may be survey-based or may be derived from end-use models. The end-use model quantifies electricity demand based on the consumers’ current and projected electricity end-use patterns (Dharmadhikary & Bhalerao, 2015).

Such bottom-up concepts work on the premise that the future energy systems across Africa will be increasingly diversified and distributed, with increasing numbers of actors as energy producers who will meet their own needs. In some cases, they may engage in selling their surplus to other users and import electricity when needed. With their flexibility, modularity and scalability, smaller distributed projects can be initiated simultaneously with significantly reduced construction

2 The UN’s Sustainable Energy for All (SE4ALL) initiative was launched in 2012. This initiative aims to ‘improve the lives of the poorest and most vulnerable people by ensuring universal access to modern energy services, increasing the share of renewable energy sources around the world, and improving energy’ (International Institute for Environment and Development [IIED], 2012).

times compared to large centralised installations (LDC REEEI, 2018). Given the urgency for action in Africa, such systems are vital in providing electrical and non-electrified systems to provide lighting, heating, cooling, transportation and other needs locally.

Estimations of demand based on end-use data enables planners and service providers to seriously think about energy efficiency and demand-side management as it can lead to a reduction in cost by doing more with less energy. Efforts in energy efficiency need to happen at the supply side as well as the demand side. According to IEA (2014), transmission and distribution losses in sub-Saharan Africa average about 18 percent with some countries recording over 20 percent losses. This transfers considerable resources that could otherwise be reinvested in the country's critical infrastructures. On the supply side, part of the strategy to reduce such transmission and distribution losses would also include having a good mix of on-grid and off-grid systems. On the demand side, the focus is on reducing the overall electricity demand of consumers (end-users) by introducing high-efficiency appliances and raising awareness about the value of energy conservation. For the off-grid contexts, demand-side efficiency improvements have been crucial in bringing down the overall cost of stand-alone and mini-grids.

Typologies of distributed rural energy in Africa

There is a wide range of business models in both the grid-based and off-grid systems. It would be beyond the scope of this chapter to explore all. Instead, given the interest of this chapter in distributed energy for local development, this chapter focuses on the business models that relate to stand-alone and mini-grids.

Although mini-grids have a long history electrifying rural villages, standalone systems are now far more common, especially in Africa. According to IRENA (2018), about 133 million people accessed lighting and other electricity-based services using off-grid renewables in 2016; mostly using pico lighting and solar home systems, and about 9 million are connected to a mini-grid. As shown in Table 3.2, to an extent these off-grid variants are competing for the same rural electrification market, albeit to power different devices, and the growth of one will have implications on the other. For example, investment in mini-grids may seem to be too risky in areas where small-scale renewables are already established as the residual unmet demand may not justify the investment. Similarly, off-grid renewables (mainly solar) may not be seen as an option in areas that already have functional mini-grids, unless the load exceeds the availability of electricity from the mini-grid.

Table 3.2 SE4ALL multi-tier framework against technology options

Energy access according to global tracking for SE4ALL	Basic		Advanced		
Attributes	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Services	Task light and phone charging	General lighting and TV and fan	Tier 2 and any low-power appliances	Tier 3 and any medium-power appliances	Tier 4 and any higher-power appliances
Peak available capacity (minimum W)	3 W	50 W	200 W	800 W	2 000 W
Duration (minimum hours)	4	4	8	16	22
Evening supply (minimum hours)	2	2	2	4	4
Affordability		√	√	√	√
Formality (legality)			√	√	√
Quality (voltage)			√	√	√
Indicated minimum technology	<ul style="list-style-type: none"> ▪ Nano-grids ▪ Micro-grids ▪ Pico-PV/solar ▪ Lanterns 	<ul style="list-style-type: none"> ▪ Micro-grids ▪ Mini-grids ▪ Rechargeable batteries ▪ Solar home systems 	<ul style="list-style-type: none"> ▪ Micro-grids ▪ Mini-grids ▪ Home systems 	<ul style="list-style-type: none"> ▪ Mini-grids ▪ Grid 	<ul style="list-style-type: none"> ▪ Mini-grids ▪ Grid

Source: Adapted from Franz et al. (2014:26)

Business models for stand-alone systems

Advances in technologies such as solar (photo voltaic or PV system), battery storage and LED lighting and rapidly decreasing prices have led to a growth in standalone electrification solutions in the past ten years. In some cases, growth has been driven by public initiatives, as in the case of the Rural Electrification and Renewable Energy Project in Bangladesh. In others, the uptake has been more private sector-driven, employing upfront cash payment by consumers or through pay-as-you-go (PAYG) schemes or long-term lease models.

Bangladesh is a leading example of deploying solar home systems at scale, reaching over 18 million people from 4.1 million systems installed as of 2017. According to the Infrastructure Development Company Limited (IDCOL), this is expected to save 3.6 million tonnes of kerosene worth \$1 300 million by 2030 (IDCOL, 2018). The Bangladesh government established the IDCOL in the late 1990s to manage and oversee funds obtained from international development finance institutions and donors for infrastructure and renewable energy. Among others, initiatives of the IDCOL focused on developing off-grid energy, including programmes on solar home systems, solar irrigation pumps, solar mini-grids and biogas electricity-based

production (Oji & Weber, 2017). IDCOL provides grants and soft loans as well as necessary technical assistance to some 56 partner organisations (POs) who select customers, extend loans, install the systems and provide after-sale service. The POs include overseas development finance institutions, suppliers of SHS, local small- and medium-sized enterprises and microfinance institutions.

African countries can draw important lessons from the experience in Bangladesh on how a government-owned non-bank financial institution can successfully operate a public-private partnership programme to finance off-grid renewable projects. One of the lessons learnt is that the investment management should remain independent of interference and pay attention to market signals. Other lessons learnt are the importance of a single channel for distributing finance and the design of smart subsidies to grow the market. Interest in the IDCOL model is growing among African countries, and in the past few years, a number of experience-sharing and training programmes have been undertaken. By providing the product, the required after-sales service, and the microcredit, the partner organisations in the IDCOL model build trust among consumers.

The recent experience in the PAYG schemes in East Africa resonates well with the Bangladeshi experience in their strong customer-centric focus. Pay-as-you-go involves households or individuals procuring the system from a supplier through a down payment, followed by periodic payments that are set at affordable levels under an arrangement of a perpetual lease or eventual system ownership after a defined period (IRENA, 2018). Table 3.3 describes different types of PAYG schemes.

Table 3.3 Differences among PAYG companies' consumer finance mechanism

Impact	Rent-to-own (Product + finance focus)	Long-term lease (Pure service focus)
Impact on consumers	<ul style="list-style-type: none"> ▪ Higher regular payments (for equal product specs) ▪ Consumer/cultural preference for ownership ▪ Theoretical ability to collateralise assets after they are paid off 	<ul style="list-style-type: none"> ▪ Perpetual service guarantee reduces warranty anxiety
Impact on energy access challenge	<ul style="list-style-type: none"> ▪ Raised capital can reach more customers due to faster cost recovery 	<ul style="list-style-type: none"> ▪ Lower regular payments widen the pool of potential customers
Impact on companies or investors	<ul style="list-style-type: none"> ▪ Shorter duration of cash flows ▪ Faster recycling of capital towards new customers ▪ Broader diversification of debt capital across a wider customer pool ▪ Potential for additional income streams from collateralised assets 	<ul style="list-style-type: none"> ▪ Longer duration of cash flows ▪ Higher exposure to technology risk ▪ Higher exposure to company execution risk ▪ Higher exposure to currency risk ▪ Stronger customer relationship ▪ Better opportunities for upselling to larger systems or appliances
<i>Examples:</i>	Fenix International, M-KOPA	Off-grid Electric

(Source: Orlandi, Tyabji and Chase, 2016:31)

Payments are made via mobile phones for the electricity consumed and access to electricity can be discontinued in case of non-payment. The strength of the PAYG business model is less about selling electricity in much the same way as utilities or mini-grid operators, but in their focus to provide services such as lighting, communications, information and communications (e.g., mobile charging). Another key attraction in the PAYG schemes relates to the flexible credit facilities tailored to what users can afford and enables them to scale up their solar solutions, products and services. Stand-alone PV systems have been developed in a relatively unregulated market environment and so the barriers to entering the market are reduced and the business case for a profitable business is easier to determine (PricewaterhouseCoopers [PwC], 2016).

The firm in a PAYG scheme often plays the three roles of system owner, operator and maintenance provider and bill collector (or a separate company may be brought in to handle customer collections). But what is clear is that as the market has expanded, the firms may build up large portfolios of loans, which are paid in the local currency, while the capital that finances the company may be denominated in international currency (e.g., USD or euros). Therefore, the emerging business models carry currency exchange risks where in the event that the local currency is devalued, an additional cost will be levied that is outside of the business and operations domain. It is therefore important to explore other business models that limit the risk of losses due to potential currency volatility. Some of the market leaders in the PAYG market are firms such as M-KOPA, Mobisol and BBoxx, which operate through hundreds of service centres or retail shops across Kenya, Tanzania, Uganda and Rwanda.

Other business models for the delivery of stand-alone systems also exist. For example, the retail or over the counter model is the most common delivery model for Tier 1 (task lighting and phone charging) products such as the pico lantern (in the \$10–\$20 price range) and pico solar home systems (in the \$100–\$200 price range). Transactions for the pico systems are mostly cash-based, often with shops offering short-term credit to their distributors. Given an average lifetime of products of between three to five years, the viability of the business is dependent on effective marketing, supply and distribution models.

Business models for mini-grids

Mini-grids are at an earlier stage of development in Africa but given that it is in Africa where access to energy remains lowest, the developments there are of particular interest. For example, according to the IRENA report (2018), Kenya has about 20 MW of operational mini-grids capacity, and Cameroon has over 23 MW.

According to the WRI, Tanzania has become a regional leader in mini-grid development with over 109 mini-grids, amounting to an installed capacity of over 155 MW and serving about 184 000 customers. Of the total, 15 percent were connected to the national grid with the remaining 85 percent operating as isolated mini-grids consisting of hydro, biomass, solar and fossil-based systems (cited in Odarno et al., 2017). Mali is another African country that has had some success in developing isolated mini-grids where there are more than 200 mostly small diesel mini-grids in operation in the country. Around 60 of those are privately run and many are in the process of hybridisation (PwC, 2016).

Business models for mini-grids can often be classified in terms of the operating or ownership and financing arrangements. The performance of mini-grid operation models will be context-specific and will depend on various factors, such as the investment environment, geography and resources, socio-economic conditions, and the policy/regulatory environment. By their nature, mini-grid developers focus on densely populated areas where there is sufficient load to justify the investment. Four main mini-grid operation models are being implemented in different parts of Africa. These include mini-grids that are utility-operated, privately-operated, community-operated, or hybrids that combine a mix of the others (Table 3.4). It is not unusual for a combination of different actors to be involved, owning or operating different parts of the system, such as the production, distribution and demand management systems.

Table 3.4 Summary of mini-grid operator models

	Utility models	Private model (unregulated)	Private model (regulated)	Hybrid	Community
Ownership	Utility	Private	Private	Private/utility/community	Community
How it works	The government or utility manages all aspects of the mini-grid.	A private company manages all aspects, in the absence of government regulation.	A private company manages all aspects, in a regulated environment.	Private actors generate and utility distributes the electricity, vice versa. <i>OR</i> Private actors commercialise electricity generated by and distributed through public assets.	Community members organise to manage generation and distribution in a regulated environment, with support and/or coordination from an NGO or private company.
Pros	<ul style="list-style-type: none"> Can absorb funds easily Less regulation needed Connection of mini-grid to main grid can be easier Cross-subsidisation of tariffs, thus affordability easier ensured Aim to fulfil national electrification aims 	<ul style="list-style-type: none"> Commercial sustainability creates incentives for long-term operation Can act fast without government interference Profitability ideally allows for scaling-up of operations Faster pace of electrification 	<ul style="list-style-type: none"> Scalability through private capital Technical know-how, high reliability Profitability ideally allows for scaling-up operations Legal security of regulated market attracts private finance Lower subsidy required 	<ul style="list-style-type: none"> Different actors contribute their strengths, technical and management know-how Scalable, profitable Less conflict potential with customers in case of distribution by utility with cross-subsidised tariffs 	<ul style="list-style-type: none"> Design adapted to community needs Less conflict potential with customers and officials Creating assets and local ownership and cooperation Enabling self-determination and economic development
Cons	<ul style="list-style-type: none"> Not the core business Unsuited company structure for smaller projects Financial burden on utilities Possible political interference Possibly higher tariffs for main grid customers; slower pace of electrification 	<ul style="list-style-type: none"> No financial support from public sources Grid inter-connection challenging Changes in regulations and fixed tariffs can reduce profitability Possible conflicts with customers due to monopoly Insufficient quality and safety risks of service can occur if it is not supervised 	<ul style="list-style-type: none"> Reliable regulation needed Dependency on lengthy approval procedures Debt financing needed for scaling up Vulnerable to changes in regulation, fixed tariffs and conflict with customers High transaction costs Potential risk: grid interconnections 	<ul style="list-style-type: none"> Complex management, feasibility of models depend on regional/local context/structures Non-fulfilment of contracts due to conflicts between business partners Insolvency of one partner puts a full operator model at risk 	<ul style="list-style-type: none"> Insufficient local human (technical and management) capacity Often unclear ownership structure Usually high grants needed Tariffs not covering operation and maintenance (O&M) and reinvestment costs
Examples:	Widespread	Diesel mini-grids in Somaliland	Powerhive (East Africa)	Santo Trigo (Cape Verde); AMEDER mini-grids (Mali)	Multi-functional platform (Mali, Senegal)

(Source: Adapted from Orlandi et al., 2016:32)

In a community-based model, the mini-grid is owned, operated and managed by the community or local non-governmental organisation, normally including maintenance and tariff collection. Mini-grids are typically financed by grants from donors or other external financiers with the local community providing contributions in-kind. Mini-grids tend to set tariffs to only cover operation and maintenance costs, which often means they are budget-constrained and do not generate sufficient profits to scale up. Third parties often carry out the planning and procurement of equipment, installation and commissioning, but the systems are generally operated by local teams. In many cases, local communities lack technical expertise, and the systems may suffer with poor maintenance and lengthy repair times. Small community models require effective social and decision-making structures in the village to prevent conflicts. Larger community-driven cooperative models running generation in the multi-MW scale are more formalised and depend less on local structures (Franz et al., 2014).

In a utility-based model, the national electricity utility owns and operates the mini-grid, which is often run on diesel. The initial financing is usually provided by the national treasury or government or donors. The utility is responsible for the installation, maintenance and operation (and sometimes tariff collection) of the system. This model is the most common for rural electrification in developing countries where, as part of the government's social objectives, the utility may be required to charge tariffs at similar levels as those connected to the national grid. This means that tariffs paid by those connected to the national grid may be used to cross-subsidise those served by the mini-grids, creating difficulties for utilities that may already be cash-constrained (Franz et al., 2014) This has resulted in many mini-grids being poorly maintained and short of funds to allow for a smooth and long-term operation.

Private sector-based models are ones where a private investor establishes, owns and operates the mini-grid system. In some cases, the investor builds the system and transfers it to another actor. Various types of private-sector models include the franchise, the ABC (Anchor-Business-Community) and the local entrepreneur approaches. Funding usually comes from a mix of private sources, including equity and commercial loans, and public sources such as grants, subsidies or loan guarantees. Such resources from public or grant funds are important to cover part of the project development costs and to keep tariffs at an affordable level for the end-users. However, some purely private-sector models do exist, for example, Powerhive in Kenya was the first private company in Kenya to receive a utility licence to develop, distribute and sell electricity to end-users. This came following Powerhive's successful operation of renewable energy mini-grid projects. The Kenya Power and Lighting Company (KPLC) connected the grid, which served around 1 500 rural customers in four villages, including a cluster of users involved in

commercial activities such as welding, carpentry and milling (World Bank, 2017b). This also means that Powerhive is regulated as a utility, implying that it can access government-sponsored incentives. The collective experiences in mini-grids, not only in Africa but elsewhere, shows that establishing mini-grids in the private sector will require substantial subsidies as well as an anchor load to sustain them.

A hybrid business model combines different aspects of the above three models, depending on a regulatory framework that allows mixed ownership and management. For example, a utility or a private company could implement and own a renewable energy mini-grid power system, while a community-based organisation manages it on a daily basis and a private company provides the technical back-up and management advice (Franz et al., 2014). Another model could be that the utility owns and operates the mini-grid distribution assets and a small power producer would own and operate the generation assets. The relationship is transacted through a standard power purchase agreement (PPA), which makes the process of interconnection when the grid arrives easier given that the distribution assets are already owned by the utility and the generation assets can be relocated to another village where there is no grid.

Tenenbaum et al. (2014) classify Small Power Producers (SPPs) based on three characteristics: (i) the fuel or technology used to generate electricity, (ii) whether the SPP is connected to the national grids or operates an isolated mini-grid, and (iii) whether the SPP is selling at retail or wholesale or both. They go on to argue that focusing on the last two characteristics, four types of SPPs can be identified in Africa. Figure 3.5 shows the various combinations where an SPP may sell directly to final customers from an isolated mini-grid, which represents the most common mini-grid business model – a stand-alone, low-voltage distribution grid that is supplied with electricity from one or more small generators connected only to the isolated mini-grid. Another model is where an SPP sells wholesale to the national utility on the main grid but at the same time sells at retail to households and businesses on new mini-grids that are electrically connected to the main grid but operate as separate distribution businesses.

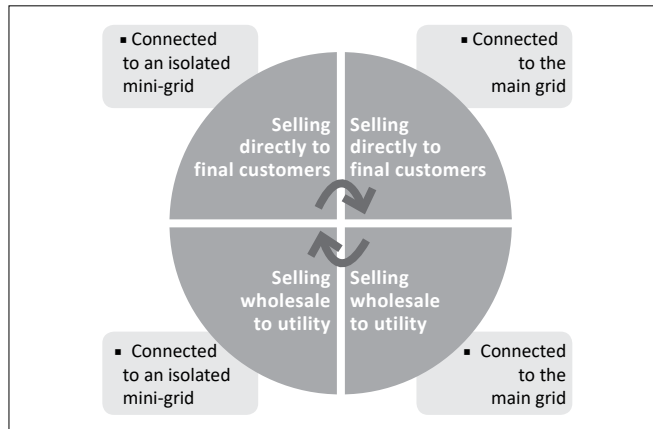


Figure 3.5 Types of electricity sales involving SPPs
 (Source: Adapted from Tenenbaum et al., 2014:3)

Key barriers for scaling up distributed energy systems

There are clear opportunities in expecting transformative change. But there are barriers that need to be overcome. The paragraphs that follow consider some of these barriers.

Affordability gap in off-grid systems

Achieving universal access to energy services by 2030 will necessitate a heavy investment in off-grid systems. Conventional thinking in this area would argue that innovative business models would be needed to mobilise private investment to finance stand-alone or mini grids systems because public subsidies are neither sufficient to address the shortfall or regarded appropriate financing instruments. However, there are two problems with this standpoint. Firstly, there is a significant affordability gap with current technologies for low-income users, namely a gap between cost recovery tariffs and what the users can spend on energy services. For example, even if decentralised PV mini-grids were made available, and even if appliances for basic needs were affordable, the cost of electricity (average cost of \$0.24/kWh) to provide basic services with existing appliances may be too high for low-income users (Mitra & Buluswar, 2015). Hence, either the cost of electricity needs to come down significantly to be affordable or appliances need to become proportionally more efficient, or both need to happen for a similar combined effect. The second problem relates to the inadequacy of money to make subsidies viable for off-grid programmes in the face of massive public support for the fossil fuel industry. In a study for the IMF, Coady, Parry, Sears and Shang (2015) estimated post-tax energy subsidies at \$4.9 trillion (6.5 percent of global GDP) in 2013 and projected to reach \$5.3 trillion (6.5 percent of global GDP) in 2015. The study defined fossil fuel subsidies broadly to reflect undercharging for environmental costs and general taxes, as well as production costs.

This unequal distribution of subsidies creates structural obstacles for off-grid programmes to become established. Whilst business models and private capital are important, carefully targeted public finance will be critical in closing the affordability gap.

Skills and capacity gap

As countries across Africa are looking to invest in their energy sector to transform their economies, the effectiveness of these efforts will be dependent on the quality (and quantity) of their human resources and institutional capacity. Indeed, meaningful country ownership of programmes means having the requisite and homegrown technical, policy and managerial skills to build and maintain infrastructures. At present, countries in the regions face a critical shortage of hands-on technical and engineering skills with the ability to build and maintain projects. The result of having too few skilled workers means that energy industries rely on expatriate skills, often with little contextual knowledge, to the detriment of local industries and jobs. Further, Africa lacks its own research and innovation solutions with no coherent national strategy across the region to address the system-wide gap in skills in the energy sector. Part of the practical steps that could be taken would involve improving the conditions of vocational and knowledge institutions, building in the right incentive structures for those within, and exploring workable and lasting partnerships.

Weak policy environment out of step with developmental ambitions

Most countries in the region have embarked on ambitious development plans to boost growth in agriculture, manufacturing and services to create jobs and raise living standards. However, in many cases, these aspirations for transformative change have not been matched by correspondingly bold policies on energy. If anything, energy policymakers appear stranded in their traditional incremental approaches and assumptions, oblivious to the fact that the world around them has changed markedly – it has become more interconnected and more complex. Economic growth trends and social expectations are such that major energy transitions are demanded that take into account environmental and climate change considerations. Furthermore, the consensus around the 2030 commitment of ‘energy for all’ requires the adoption of strategies that extend the provision of energy that can be reached through a combination of centralised (grid) and decentralised options (APP, 2015). Part of the rationale for this diversified perspective is that off-grid options are now mature and competitive and unserved households should no longer have to wait 15 to 20 years until grid-connection eventually arrives. The technology and cost rationale for inadequate access to modern energy no longer applies.

Lack of coherent public-private partnership

The nature of technological and market developments in recent years has underlined the continued importance of the state as a facilitator and guardian of good policies as well as an investor in energy systems. This means that policymakers need to recognise the emergence of the private sector as a major player that requires a stable policy and regulatory landscape to invest in the energy market. However, whilst much of this is intended to enhance the confidence of foreign investors, domestic entrepreneurs are likely to play a pivotal role in growing the overall investment envelope. Hence, the question around how to mobilise domestic entrepreneurs and national financial institutions to be responsive to the social agenda of clean energy access and conducive investment opportunities is critical. Incentivising these domestic actors to enter the energy market has additional benefits, namely they understand the national business context and carry lower risk thresholds. To date, there has been limited dialogue to engage these actors and establish clear roles for them to play in the development of the region's energy future.

Governance structure is at odds with policies

The development of policies and regulations is important, but their mere existence is not sufficient for achieving successful outcomes. The history of power sector reform in Africa is replete with missed opportunities and disappointing results, since reforms had mainly been founded on a false 'epistemology'. The architects of these early reforms viewed the problem through a techno-economic lens, neglecting the broader socio-political context and the essential institutional elements that are representative of the system (Thompson & Bazilian, 2013). Sectoral reforms do not take place in a societal vacuum, but rather are shaped by the political economy terrain that underpins them. To this end, the level of active commitment by government and other stakeholders is fundamental to ensure that plans have been developed in step with related policy areas and with the full participation of the national political institutions.

Discussion: Criteria for success

The debate about the drivers and consequences of energy poverty and lack of access has been raging for over four decades. It is now all too evident that countries in Africa need sustainable energy master plans that consider current and future demands, the mix of resources and infrastructures, as well as scales that are appropriate to each country context. Plans must also incorporate social, environmental and climate concerns to ensure infrastructures are resilient and the services they provide are inclusive. Part of this relates to the fact that energy systems cannot be treated in isolation from the wider development agenda and the underlying political and institutional structures. Of course, in envisioning

such a comprehensive approach, several questions emerge. What makes us think that it is different this time around? What has changed in the landscape of our policies and innovation systems to expect different outcomes against a litany failed experiments? This section will provide some of the reasons for a new sense of optimism, supported by cases from the region.

Policy instruments need to be transparent and fit national conditions

Costs for new energy options are falling and technologies such as wind turbines and grid-based PV systems are becoming competitive. However, the success of implementation depends on the viability of technologies and suitability of policies for encouraging the integration of renewable energy supplies into the energy system. To this end, debates have intensified on the most effective policy instruments to accelerate public-private partnerships and stimulate private sector investment in grid-connected renewable technologies. Feed-in tariffs (FiTs) have been the most widely used government support mechanism for accelerating private investment in renewable energy generation. One encouraging initiative is Uganda's Global Energy Transfer Feed-in Tariff (GET FiT) programme, formally launched in May 2013, which has demonstrated how the instrument can be deployed successfully in an African context to finance smaller-scale projects. The first two rounds of 'Request for Proposals' have resulted in 15 projects with a planned installed capacity of 128 MW, and a promising pipeline for the third Request for Proposals that may increase the portfolio to 20 projects (Eberhard, Kolker & Leigland, 2014).

Competitive tenders or auctions have also emerged in various countries as acceptable instruments, especially in emerging economies. South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPP) is an outstanding example of this scheme. This programme enables the utility, ESKOM, to enter into a PPA allowing Independent Power Producers (IPPs) make firm revenue projections. The guaranteed power off-take by ESKOM provides the foundation for this highly successful and rapidly growing renewable energy programme. According to the United Nations Food and Agriculture Organization (FAO), REIPPP has generated 64 new renewable energy IPPs, attracting US\$14 billion in investment for the construction of 3 922 MW of capacity in technologies like grid-connected wind, PV, and to a lesser degree, hydro, landfill gas and biomass energy (FAO, 2011). REIPPP offers many valuable lessons on how other countries in the region procure renewable energy projects rapidly and effectively. It also highlights the importance of strong banking, legal and other advisory resources in rolling out effective renewable energy programmes.

Sustained political leadership is fundamental for success

Good governance enhances the ability of any nation to reach its full economic and social development potential. This means that governance must be strong at each level, in order for countries to maintain rates of growth in an inclusive manner. One common feature is that every country that has achieved universal access has reached this goal with the support of strong leadership that can establish a common vision of the benefits of enhanced energy systems for growth and wellbeing. Leadership is critical to drive through comprehensive long-term planning in partnership with public, private and civil society stakeholders. At present, Africa lacks public administration systems that embody long-term visions, and most planning has short-term horizons and little value for laying the foundation for a sustainable energy transition.

This picture is gradually changing though and propelled by new technologies, policy reforms and innovative business models, several countries are experimenting with new pathways. Ethiopia is one of these countries that has registered rapid economic growth over the past decade and has spent considerable political and financial capital in renewable energy development as integral to its Growth and Transformation Plan. Two parallel visions characterise Ethiopia's energy plans. On the domestic front, the policymakers recognise electricity as a vital enabler of economic growth and human development, aiming to minimise the gap between demand and supply by increasing hydropower and renewable capacity from 2 000 MW to over 10 000 MW and raise national electrification rate by 75 percent. On the regional scale, the country aims to generate power for export to become one of the major contributors to the East African Power Pool. Much of the investment for this ambitious expansion programme comes from finances mobilised from local sources and concessionary loans, which is a reflection of the political imperative of economic transformation.

Agroforestry as an energy opportunity

Bio-energy will remain an important source of energy for African households, with demand continuing to grow. Assuming bio-energy production from non-sustainable forests, which is mostly the case in much of Africa, the rate of deforestation and net GHG emissions, particularly for charcoal production, is significant (World Bank, 2011). The charcoal industry in sub-Saharan Africa had an estimated value of approximately \$8 billion in 2007. Whilst there are investment opportunities in industrial plantations, agroforestry, as an integrated strategy together with improved kilns and stoves, can have a significant impact on the reduction of wood harvest pressures in forests. Advances in agroforestry science and innovations are providing farmers with greater species options and more resilient systems for tree developments on farmland.

There are numerous initiatives from multilateral organisations and from the private sector with innovative business models aimed at improving agricultural productivity for food and creating bioenergy development opportunities. Many of these initiatives have highlighted improvements in household wealth and income diversity, resulting from the sale of fuelwood and other tree products. More critically, agroforestry activities provide labour savings to women household members by reducing time spent on fuelwood collection. Thus, while there are clear benefits associated with agroforestry practices in terms of delivering income and wellbeing, one critical challenge is overcoming the length of time (often three to four years) when farmers are making initial investments (land and inputs). Improving access to loans and farm implements enables farmers to see tangible benefits in the short-term before their trees have matured and are able to yield financial and livelihoods benefits.

National entrepreneurs and business models are critical for unlocking internal investment

Given its abundant natural resources and the many innovative environment-related financing instruments available today, Africa has the opportunity to take advantage of these opportunities and pursue a clean energy path. The involvement of the domestic private sector will be a critical requirement. There is currently a vigorous discussion among local entrepreneurs across Africa on how to help fill the gap in power generation, especially in off-grid generation. This conversation is not only about investing their money in energy, but also how to leverage additional finance from external sources in support of strong growth, job creation, and poverty reduction on the continent.

There are several initiatives such as the US Government Power Africa initiative, which is designed to support African entrepreneurs to enter the energy market. Through this programme, a growing number of entrepreneurs are getting seed money to develop commercially viable ways to deliver power to unserved, often rural communities. A broad array of solutions is being developed in Ghana, Ethiopia, Liberia, Tanzania, Kenya and Nigeria, creating incubators for greater innovation. Sustaining such initiatives will be predicated on the ability of local entrepreneurs to raise sustainable finance for maintaining their activities from commercial banks to provide the necessary financing to grow the off-grid energy sector. For this to happen, innovative business models such as the 'pay-as-you-go' models would need to be mainstreamed and the level of risk perceived by investors is reduced. Fundamental to this is for entrepreneurs to demonstrate robust profit margins to service their loans, and for government to create stable regulatory and policy environment. Today, a growing number of companies are operating in at least 20 sub-Saharan African countries that use digitally-financed off-grid electricity services (Welsch et al., 2013).

Agro-industry-based co-generation as a local solution

Agro-industries account for a major source of rural employment and are significant contributors to the economy of many sub-Saharan African countries. Agro-industries in this region, such as tea, coffee and sugar estates, already utilise energy for their processing and, on occasions, supply energy to their employees within their estates. In the event of non-access to the grid, scaling up electricity service would have direct economic and social benefits to rural communities in the vicinity of these estates, and offer the agro-businesses a potentially attractive commercial opportunity for diversifying into the energy market. Where the industry is connected to the grid, feeding into the grid in times of surplus and drawing from it when supplies are low makes it very likely that communities will have access to electricity. The two ways that agro-industries relate to the energy system and influence the outcome in regards to widening energy access are different – the off-grid case requires an active engagement in investment and delivery, while the grid-based model requires a more passive engagement.

Mauritius is an African success story in co-generation. The sugar industry in Mauritius is currently self-sufficient in electricity and sells the excess it generates to the national electricity grid. The industry contributes about 16 percent of the electricity supply on the island. The importance of revenue from the sale of excess electricity from co-generation is such that it has enabled Mauritian sugar factories to remain profitable. A notable achievement has been the use of a wide variety of innovative revenue-sharing measures where the island's co-generation industry has worked closely with the government to ensure that substantial monetary benefits from the sale of electricity from co-generation are shared by all key stakeholders of the sugar economy, including the poor smallholder sugar farmers. There are three main success factors of the Mauritian programme: (i) from the outset the government has played an instrumental role in putting in place strong policies and clear regulations, (ii) the involvement of local private entrepreneurs in IPP initiatives allowed for the IPP development to piggy-back on the locally owned sugar industry, and (iii) consultations with all relevant stakeholders allowed for a negotiated and equitable revenue sharing formula.

Strengthened capacity as a prerequisite to attract investment

It is evident by now that three common problems bedevil new energy enterprises from entering the energy market: lack of investment finance, weak enabling policies and regulations, and inadequate skills and capacity. There is new thinking today that the success of projects (and programmes) should be measured in accordance with how well they create opportunities for skills and capacity within the countries. This is especially needed in areas where there is a lack of the technical, financial, and legal skills needed to deliver bankable feasibility studies and bring projects to

completion. Introducing new skills, know-how, and technologies into the energy industry will help to enable the benchmarking of performance and enhance the share of local value in the supply chain. This will facilitate innovations to reduce costs and improve efficiencies.

Conclusion

Africa is a continent under transformation, in terms of economic performance, demographic changes as well as settlement patterns towards more urbanisation. In connection with this, Africa's energy demands are increasing, and its energy mix are changing, creating the openings for innovations in technologies and policies as well as finance to manage the range of energy transitions across the continent.

This chapter has attempted to grapple with the long-standing challenge of persistent energy poverty and how it impacts on development outcomes in Africa. The chapter demonstrates that energy issues across sub-Saharan Africa are inherently complex, largely due to the dual nature of the energy system itself where traditional and modern energy systems and practices co-exist. One of the key characteristics of this dichotomy is that a large proportion of people in Africa live without access to electricity with the majority of them living in rural areas, which adds to the complexity and structural disadvantage that many citizens face across most countries. Whilst there is a growing consensus globally that the future of the energy systems should be fairer, cheaper, cleaner and climate-friendly, this has particular relevance for Africa where investment in infrastructure and systems must reflect the hopes and aspirations of people and communities. To this end, African leaders and their policymakers are making long-term decisions on infrastructure and services that will determine the character of their energy systems over the coming decades.

The chapter stresses that widening energy access is critical for social and economic transformation and to meet many of the SDGs. But Africa needs to be in control of its destiny and direction to ensure the solutions are compatible with the reality on the ground and offer genuine solutions to communities. For this, policies matter, governance is critical and understanding of context is paramount. However, even with all the diversity across the region, there are many good reasons why the clean energy route makes sense, even for those that have plenty of fossil fuel reserves. Some of these reasons are detailed below:

- The continent is richly endowed with green and renewable sources of energy. At the same time, there cannot be any talk of structural economic transformation without a massive increase in the electricity generation, and what better way is there than to generate the electricity from the abundant resources found in the continent.

- Agriculture will remain the mainstay of most African economies into the future. As such, Africans need to think hard about modernising the way agriculture is done with a view to enhancing productivity. This includes investing in energy for irrigation, processing and transport for the benefit of smallholder farmers. Much of this would be in the form of modular type energy systems that can be adapted to changing demand, thereby optimising the size of the systems.
- The world has seen rapid cost reduction in renewable energy technologies in recent years, in particular of solar and wind energy systems. Together with energy-efficiency measures, renewables offer real opportunities to change the narrative around energy access for the poor. This can create economic and job opportunities and improve air quality and contribute to climate change mitigation, thereby delivering significant human health and sustainable development co-benefits. African countries need to create enabling conditions to take advantage of these opportunities.
- Investment in clean energy has grown rapidly in recent years. In 2013, for the first time, the world added more low-carbon electricity capacity than fossil fuel capacity, and over the next 15 years, about US\$90 trillion will be invested in infrastructure in the world's cities, agriculture and energy. Africa cannot afford to miss out on these investment opportunities.

This chapter recognises that large-scale energy systems will still be important in the energy mix of African countries, and already significant resources and policy attention is devoted to such systems. However, distributed energy systems also offer serious prospects for the vast numbers of people in settlements far from grid lines and without access to energy. The chapter makes a strong argument for scaling up such systems, pointing to the fact that the past few years have seen the coming of age of distributed generation and mini-grids that are successfully extending electricity access to households, communities, cooperatives, small- and medium-sized enterprises, as well as larger companies. This enables producers and consumers of energy to collaborate meaningfully through small and locally-based systems to provide energy services for a variety of social and economic needs. Creating the policy environment, financing models, as well as appropriate institutions, will be critical to enable these bottom-up energy innovations to flourish. This chapter has attempted to ask deeper questions about efficiency of resource use, social justice as well as economic resilience associated with energy systems of the future in Africa.

References

- Africa Progress Panel. (2015). *Power, people, planet: Seizing Africa's energy and climate opportunities. Africa progress report 2015*. Geneva: APP.
- Allen, M.R., Dube, O.P., Solecki, W., Aragón-Durand, F. & Cramer, W. et al. (2018). Framing and Context. In: V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts & J. Skea et al. (Eds). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*.
- Bailis, R., Drigo, R., Ghilardi, A. & Masera, O. (2015). The carbon footprint of traditional woodfuels. *Nature Climate Change* 5: 266–272. <https://doi.org/10.1038/nclimate2491>
- Bardouille, P., Avato, P., Levin, J., Pantelias, A. & Engelmann-Pilger, H. (2012). *From gap to opportunity: Business models for scaling up energy access*. Washington, DC: International Finance Corporation/World Bank.
- Boden, T.A., Marland, G. & Andres, R.J. (2017). *Global, regional, and national fossil-fuel CO₂ emissions*. Oak Ridge, TN: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. https://doi.org/10.3334/CDIAC/00001_V2017 [Accessed 18 September 2019].
- Brander, M., Sood, A., Wylie, C., Houghton, A. & Lovel, J. (2011). Technical paper / Electricity-specific emission factors for grid electricity. *Ecometrica*. <https://bit.ly/31cu7HW> [Accessed 1 October 2019].
- Bruckner T., I.A., Bashmakov, I.G., Mulugetta, Y., Chum, H., de la Vega Navarro, A. et al. (2014). Energy systems. In: O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner et al. (Eds), *Climate change 2014: Mitigation of climate change. Contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change*. New York: Cambridge University Press.
- Castellano, A., Kendall, A., Nikomarov, M. & Swemmer, T. (2015). *Brighter Africa: The growth potential of the sub-Saharan electricity sector Africa*. <https://mck.co/2MFSjgD> [Accessed 22 July 2018].
- Coady, D., Parry, I. Sears, L. & Shang, B. (2015). *How large are global energy subsidies?* IMF Working Paper WP/15/105, International Monetary Fund. <https://doi.org/10.5089/9781513532196.001>
- Daly, H.E. (1993). Sustainable growth: An impossibility theorem. In: H.E. Daly & K.N. Townsend, *Valuing the earth: Economics, ecology, ethics*. Cambridge, MA: The MIT Press.
- Dharmadhikary, S. & Bhalariao, R. (2015). *How much energy do we need: Towards end-use based estimation for decent living*. Pune, India: Prayas (Energy Group).
- Eberhard, A., Kolker, J. & Leigland, J. (2014). *South Africa's renewable energy IPP procurement programmes: Success factors and lessons*. Washington, DC: The World Bank Group.
- Falcone, P.M. (2014). Sustainability transitions: A survey of an emerging field of research. *Environmental Management and Sustainable Development* 3(2): 61–83. <https://doi.org/10.5296/emsd.v3i2.6239>
- Fleurbay, M., Kartha, S., Bolwig, S., Chee, Y.L., Chen, Y. et al. (2014). Sustainable development and equity. In: O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner et al. (Eds), *Climate change 2014: Mitigation of climate change. Contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change*. New York: Cambridge University Press.

- Food and Agriculture Organization of the United Nations. (2011). Highlights on wood charcoal: 2004–2009. Rome: FAO Forestry Department. <https://bit.ly/2OF1il7> [Accessed 15 March 2018].
- Foster, C. & Heeks, R. (2015). *Policies to support inclusive innovation*. Manchester Centre for Development Informatics Working Paper No. 61, University of Manchester. <https://doi.org/10.2139/ssrn.3433962>
- Franz, M., Peterschmidt, N., Rohrer, M. & Kondev, M. (2014). *Mini-grid policy toolkit: Policy and business frameworks for successful mini-grids roll out*. Eschborn, Germany: EU Energy Initiative Partnership Dialogue Facility EUEI-PDF. <https://bit.ly/2ph16xF> [Accessed 21 July 2018].
- Fuso-Nerini, F., Tomei, J., To, L.S., Bisaga, I., Parikh, P. et al. (2018). Mapping synergies and trade-offs between energy and the sustainable development goals. *Nature Energy* 3: 10–15. <https://doi.org/10.1038/s41560-017-0036-5>
- Geels, F.W. (2005). *Technological transitions and system innovations. A co-evolutionary and socio-technical analysis*. Cheltenham, UK: Edward Elgar Publishing Ltd. <https://doi.org/10.4337/9781845424596>
- Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G. et al. (2016). The enactment of socio-technical transition pathways: A reformulated typology and a comparative multilevel analysis of the German and UK low-carbon electricity transitions (1990–2014). *Research Policy* 45(4): 896–913. <https://doi.org/10.1016/j.respol.2016.01.015>
- Goldemberg, J., Johansson, T.B., Reddy, A.K.N. & Williams, R.H. (1985). Basic needs and much more with one kilowatt per capita. *Ambio* 14(4/5): 190–200. <https://bit.ly/2nGtSr1> [Accessed 15 October 2018].
- Harlan, S.L., Pellow, D.N., Roberts, J.T., Bell, S.E., Holt, W.G. et al. (2015). Climate justice and inequality. In: R.E. Dunlap & R.J. Brulle (Eds), *Climate change and society: Sociological perspectives*. New York: Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199356102.003.0005>
- Hiremath, R., Shikha, S. & Ravindranath, N. (2007). Decentralized energy planning; modeling and application – a review. *Renewable and Sustainable Energy Reviews* 11(5): 729–752. <https://doi.org/10.1016/j.rser.2005.07.005>
- Hogart, J.R., Haywood, C. & Whitley, S. (2015). *Low carbon development in sub-Saharan Africa*. London: Overseas Development Institute Report, ODI.
- Humphreys, S. (2017). Climate, Technology, Justice. In: A. Proelß (Ed.), *Protecting the Environment for Future Generations – Principles and Actors in International Environmental Law*. Berlin: Erich Schmidt Verlag.
- Iiyama, M., Neufeldt, H., Dobie, P., Njenga, M., Ndegwa, G. et al. (2014). The potential of agroforestry in the provision of sustainable woodfuel in sub-Saharan Africa. *Current Opinion in Environmental Sustainability* 6: 138–147. <https://doi.org/10.1016/j.cosust.2013.12.003>
- Infrastructure Development Company Limited. (2018). Project and programmes: Solar home system programme, IDCOL, Dhaka. <https://bit.ly/318gv0t> [Accessed 10 November 2018].
- International Energy Agency. (2014). *Africa energy outlook – A focus on energy prospects in sub-Saharan Africa*. Paris: IEA.
- International Institute for Environment and Development. (2012). What is the sustainable energy for all initiative? <https://bit.ly/2plnwO9> [Accessed 2 September 2019].
- International Monetary Fund. (2019). *Regional economic outlook: Sub-Saharan Africa, April 2017*. Washington, DC: IIED. <https://bit.ly/2q8nv0x> [Accessed 28 April 2019].

- International Renewable Energy Agency. (2015). *Off-grid renewable energy systems: Status and methodological issues*. IRENA Working Paper, IRENA, Abu Dhabi, UAE. <https://bit.ly/2q2MQZI> [Accessed 12 August 2018].
- International Renewable Energy Agency. (2016). Solar PV in Africa: Costs and markets. <https://bit.ly/35ox1ga> [Accessed 2 August 2018].
- International Renewable Energy Agency. (2018). Off-grid renewable energy solutions. <https://bit.ly/33vKb9B> [Accessed 15 October 2018].
- Kemp, R. & Loorbach, D. (2006). Transition management a reflexive governance approach. In: J-P. Voss, D. Bauknecht & R. Kemp (Eds), *Reflexive governance for sustainable development*. Cheltenham, UK: Edward Edgar Publishing.
- Least Developed Countries Renewable Energy and Energy Efficiency Initiative. (2018). LDC REEEI: By LDCEs for LDCEs. <http://ldcreeei.org> [Accessed 1 October 2019].
- Loorbach, D. (2010). Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance: An International Journal of Policy, Administration, and Institutions* 23(1):161–183. <https://doi.org/10.1111/j.1468-0491.2009.01471.x>
- Lovins, A.B. (1977). *Soft energy paths: Towards a durable peace*. Cambridge, MA: Ballinger Publishing Company and Friends of the Earth International.
- Lucas, P.L., Nielsen, J., Calvin, K., McCollum, D.L., Marangoni, G. et al. (2015). Future energy system challenges for Africa: insights from Integrated assessment models. *Energy Policy* 86: 705–717. <https://doi.org/10.1016/j.enpol.2015.08.017>
- Mitra, S. & Buluswar, S. (2015). Universal access to electricity: Closing the affordability gap. *Annual Review of Environmental Resources* 40: 261–283. <https://doi.org/10.1146/annurev-environ-102014-021057>
- Mulugetta, Y., Ben Hagan, E. & Kammen, D. (2019). Energy access for sustainable development. *Environmental Research Letters* 14(2): 1–6. <https://doi.org/10.1088/1748-9326/aaf449>
- Mulugetta, Y. & Castan-Broto, V. (2018). Deep mitigation opportunities and urbanization patterns in LDCs. *Current Opinion in Environmental Sustainability* 30: 82–88. <https://doi.org/10.1016/j.cosust.2018.03.007>
- Odarno, L., Sawe, E., Swai, M., Katyega, M.J.J. & Lee, A. (2017). *Accelerating mini-grid deployment In sub-Saharan Africa: Lessons from Tanzania*. World Resources Institute and TaTEDO. <https://bit.ly/32a0RmM> [Accessed 10 October 2018].
- Oji, C. & Weber, O. (2017). *Beyond the grid: Examining business models for delivering community-based REPs in developing countries*. CIGI Paper No. 130, Centre for International Governance Innovation, Waterloo, Canada.
- Okereke, C. (2010). Climate justice and the environmental regime. *Wiley Interdisciplinary Reviews: Climate Change* 13: 462–474. <https://doi.org/10.1002/wcc.52>
- Okereke, C., Coke, A., Geebreyesus, M., Ginbo, T., Wakeford, J. et al. (2019). Governing green industrialisation in Africa: Assessing key parameters for a sustainable socio-technical transition in the context of Ethiopia. *World Development* 115: 279–290. <https://doi.org/10.1016/j.worlddev.2018.11.019>
- Orlandi, I., Tyabji, N. & Chase, J. (2016). *Off-grid solar market trends report 2016*. <https://bit.ly/2CqPpCE> [Accessed 18 September 2019].
- Pachauri, S., van Ruijven, B.J., Nagai, Y., Riahi, K., van Vuuren, D.P. et al. (2013). Pathways to achieve universal household access to modern energy by 2030. *Environmental Research Letters* 8(2): 024015. <https://doi.org/10.1088/1748-9326/8/2/024015>

- Pezzey, J. (1992). *Sustainable development concepts: An economic analysis*. Washington, DC: World Bank. <https://doi.org/10.1596/0-8213-2278-8>
- Practical Action. (n.d.). Total energy access is achievable – Infographic. <https://bit.ly/2ouhv1U> [Accessed 1 October 2019]. <https://doi.org/10.3362/9781780449357>
- Practical Action. (2010). *Poor people's energy outlook 2010*. Rugby, UK: Practical Action Publishing.
- Practical Action. (2016). *Poor people's energy outlook 2016: National energy access planning from the bottom up*. Rugby, UK: Practical Action Publishing.
- PricewaterhouseCoopers. (2016). *Electricity beyond the grid: Accelerating access to sustainable power for all*. <https://pwc.to/33C1rdp> [Accessed 19 September 2019].
- Raven, R., van den Bosch, S. & Weterings, R. (2010). Transitions and strategic niche management: Towards a competence kit for practitioners. *International Journal of Technology Management* 51(1): 57–74. <https://doi.org/10.1504/IJTM.2010.033128>
- Ribera, T., Sachs, J., Colombier, M., Schmidt-Traub, G., Waisman, H. et al. (2015). *Pathways to deep decarbonization*. New York: SDSN/IDDRI.
- Robbins, P. (2004). *Political ecology*. London: Blackwell Publishing.
- Roberts, J.T. & Parks, B. (2006). *A Climate of injustice: Global inequality, north-south politics, and climate policy*. Cambridge, MA: MIT Press.
- Sen, A. (2000). *Development as freedom*. New York: Alfred A. Knopf.
- Showers, K.B. (2011). Electrifying Africa: An environmental history with policy Implications. *Geografiska Annaler Series B Human Geography* 93(3): 193–221. <https://doi.org/10.1111/j.1468-0467.2011.00373.x>
- Shue, H. (2013). Climate hope: Implementing the exit strategy. *Chicago Journal of International Law* 13(2): 380–402. <https://bit.ly/35yJNxl> [Accessed 12 September 2019].
- Sokona, Y., Mulugetta, Y. & Gujba, H. (2012). Widening energy access in Africa: Towards energy transition. *Energy Policy* 47, Suppl. 1: 3–10. <https://doi.org/10.1016/j.enpol.2012.03.040>
- Tenenbaum, B., Greacen, C., Siyambalapitiya, T. & Knuckles, J. (2014). *From the bottom up: How small power producers and mini-grids can deliver electrification and renewable energy in Africa*. Directions in Development. Washington, DC: World Bank. <https://bit.ly/1g4PspF> [Accessed 20 September 2019]. <https://doi.org/10.1596/978-1-4648-0093-1>
- Thompson, G. & Bazilian, M. (2013). Democratization, energy poverty, and the pursuit of symmetry. *Global Policy* 5(1): 127–131. <https://doi.org/10.1111/1758-5899.12103>
- United Nations Department of Economic and Social Affairs. (2015). *World population prospects: 2015 revision*. Geneva: UNDESA. <https://bit.ly/2OF2Bk1> [Accessed 2 October 2019].
- United Nations Environment Programme. (2017). *Atlas of Africa energy resources*. Nairobi: UNEP. <https://bit.ly/2otNVJW> [Accessed 28 April 2019].
- United Nations Framework Convention on Climate Change. (2016). *Aggregate effect of the intended nationally determined contributions: An update*. <https://bit.ly/2VBDTSS> [Accessed 1 October 2019].
- Wang, Y.-D. (2001). Development of an alternative energy system: The challenge and its future. In: H-K. Kim, *Energy and Korean Life*. Seoul: Korean Future Society.
- Welsch, M., Bazilian, M., Howells, M., Divan, D., Elzinga, D. et al. (2013). Smart and just grids for sub-Saharan Africa: Exploring options. *Renewable and Sustainable Energy Reviews* 20: 336–352. <https://doi.org/10.1016/j.rser.2012.11.004>

- World Bank. (2011). *Wood-based biomass energy development for sub-Saharan Africa: Issues and approaches*. Washington, DC: World Bank. <https://doi.org/10.1596/26149>
- World Bank. (2017a). *Mini-grids in Cambodia: A case study of a success story*. Energy Sector Management Assistance Program. Washington, DC : World Bank Group. <https://bit.ly/35uM7Rf> [Accessed 18 September 2018].
- World Bank. (2017b). *Mini-grids in Kenya: A case study of market at a turning point*. Energy Sector Management Assistance Program. Washington, DC: World Bank Group. <https://bit.ly/2OJzRXp> [Accessed 20 October 2018].
- World Bank. (2017c). *State of electricity access report 2017*. Washington, DC: World Bank.
- World Bank. (2018). *Tracking SDG7: The energy progress report*. Washington, DC: World Bank.
- World Commission on Environment and Development. (1987). *Our common future*. New York: United Nations.
- World Economic Forum. (2019). *Fostering effective energy transition*. Geneva: World Economic Forum.
- World Resources Institute. (2014). *Climate analysis indicators tool – CAIT 2.0*. <https://bit.ly/2B6ZxFf> [Accessed 18 September 2019].



4

INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT FOR AFRICA

Desta Mebratu

Introduction

The first industrial revolution, which started in the United Kingdom in the eighteenth century, heralded the beginning of the second major social transformation in human history. The introduction of coal as the primary energy source for socio-economic activity and steam power as the primary driver of manufacturing processes were the two significant features that characterised the period. Over the subsequent two and a half centuries, the industrial revolution has gone through different stages of development that fundamentally reshaped the national and global economy. As a result of these developments, global gross domestic product output grew by 23-fold from 1900 to 2010 (International Resource Panel [IRP], 2014) leading to significant improvement of wellbeing, particularly in developed countries. However, this economic growth was registered at a considerable price on the natural system which resulted in a ten-fold increase in extraction of natural resources, a 34 fold increase in extraction of construction

minerals and a 27-fold increase in extraction of industrial ores and minerals (IRP, 2014). Besides the destruction of the natural habitat, the unsustainable exploitation and use of fossil fuels resulted in the systemic deposition of greenhouse gases leading to climate change, which is the most complex challenge faced by humanity.

African countries have been aspiring to industrialise their economies since their early years of liberation. By the mid-1960s, many African governments conceived bolder plans and programmes on industrialisation. This was given a continental scope with the adoption of the Lagos Plan of Action in April 1980 for the collective industrialisation of Africa. Since the 1970s, more specifically as a follow-up to the Lagos Plan of Action, many African countries embarked upon ambitious industrial development programmes that were primarily driven by massive public investment in building physical infrastructure. Nevertheless, except for a couple of North African countries and South Africa, most of them failed to achieve their stated goals. As a result, for decades Africa's share of global manufacturing output remained minuscule compared to other regions. Over the last decade, Africa has seen a renewed interest in industrialisation from within and from the outside world. The United Nations Economic Commission for Africa (UNECA) noted that industrialisation is an imperative for Africa to meet the objectives of Agenda 2063 within a global economy constrained by climate change and driven by competitive supply chains and complex supply and demand dynamics (UNECA, 2015).

Industrialisation in Africa, however, does not necessarily need to follow the same path of polluting and inefficient industrialisation process that had been followed by countries in other regions. Given the complex socio-economic and socio-ecological challenges faced by African countries and the emerging trends of industrialisation, it is not a matter of choice for African countries but to adopt a new path of industrialisation that creates jobs and livelihood to its people, particularly its large young population, while at the same time maintaining the sustainability and integrity of its natural ecosystems.

The objective of this chapter is to provide an overall framework for an industrial development in Africa that is inclusive, low carbon and resource efficient. To this end, the first section looks at the various stages of industrialisation with a particular focus on emerging industrialisations trends and drivers. This is followed with a section on status and trends of industrialisation in Africa with a focus on the lessons that are drawn from past experiences. The final section presents a generic framework for inclusive and sustainable industrialisation in Africa.

Drivers of industrialisation and its impact

There is a vast volume of literature on various models of industrialisation that have been followed by many countries over the last couple of centuries. While some useful lessons could be drawn from the experiences of these countries, neither the European model nor the ‘so-much-talked-about’ Asian models of industrialisation are appropriate for Africa for the following two main reasons. Firstly, attempting to industrialise through the conventional model of industrialisation is neither feasible nor sustainable within the available regenerative and assimilative capacity of the planetary ecosystem, which is already constrained. The *Global Resource Outlook* produced by the IRP (2019) stated that the decoupling of natural resource use and environmental impacts from economic activity and human wellbeing is an essential element in the transition to a sustainable future. Secondly, the industrialisation of the twenty-first century is fundamentally different from previous industrialisation paths, both in terms of its technological drivers and the expected socio-economic outcome and impacts. In this context, it is vital that African countries understand the fundamental technological drivers and resource constraints of industrialisation in the twenty-first century.

The twentieth century was a century of unprecedented economic growth driven by a faster pace of industrialisation and globalisation. However, it was also a century that saw exponential growth in the volume of resources extracted from the natural environment and the related environmental degradation. The need for a fundamental transformation in our production and consumption structure is already agreed globally through the Paris Declaration on Climate Change and the Agenda 2030 on Sustainable Development Goals (SDGs). While the industrialisation process may have a different scope and context from one country to another, technological innovation has been one of the common drivers of industrialisation. Another critical feature of industrialisation that took a global dimension has been the adverse impact of industrial activities on the natural environment and the subsequent global reaction to it. This subsection highlights the key features of technological innovations that have determined the path and pace of industrialisation over the years. It also reviews the dominant thinking that emerged on how to address the adverse impact of industrialisation on the natural environment.

Technological innovation as a driver of industrialisation

From a transformative development perspective, innovation holds a central place in any form of social transformation in human history. Besides the production of various hunting tools, the creation of fire had been the first and, perhaps, the most

significant innovation that defined the fundamental distinction between the homo-sapiens and its closely related animals. This was followed by the domestication and use of the bio-energy of animals for productive activities, including for farming and mobility, together with the production of various types of farming tools, which led to permanent settlement and expansion of agricultural farming. The process of technological innovation has been the most potent driver of industrialisation and wealth creation since the onset of the industrial revolution. Schwab (2018) identified the following four stages of the industrial revolution in relation to technological innovation:

- **First industrial revolution:** This stage represents the period from the mid-eighteenth century to the mid-nineteenth century which transformed every sector of production from machine tools to steel manufacturing, the steam engine and railways. New technologies led to shifts in cooperation and competition that, in turn, created entirely new systems of value production, exchange and distribution, and opened sectors from agriculture to manufacturing, from communication to transport.
- **Second industrial revolution:** A new wave of interrelated technologies that came from 1870–1930 compounded the growth and opportunity that came from the first industrial revolution. This included new communication technologies driven by the transformative power of electricity, transportation technologies driven by the internal combustion engine, the ability to produce diverse materials from plastics to fertilisers driven by the development in chemical processes.
- **Third industrial revolution:** The revolutionary breakthrough that occurred around the middle of the twentieth century in information theory and digital computing is at the heart of the third industrial revolution. The ability to store, process and transmit information in digital form reformatted almost every industry and dramatically changed the working and social lives of billions of people.
- **Fourth industrial revolution:** Emerging technologies that drive the fourth industrial revolution build upon the knowledge and systems of previous industrial revolutions, in particular, the digital capabilities of the third industrial revolution. These emerging technologies include artificial intelligence (AI) and robotics, additive manufacturing, new materials and energy technologies, biotechnologies, and virtual and augmented reality.

While Schwab looks at the different stages of the industrial revolution from the perspective of how productive economies are structured and organised, Jeremy Rifkin looks at how energy and communication technologies drove economic transitions. Rifkin (2011) argues that significant economic transformations in

history occur when new communication technology converges with new energy systems. He further notes that the new form of communications became the medium for organising and managing the more complex civilisations made possible by the new sources of energy. Based on this, Rifkin identifies the following three stages of the industrial revolution (Rifkin, 2011):

- **First industrial revolution:** The introduction of steam-powered technology into printing transformed the medium into the primary communications tool to manage the first industrial revolution. The advent of public schooling between the 1830s and 1890s created a print-literate workforce to organise the complex operations of a coal-powered, steam-driven rail and factory economy.
- **Second industrial revolution:** The convergence of electrical communication with the oil-powered mineral combustion engine during the first decade of the twentieth century gave rise to the second industrial revolution. The electrification of factories ushered in the era of mass-produced goods, the most important being the automobile.
- **Third industrial revolution:** The conjoining of internet communication technology and renewable energy represents the latest convergence of communication technology and energy systems, thereby laying the foundation for the third industrial revolution. This convergence will enable hundreds of millions of human beings to generate their own green energy from the roof of their homes, offices and factories and share it across intelligent distributed electricity networks.

As a result of the significant economic transformation caused by the different stages of the industrial revolution, average real income per person in industrialised economies has increased around 2 900 percent since the industrial revolution, while life expectancy at birth has more than doubled in almost every country (Schwab, 2018). Rifkin (2011) noted that the third industrial revolution would have as significant an impact in the twenty-first century as the first industrial revolution had in the nineteenth century and the second industrial revolution in the twentieth century.

Rifkin (2011) also underlined that the traditional top-down organisation of society that characterised much of the economic, social and political life of the fossil-fuel-based industrial revolution is giving way to a distributed and collaborative relationship in the emerging green industrial era. While Schwab and Rifkin may seem to start with different premises, both of them come to similar conclusions on the vital role of innovation in industrialisation and the possible path of industrialisation in the twenty-first century. Perez (2010) noted that the Information and communications technology (ICT)-led shift in the development

paradigm needs to be production-centred, pro-development with dynamic locally differentiated markets that enhance national identities and reach towards optimum worldwide welfare. This is all good news from a developing country context as many developing countries are well-positioned to become nodal centres of this new global (re-)industrialisation which drives a new period of global growth that is more equitable and contributes to unprecedented wellbeing.

Industrialisation and environment

The natural system possesses self-regulating mechanisms, which are composed of a complex web of positive and negative feedback systems operating within the context of the carrying, regeneration and assimilation capacity of the respective ecosystems. However, the industrialisation of the past two centuries changed the ecological dynamics in ways that no one could have imagined. The utilisation of coal led to steam engines, and machines replaced land as the central means of production. This development led to great material productivity and a world that today supports, at least partially, more than seven billion people. The expansion of industrialisation led to environmental deterioration from the poles to the tropics, from the top of the mountains to the ocean depths (Meadows, Meadows & Randers, 1992). The success of the industrial transformation, like the more limited successes of the agricultural transformations, led to ecological scarcities, not only in terms of natural resource supply but also in terms of the absorptive capacity of the natural sinks and species losses.

Thomas Robert Malthus (1766–1834) is considered to be the first economist to foresee the limits to growth caused by resource scarcity. While he fits into the classic economics tradition, Malthus is sufficiently at variance with some basic principles (Oser & Blanchfield, 1975). By 1798, many of the evil effects of the industrial revolution had surfaced. Unemployment, poverty, and disease were already problems calling for remedial treatment. Contrary to the ideas of William Goldwin (1756–1836) and Marquis de Condorcet (1743–1794), Malthus said that the vices and misery that plague society are not due to evil human institutions but are due to the fecundity of the human race (Oser & Blanchfield, 1975). This led to his theory of population dynamics. According to Malthus's theory, population, when unchecked, increases geometrically while subsistence increases arithmetically, at best (Oser & Blanchfield, 1975).

Together with David Ricardo (1772–1823), who fundamentally agreed with his population theory, Malthus expressed his 'environmental limits thinking' in terms of the limits on the supply of good quality agricultural land and the resultant diminishing returns in agricultural production (Pearce & Turner, 1990). For Malthus, the fixed amount of land available meant that as the population grew,

diminishing returns would reduce the per capita food supply. The standard of living would be forced down to a subsistence level, and the population would cease to grow. Diminishing returns set in, not so much because of absolute scarcity, but because the available land varied in quality. The fundamental shortcoming of this theory is that, in both cases, the subject of diminishing returns was defined based on keeping the total production curve fixed (Pearce & Turner, 1990). In reality, technical innovations, such as the use of fertilisers, have shifted the total production curve upwards, increasing output per unit of input and offsetting the tendency towards diminishing returns. Despite such limitations, the Malthusian theory of 'environmental limits' may be considered a precursor to some of the fundamental principles of sustainable development (Mebratu, 2000).

On the political economy front, Roszak (1989) concluded that it would be no exaggeration to call Ernst Schumacher the Keynes of post-industrial society, by which he meant a society that has left behind its lethal obsession with those mega systems of production and distribution that Keynes tried so hard to make manageable. The first work of Schumacher appeared in 1959 under the title, *The Crucial Problems of Modern Living*. His works culminated in international recognition and fame after the publication of his famous book, *Small is Beautiful*, in 1979. The themes addressed in this book included:

- sharp criticism of over-organised systems as destructive of the human spirit and the planet alike;
- concern about the rapid depletion of natural resources and the corresponding destruction of the environment;
- the concept of intermediate or appropriate technology and the importance of human scale, perhaps the concept for which the book is best known;
- the failure of traditional economics to bring incommensurable 'noneconomic factors' into the policy-making process; and
- a need for human beings to be close to the nurturing land, in both fact and spirit (McClaghry, 1989).

To a world awakening to the spectre of global pollution, resource exhaustion, corporate concentration, and the corresponding diminution of individual liberties, Schumacher's book was 'a ray of hope' (McClaghry, 1989). As a result, in the mid-1970s, 'Small is Beautiful' became a rallying cry while the concept of appropriate and intermediate technology became the catchphrase of the following decade. Although the book contains some controversial and debatable ideas, Schumacher's concern about the exhaustion of the planet's resources gave new impetus to a whole generation of environmental defenders. His effort of looking

at the economic, ecological, and social aspects of a given system added a new dimension to the discourse on the ‘scale of organisation.’

Since the middle of the twentieth century, there have been numerous efforts to address the environmental impacts of industries. Initially, most of the efforts were limited to the reduction and/or containment of the adverse effects of industrial activities on human health through the end-of-pipe management of industrial wastes. As a result, since the middle of the twentieth century, many end-of-pipe management technologies and techniques that included treatment and disposal techniques were developed and introduced. While such measures led to the improvement of the ambient environmental conditions in some areas, it was not sufficient to fully contain or reduce the pollution impact. The publication of Rachel Carson’s *Silent Spring*, a book on the global problems of pesticides published in 1962, heralded the arrival of the contemporary environmental era that was characterised by a flurry of environmental activities in the developed world in the subsequent decade (Mebratu, 2000). As a consequence, the focus shifted to the broader objective of reconciling industrial activities with the ecological balance of the natural system starting from the mid-1970s. This required a fundamental rethinking of industrial structures and operations which led to the evolution of different concepts related to sustainable industrial development, as highlighted in the next subsection.

Sustainable industrial development tools

As was noted in earlier sections, the industrial development path that had been followed by many of the industrialised countries until the middle of the twentieth century had been exclusively based on uncontrolled and unlimited extraction of natural resources and discharge of industrial pollutants. This led to numerous environmental havocs, which in turn led to public dissent and outcry in most of the developed countries in the nineteen sixties and seventies. As a result, the improvement of the environmental performance of industries at the plant level through the application of end-of-pipe management techniques and technologies became the primary focus of industries. The process that started as an end-of-pipe management exercise has subsequently led to looking back at the whole process of production in the nineteen-eighties and nineties. This led to the evolution of numerous concepts that are aimed at improving operational performance at various levels.

Three major aspects of industrial operations have emerged as the principal foci of the environmental performance improvement at the plant level. These are organisational management, product development, and production processes. The introduction of environmental management systems (EMS), extended producer

responsibilities (EPR), and eco-industrial parks (EIPs) development are the three major industrial development tools that constitute the organisational interventions for sustainable industrial development. An EMS is a system by which a company controls the activities, products and processes that cause, or could cause, environmental impacts and in doing so minimises the environmental impacts of its operation (Roberts & Robinson, 1998). Extended producer responsibility assists in reaching an environmental objective of a decreased total environmental impact from a product by making the manufacturer of the product responsible for the entire lifecycle of the product. This especially includes the take-back, recycling and final disposal of the product (Lindhqvist, 1998). Taking the concept of an ecosystem as a basis, an eco-industrial development is defined as a community of local administration, manufacturing and service businesses seeking enhanced socio-economic and socio-ecological performance through collaboration in managing environmental and resource issues including energy, water, and materials (Mebratu, 2000:87).

Table 4.1 summarises key features and impacts/outcomes of the major tools for sustainable organisational management.

Table 4.1 Tools for sustainable organisational management

Category	Major tools	Key features	Impacts/Outcome
Organisational management	Environmental management systems	Promotion of continuous improvement	Reduction of pollution discharges and impacts
	Extended producer responsibility	Promotion of reuse of materials through a take-back system	Higher resource reuse and better management of toxic substances
	Eco-industrial parks	Promotion of industrial symbiosis between industries	System-level efficiency on resource use and recycling

Sustainable product development and development of product-service systems constitute the two major technical shifts observed in the area of product design and development. Sustainable product development is defined as resource-, context-, and future-oriented product development, aimed at the fulfilment of primary needs, a better quality of life, equity, and environmental harmony over the whole life cycle of a product (Van Weenen, 1997:15). The product-service system focuses on continuous improvement of the functional service provided by products while reducing the overall resource and environmental impacts of the product over its lifetime (Mebratu, 2000). Under such systems, the consumers only pay for the services they acquire from a given product while keeping the ownership of the products with the producers or leasing agents, thereby reducing the systemic deposition of post-consumer products in the natural system. The progress made in this area has led to a significant reduction of the material and energy intensity of successive generation of products.

Table 4.2 summarises key features and impacts/outcomes of the major tools for sustainable product development.

Table 4.2 Sustainable product development tools

Category	Major tools	Key features	Impacts/Outcome
Product development	Sustainable product development	Optimising the life-cycle impact of a product	Reduction of the material and energy intensity of a product
	Product-service systems	Optimising product functionality and service delivery of products	Reduction of resource extraction and habitat destruction

The introduction of cleaner production (CP), resource efficiency and green industry represent significant milestones of the transition within industrial production systems. The first United Nations Environmental Programme (UNEP) International High-level Seminar held in 1990 defined cleaner production as the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks for humans and the environment (UNEP, 2002:08). Resource efficiency is a systematic and integrated approach to managing raw material, energy, water and chemical inputs efficiently while eliminating or minimising wastes and emissions from an industrial system on a sustainable and cost-effective basis (UNEP & United Nations Industrial Development Organization [UNIDO], 2010:11–12). Green Industry means economies striving for a more sustainable pathway of growth, by undertaking green public investments and implementing public policy initiatives that encourage environmentally responsible private investments (UNIDO, 2009).

Table 4.3 summarises key features and impacts/outcomes of the major tools for sustainable production.

Table 4.3 Tools for sustainable production

Category	Major tools	Key features	Impacts/Outcome
Production processes	Cleaner production	Reduction of waste generation at the source	Improved resource utilisation and reduced pollution discharge
	Resource efficiency	Industrial optimisation from a life-cycle approach	Reduction of resource and pollution intensity per unit output
	Green industry	Promoting sector-wide transformation through strategic intervention	Development of new products and sectors that are resource efficient and inclusive

Even if the above-highlighted tools were presented as a cluster for ease of understanding and presentation, most of them are very interdependent on one another right from their development stage through implementation. The major influences of these and other evolving concepts can be categorised under the following points (Mebratu, 2000):

- **Market restructuring:** Some of the evolving concepts and tools enhance the market restructuring process by facilitating the creation of a new segment of consumer behaviour that has a preference for environmentally friendly products. In this context, the number of consumers that demand a certain level of environmental quality from products and services is on the rise. The recognition given to different kinds of environmental (eco-) labelling schemes as a marketing tool is an outcome of this change, and this is expected to influence the global market structure and global value chain.
- **Technological innovation:** Environmental considerations promoted through the various concepts and tools act as one of the significant drivers of technological innovations in product design and processes development. This has led to the evolution of new generations of technologies that are both ecologically and economically efficient. The advance that is being made in product and process development is expected to influence the nature of technology transfer from the industrialised world to the developing world and vice versa.
- **Organisational innovation:** Most of the concepts that are evolving in response to environmental challenges have triggered a corresponding organisational innovation process. The critical element of this organisational innovation process is the development of a learning organisation that is responsive to the dynamic changes. This has posed a challenge to all levels of an organisation including the demand for organisational change in the major global institutions.

In general, the evolving tools and concepts and their subsequent influence on the industrialisation process are clear indicators of the beginning of a new transformation process. This process is going to pose a significant challenge to African economies in terms of keeping and increasing their industrial product's share in the global market. However, it also creates a vast opportunity of leapfrogging to more inclusive, resource-efficient and low-carbon economies. In this context, Africa needs to keep pace with these evolving concepts and tools and make its contribution to the transformation process, if it desires not to be left behind.

Industrialisation and Africa

The onset of industrialisation in Europe unleashed a growing appetite for natural resource inputs that went beyond the regenerative capacity of the natural systems in European countries. This led to a more concerted effort of colonising countries in the form of complete occupation or colonising and using them as a source of raw materials input. African countries have been aspiring to industrialise their

economies since their early years of liberation. These aspirations were reflected in the development and promotion of some main regional and national industrial development strategies. Unfortunately, the overall progress made in bringing about the desired structural transformation in African economies was minimal. This section highlights the major features of the main strategies and the performance of the industrial sector over the last couple of decades with the purpose of identifying the key lessons that need to be considered.

Industrialisation strategies and initiatives

A broad overview of industrial development strategies in Africa shows that there have been three major groups of development strategies that attempted to influence national development strategies in Africa. The first group consists of strategies associated with the adoption of the Lagos Plan of Action (LPA) as a post-liberation strategy of industrialisation. This was subsequently encapsulated within the New Partnership for Africa's Development (NEPAD) that was developed as Africa's development blueprint in the twenty-first century. The second group of industrialisation strategies are associated with national strategies that were promoted through the Industrial Development Decade for Africa (IDDA). The third group of industrialisation strategies are associated with the broad economic policy influence that was imposed by the global financing institutions such as the World Bank and the International Monetary Fund. This includes the structural adjustment programmes (SAPs) that were imposed in the 1980s and 1990s.

The LPA is perhaps the most important regional economic development strategy that was developed after a thorough assessment of the state of African socio-economic development, towards the end of the 1970s. The Lagos Plan of Action and the Final Act of Lagos for the collective industrialisation of Africa was adopted by member states of the Organization of African Unity (OAU) as a regional economic development blueprint. The adoption of the LPA was based on the two principles of self-sustained and self-reliant industrialisation. The Lagos Plan of Action, designed jointly by all countries of Africa, constitutes a charter for the development of the continent for the period 1980–2000. The Final Act of Lagos, adopted in 1980, generated a feeling of optimism and expectation that the last two decades of the century would witness a significant breakthrough in African economic and social development and establish a firm foundation for progress in the twenty-first century.

The LPA not only emphasised industrial growth but, more specifically, self-sustained industrialisation designed to meet domestic needs. According to UNECA, many strategic measures were proposed, including the following:

- Building up of an industrial production structure capable of meeting changing domestic needs through the preparation and implementation of an integrated industrial development programme.
- Establishment of a core of production, marketing, research and development activities which provide the impetus for economy-wide growth processes.
- Selection of products appropriate to the satisfaction of the basic needs of the mass of the population and the promotion of self-sustaining development.
- Expansion and restructuring of domestic markets by integrating the rural economy with the modern sector through the construction of the necessary infrastructure.
- Sub-regional economic integration aimed at developing basic and capital goods industries in integrated sub-regional markets.
- Generation and use of information and data in economic planning and decision making. (UNECA, 1980)

The concept of structural adjustment programmes, as commonly used in the 1980s, has its origins in the global economic events of 1973–1974 and the first oil shock (Reed, 1992). Throughout the later parts of the 1970s, the International Monetary Fund (IMF) and national governments took many crisis management measures, but with few positive results. It is under such circumstances that the World Bank decided to commit its resources to help correct the pervasive macroeconomic imbalances (Mosley, Harrigan & Tate, 1991). The SAP package is based on the belief that the market is a more efficient mechanism for promoting optimum resource allocation than state planning and ‘dirigisme’. It covered the adoption of realistic exchange rates that reflect the true value of a country’s currency and the promotion of exports without placing a premium on imports; interest rates that are higher than the inflation rates and that will, consequently, encourage savings; trade liberalisation and the removal of bureaucratic constraints and controls on exports and imports; the avoidance of large budgetary deficits; and the avoidance of artificial subsidies (Rasheed & Luke, 1995).

According to UNECA (1991), the analysis of the evaluation carried out by the World Bank in 1988 indicated that sub-Saharan African countries implementing structural adjustment programmes experienced a severe economic decline after the adoption of SAPs. According to this report, sub-Saharan African countries’ economies registered a decline in gross domestic product (GDP) growth from 2.7 percent to 1.8 percent, a decline in the investment/GDP ratio from 20.6 percent to 17.1 percent, a rise in the budget deficit from –6.5 percent to –7.5 percent of GDP and a rise in debt service/export earnings ratio from 17.5 percent to 23.4 percent.

The only improvement was a minor decline in the current account/GDP ratio from -9.4 percent to -6.5 percent. UNECA (1991) concluded that both on theoretical and empirical grounds, the conventional SAPs were inadequate in addressing the real causes of economic, financial, and social problems facing African countries which are of a structural by nature. The big question that was raised by all parties was why adjustment did not lead in Africa to its intended consequences.

From the perspective of the World Bank and the IMF, the cause of Africa's malaise was a direct result of the policies pursued by the governments of Africa before the introduction of SAP. However, others argue that the reason is more than policy failures on the African government side, even if this has contributed. Howard Stein argues that the reason is mainly theoretical. According to Stein (1998), SAPs adjustment theories have their roots in neo-classical economic theory which is severely flawed as a guide to understanding how to build economies capable of structural transformation and sustainable development. In other words, it is not an implementation problem but a conceptual problem. Stein further noted that the thinking behind the model is rational deductive and axiomatic and the apparent problem with the approach is that the need for adjustment is a product of the model of adjustment, and the model of adjustment is a product of a series of theoretical premises of abstraction. Thus any divergence of the real cause from the premised cause will lead to severe errors in the realm of policy formulation and implementation (Stein, 1998).

The Industrial Development Decade for Africa (IDDA) was developed based on the LPA and the concept of the United Nations Development Decade. The development of the IDDA was based on the recognition of the persistence of at least three significant structural weaknesses, namely dependence on a few primary export commodities, dependence on broadly the same markets for selling primary commodities and for buying capital and consumer goods and services, and persistence of market enclaves and dysfunctional relations within national economies (UNIDO, 1982). The Industrial Development Decade for Africa was based on the much broader concept of designing and constructing internal engines of growth in Africa to replace the prolonged and accelerating weakening of an external engine of growth resting on trade and economic relations with the developed economies of western Europe and the United States. The IDDA programme, which consists of objectives, principles and priorities, constitutes one small but crucial component in the design, construction and working of the internal engine of growth that was enshrined by the LPA. The heart of the programme was the production, supply and use of factor inputs for designated core industries and the use of the outputs of core industries for promoting the growth of strategic sectors.

During the earlier part of the first IDDA, some public investments were made in industrial projects, although funding and other constraints did not permit investments of the desired scale. Well-intentioned as these investments were, they were not successful. According to a report by the Economic and Social Council (ECOSOC) of the UN (1992), massive problems have arisen in technology absorption, machinery maintenance and management. The net results were that input-output ratios were sub-optimal, consumption coefficients were below standard, productivity was low, and capacity utilisation was below the break-even point. According to this report (UN, 1992), it was roughly assessed that the average capacity utilisation of the African industries ranges between 30 to 40 percent. As a result, many of the industries set up were running at a loss, and some were at a point of bankruptcy. Since many of these plants were in the public sector, they were kept going through state subsidies and thus became a burden to the nations.

IDDA-2 and IDDA-3 have followed the first IDDA in the subsequent decades. The main goals of the second and third IDDA are not fundamentally different from those adopted for the first decade. The vision continued to be that of a programme to end the over-dependency which African countries have on the industrialised world, to promote internal engines of growth, to build on Africa's wealth and natural resources and progressively to achieve self-reliance and self-sustainment. However, it was claimed that there had been a significant departure in the 'modus operandi' of preparing the programme for the second IDDA (Organization of African Unity [OAU], Economic Commission for Africa [ECA] & UNIDO, 1997) and preparations of the plan for the second IDDA have moved to the national level. Each member state has undertaken the task of framing a national programme for the second IDDA keeping in mind the realities, environmental circumstances, natural resources and priorities of each member state. This is mainly due to the experiences of the first decade, the changing world environment and the adoption, by a large number of African countries, of World Bank sponsored structural adjustment programmes.

In general, the IDDA process was profoundly influenced by the philosophical foundation of the LPA which promotes the interventionist approach with heavy reliance on state planning and control. This approach has led to the continuous undermining of the development of the private sector and the marginalisation of the existing private sector from the development process (Mebratu, 2000). Furthermore, as an industrialisation process that is mainly driven by public investment, IDDA was primarily focused on the establishment of large-scale industries. As a result, some industrial projects, that were intrinsically uneconomical, were launched in the earlier years of the implementation of IDDA while others that could have been competitive were not given sufficient capability

and institutional support (World Bank, 1989). This has contributed to the further weakening of national economies in Africa.

There have been different conclusions made on the limitations of development strategies promoted in Africa from different perspectives. Mebratu made the following conclusions after analysing the major groups of regional initiatives developed since liberation:

- The regional strategic initiatives spearheaded through the regional bodies were based on the achievement of self-reliance and self-sustainment through active state intervention. On the contrary, the initiatives promoted by the international financing institutions were based on the promotion of a neo-liberal economy that is entirely governed by the market.
- The disoriented and often conflicting emphasis on the self-sustainment philosophy of regional strategies and liberalisation of structural adjustment programmes was not able to provide a sound basis for the development of effective development strategies.
- All groups of strategies were inclined towards transplanting development either through foreign investment/technology flow and/or through central planning instead of building upon the transformational dynamics of the local socio-economic factors.
- The strategies have weak considerations for socio-ecological factors. In cases where they considered socio-ecological factors, they have been limited to 'environmental policy add-ons' instead of mainstreaming socio-ecological considerations.
- All groups of strategies have suffered from frozen policy and strategy frameworks that gave little room for adaptation of the frameworks to changing environments. Their review process was limited to minor tinkering of the performance variables and finding external explanations for the limited successes.
- Despite the massive effort of promoting the two groups of strategies, the socio-economic situation in most African countries became worse in the 1980s. Even if some sub-Saharan African countries have registered improvements in the 1990s, they had a problem of sustaining their socio-economic gains. (Mebratu, 2000:136)

At the dawn of the new millennium, African heads of state and government pledged to take responsibility, through the New Partnership for Africa's Development (NEPAD), for the future of their continent and to establish a new relationship with bilateral development partners and multilateral organisations based on mutual trust, respect and accountability (African Union [AU], 2001). The New Partnership for Africa's

Development is a comprehensive and integrated sustainable development initiative for the revival of Africa through a constructive partnership between Africans themselves and between Africa and the developed world. It is the first comprehensive development approach initiated, implemented and owned by African governments with the full support of the international community. It provides a vision of the kind of society and economy that African governments want to build. The broad, long-term objectives of NEPAD are to eradicate poverty, put Africa on a sustainable development path, and halt the marginalisation of Africa. In the NEPAD framework document, African leaders identified the following issues and priority areas as crucial for achieving the broad objectives of NEPAD:

- Establishing conditions for sustainable development through maintaining peace and security and also improving economic, corporate and political governance.
- Promoting investment and policy reforms in priority areas such as infrastructure, human resource development, agriculture, the environment, and science and technology.
- Strengthening the mobilisation of resources through, for example, boosting domestic savings as well as official development assistance and private capital flows, reducing external debt, and diversification of production and exports. (United Nations Conference on Trade and Development [UNCTAD], 2012)

The New Partnership for Africa's Development can be considered as a blueprint for African development and industrialisation (Muriithi, 2005). Furthermore, it is not only a development framework, philosophy or vision, but also a development programme with concrete projects geared towards addressing Africa's development needs and challenges. NEPAD is considered as the twenty-first-century version of the Lagos Plan of Action with a new model of partnership between African countries and Africa and its development partners. NEPAD led to the development of many regional framework programmes that are dealing with the key sectors that are crucial for Africa's development. One of these programmes is the Programme for Infrastructure Development in Africa (PIDA). This programme mainly focuses on the development of energy infrastructure as a driver for industrial development in Africa. Even if they were launched with much optimism, the implementation of NEPAD programmes, including PIDA, has not been as successful as it was expected.

Trends of industrial development in Africa

As noted in the earlier section, until the end of the nineteen seventies the national development strategies of most African countries promoted active state intervention in development planning and implementation. Throughout the subsequent decades, development strategies of most African countries moved between the two

extreme positions of active state intervention and laissez-faire approaches, with very few countries exclusively endorsing one or another form of the strategy. The development effort spearheaded by the development decade concept led to some positive, but not satisfactory results in the areas of social development. For instance, between 1960 and 1994, life expectancy increased from 40 years to 52 years, while since the mid-1980s the proportion of the population with access to safe water was almost doubled, from 25 percent to 43 percent of the total (Spark, 1998). During the same period, adult literacy advanced from 27 percent to 55 percent. However, the economies of most African countries declined in virtually every measurable way from the 1970s through to the mid-1990s.

Most of these economies declined in terms of GDP and per capita GDP after an impressive start at independence. Rodrik (2016) points out that the low-income economies of sub-Saharan Africa have been affected nearly as much by what he called ‘premature deindustrialisation’ as the middle-income economies of Latin America – though there was less manufacturing, to begin with in the former group of countries. The trade liberalisation policy that was pushed through globalisation is believed to have made a significant contribution to the transition of most sub-Saharan African economies to service economies before having meaningful industrialisation. This laid the basis for what is called ‘premature deindustrialisation. On the other hand, Africa’s debt has grown geometrically during the period from the 1960s to the 1990s. In 1960, the region’s external debt amounted to less than three billion USD, and the average debt service ratio was only 2 percent of exports. In 1996, the region’s aggregate ratio of debt to exports was estimated at 239.9 percent (UNECA, 1996). Africa has also been missing from the massive expansion of international trade. Africa’s share of global trade has fallen from around 3 percent in the 1950s to about 1 percent in 1995.

Since the turn of the century, however, some African countries started showing signs of economic recovery as reflected in the sustained growth rate in their national GDP. According to UNECA, around twenty African countries registered an average GDP growth of more than 5 percent during the period from 2000 to 2014 and more than half of African countries registered an average GDP growth rate of more than 4 percent during the same period. Only four countries that are plagued with internal conflict and war registered negative GDP growth during the same period (UNECA, 2016a). McKinsey Global Institute (2016) reported that Africa’s real GDP grew at an average of 3.3 percent a year between 2010 and 2015, which is considerably slower than the 5.4 percent from 2000 to 2010. It, however, also noted that this average disguises stark divergence as growth slowed sharply among oil exporters and North African countries while the rest of Africa posted accelerating growth at an average annual rate of 4.4 percent in 2010 to 2015, compared with 4.1 percent in 2000 to 2010.

The improved economic growth rate registered over the last two decades led to the change of the narrative about Africa's prospect for economic development as captured by an article in *The Economist*, 'The Sun shines bright' in 2011 and *Time* magazine's piece, 'Africa Rising', in 2012 (UINECA, 2016b). The proponents of this narrative (Andersen & Jensen, 2013; McKinsey Global Institute, 2010; Radelet & Sirleaf, 2010; Robertson, Mhango & Moran, 2012) gave some reasons to explain why this time around the growth has come to stay. This includes an increase in the number of democracies and a more open political domain; a significant drop in the level of violence from 55 percent to 24 percent (Africa Progress Panel [APP], 2012); and lessons have also been learned from the policy mistakes of the 1960s and the 1970s. In addition, some claim that a technological revolution has taken hold across the continent, most dramatically illustrated by an increase in the use of cellular phones.

However, there are numerous criticisms and reservations expressed with the support of some rigorous and more nuanced analysis of economic growth trends of African countries which showed that the 'Africa rising' narrative misses out many essential points. Rodrik (2017) argues that without manufacturing gains, the growth rates brought about recently by rapid structural change in low-income African countries are exceptional and may not last. UNECA (2016b), highlighted the following as some of the major reservation points expressed by different groups:

- Over the same period under consideration, per capita growth in developing countries in East Asia and Pacific countries (EAP) averaged 7.71 percent, whereas developing countries in Africa registered 2.09 percent. This means that developing countries in EAP have been growing over three times faster than those in Africa.
- As was pointed out by Arbache and Page (2009), the improved economic performance in Africa after 1995 can be mainly attributed to the increase in growth accelerations of resource-dependent countries that created a commodity price boom. This makes the sustenance of this relatively modest growth performance unlikely in the long run for most countries.
- Even if Africa can sustain its recent growth performance, the poor quality of recent growth in Africa in terms of employment and poverty makes it doubtful that it will have significant positive impacts on the lives of most people.
- The ILO (2014) reported that in 2013 the vulnerable employment rate in Africa (excluding North Africa) was estimated at 77.4 percent of all jobs, the highest of all developing regions in the world. This is only 2.3 percentage points lower than in 2001.

- From 2000 to 2011, the population share in Africa (excluding North Africa) living on less than \$2 a day (PPP)¹ was reduced from 77.5 percent to 69.5 percent showing that Africa's recent growth was also of poor quality in terms of its impacts on poverty.
- From 1980–2013, the share of manufacturing in economic output on the continent declined from more than 12 percent to around 11 percent, currently the lowest of all developing regions in the world. (UNECA, 2015)

UNECA (2016b) concludes that Africa is doing better in many ways compared to 15 years ago. However, in terms of the development of productive capabilities, which is the essence of sustained economic development, one can conclude that the 'Africa rising' narrative is mostly hype. On top of all these, most of the rise in GDP is associated with sales of commodities from extractive sectors, which left behind a huge environmental cost to the countries. Paul Cilliers (2010) notes that resource-dependent growth tends to stimulate short-term growth but could undermine long-term growth. Further growth and development will, therefore, depend on whether revenues from resource rent are re-invested in laying the foundation for long-term development. Furthermore, the growth in national GDP that has been applauded by the 'Africa rising' proponents will essentially be wiped out when we account for the cost of environmental degradation and destruction caused by these extractive industries. Africa as a whole is still projected by the IMF to be the world's second-fastest-growing economy to 2020. Nonetheless, most African countries are yet to go through the essential process of structural transformation and reverse the recent trend of deindustrialisation.

Inclusive and sustainable industrialisation

The fast rate of socio-economic development witnessed over the last couple of centuries has clearly shown that the development of the industrial sector in general and the manufacturing sector, in particular, is the primary engine for economic growth. Recent economic history has also shown that industrial development that is exclusively driven by profit maximisation and wealth accumulation leads to significant damage to the natural ecosystem and exclusion of billions of people from economic prosperity. Progress made in the development of more resource-efficient production technologies and techniques has also shown that newly developing countries do not need to follow the same old inefficient and polluting paths of industrialisation that have been followed by industrialised and newly

1 Purchasing power parity (PPP) is a macroeconomic analysis metric to compare economic productivity and standards of living between countries. It is an economic theory that compares different countries' currencies through a 'basket of goods' approach.

emerging countries. As a result, there is a growing global consensus that underlines that economic development in the twenty-first century has to be inclusive, low carbon and resource efficient.

In this subsection, we will look at some of the major sustainable industrial development tools that are relevant to Africa's industrialisation and propose a framework for sustainable industrial development, which could be adopted and implemented by African countries.

Strategic considerations for inclusive and sustainable industrial development

Looking back at the economic history of Africa over the last two centuries, it is evident that the region has mostly missed all three stages of the industrial revolution. We are now faced with the prospect of the fourth industrial revolution, which is expected to have a much higher impact on their economies. Depending on how they prepare and position themselves, African countries would either be further marginalised from the global economy or be an active contributor and beneficiary from this transition. African countries need to focus on developing an inclusive and sustainable industrial development policy framework in order to be active players and beneficiaries of the industrial revolution of the twenty-first century. Such a framework has to enhance national capacity to overcome the challenges of getting locked-in in an obsolete and inefficient industrial infrastructure and provide the basis for effective utilisation of emerging efficient systems and technologies for the improvement of the wellbeing of its people.

Industrial policy is about anticipating important long-term trends of technology and market development and providing incentives to adopt the structure of a national economy in such a way that it can take advantage of the change (Partnership for Action on Green Economy [PAGE], 2017). Besides understanding the current and emerging economic and technological dynamics, there are some key lessons that African countries should consider from the success and failure of the major regional and national industrial development policies and strategies that have been implemented in the last couple of decades. The following are some of the critical issues that need to be considered in developing and implementing an inclusive and sustainable industrial development policy:

- Targeted public sector investment on development of the physical structure required for industrial development has a significant catalytic role to play, particularly if it focuses on developing the highly needed energy, transportation and communication infrastructure. However, such investment needs to be coupled with building the required capacity for the effective management

and operation of such infrastructural facilities. Building such infrastructure with external debt and giving the management of their operation to foreign companies, as it is happening in some African countries, is not a right strategy that leads to an inclusive and sustainable industrial development.

- The most critical infrastructural prerequisite for industrialisation is the institutional infrastructure, which includes creating the required human skill-sets and institutional systems that drive the industrialisation process. Development of an effective industry-university linkage is one of such institutional system besides having a sound and context-relevant policy environment. Most of the investment that went into the development of huge physical infrastructure across the region so far largely failed to deliver due to the limitations in institutional infrastructure development.
- Enhancing national capacity on effectively managing the selection and transfer of industrial manufacturing technologies is a crucial prerequisite for successful industrialisation of any country. African countries need to recognise that they can never industrialise by becoming a dumping ground for obsolete and inefficient industrial production processes in the name of foreign direct investment (FDI). This is particularly a critical issue now when we consider the progress that is being made in different sectors towards more resource-efficient industrial systems, which has created the condition for shifting and relocating polluting industries to African countries under the guise of FDI.
- Promoting the development of a dynamic and adaptive innovation ecosystem that is responsive to emerging technological trends based on creativity of its youth is a critical success factor for any African country. The innovation space of the twenty-first century is becoming fundamentally different from the conventional innovation systems supported by public institutions. The growing influence of open spaces and creative commons as public innovation platforms is opening new opportunities and relationships among innovators and entrepreneurs. Coupling such innovation ecosystems with different forms of blended financing is a key determinant of leapfrogging to a high-efficiency trajectory.
- African countries should recognise that industrialisation does not involve an either-or choice between import substitution and export promotion. Rather than focusing on such false dichotomy, countries should focus on an industrial strategy that deploys a combination of these components with a focus on maximising the return from their comparative advantages and improve the wellbeing of its people through job creation and higher value addition to the local resource.

- African countries need to prepare themselves to contain the adverse impact and maximise the benefit from the opportunities of digitisation of the global economy. They should make a maximum effort to exploit the emerging opportunities created by recent development in disruptive technologies. This includes the opportunities from development in the application of artificial intelligence including block-chain technologies, distributed energy systems driven by renewable energy resources, and distributed manufacturing systems that include modularisation of industrial processing technologies. This is crucial not only for their exponential economic impacts but also because of their significant distributional outcomes that promote or discourage inclusivity.
- Industrial development policies of African countries should particularly need to consider the possible impacts and positive contributions of disruptive technologies, such as block-chain technology, on the global value chain. The potential benefit it could provide in terms of facilitating sustainable supply chain and distributed manufacturing systems are two key benefits on which African countries should mainly focus. This is because of their significant contribution to local value addition and job creation.
- Development of industrial parks or estates, which has been promoted as a key element of industrial development strategy since the middle of the twentieth century, has made a significant contribution to the industrialisation of developing countries. However, the economic gains often come at a considerable loss of environmental quality and social impacts within and around industrial estates. Experience from many developing countries has shown that ecological and social issues have often not been adequately considered and integrated into the planning and development of industrial parks. As a result, their industrialisation has come at a considerable cost of environmental pollution and degradation and social displacement. African countries can overcome such challenges by developing eco-industrial parks that are effectively integrated, horizontally and vertically, with local economies and are resource efficient.
- History and experience demonstrate that urbanisation is closely linked to economic growth and the transformation of economies towards productive sectors, namely industry and services. Available evidence suggests that urban and industrial development in Africa is disconnected, resulting in lost opportunities for job creation and improved wellbeing. Reconnecting urban and industrial development in Africa through deliberate policies, strategies and investments is a priority for the sustainability of both cities and industries (UNECA, 2017).

Box 4.1: Lessons for the development of eco-industrial parks

Industrial parks (IPs) in emerging and developing countries provide an institutional framework, modern services and a physical and often social infrastructure, which might not be available in the rest of the country. The concentration of companies can foster innovation, technological learning and company growth. Economies of scale of the supply of services and facilities reduce the costs for companies; thus successful IPs contribute to high-growth regions and national economic development. However, the economic gains often come at a loss of environmental quality within and around industrial estates. This is because environmental issues have often not been adequately considered and integrated into the planning and construction of IPs (UNEP, 2001).

An industrial park in which companies cooperate with one other and with the local community trying to reduce waste and pollution, efficiently share resources and help to achieve sustainable development, with the intention to augment economic gains and improve environmental quality, can be called an eco-industrial park (EIP). The reported potential advantages of environmental management at the level of industrial parks include the following:

- IPs are in line with international standards, and therefore the environmental management practices of IP companies become gradually in line with these standards.
- Environmental management should rely on measurements to achieve high efficiency.
- Environment affects investment, and EIPs put more effort into controlling environmental quality than regular areas.
- EIPs can serve as special designated areas to test new environmental management practices and advanced instruments.

An industrial zone, sector or park can turn into an eco-industrial park through the combination of:

- plant-level efficiency: resulting in minimisation of waste and emission generation from individual enterprises;
- collective synergies: resulting in optimised resource exchanges between companies;
- common environmental and utility systems and management of park operations; and
- proper zoning and planning.

One of the main recommendation informed by the various case studies is that EIPs are valuable especially in developing and emerging countries as they are beneficial in the form of local infrastructure and environmental, economic and social benefits. Therefore, governments and international organisations should promote the development of EIPs.

(Source: Adapted from UNIDO, 2016:4)

Framework for inclusive and sustainable industrial development

Taking the above points and other issues highlighted in this chapter into consideration, the framework for inclusive and sustainable industrial development, highlighted in Figure 4.1, is suggested. The framework is proposed as a generic framework that could be further adapted in response to the specific contexts and

needs of each country. To this effect, it focuses on vital elements of infrastructure that are necessary for the development of an inclusive and sustainable industrial economy. These are clustered under four group of infrastructure, namely institutional, physical, technological, and compliance assistance infrastructure.



Figure 4.1 Framework for inclusive and sustainable industrial development

The four subsections that follow explore each of these interventions in turn. Note, however, that even though the elements of intervention have been clustered in four groups, it is essential to note that their development and implementation has to be carried out in an integrated manner. This is important to have a more synergistic effect while at the same time assist in avoiding operation bottlenecks that are caused by missing one of the elements.

Institutional infrastructure

The key element of the institutional infrastructure is the development of a policy for an inclusive and sustainable industrial development that takes into account the lessons and issues highlighted under this section. To ensure the soundness and context-relevance of the policy framework and ensure its effective implementation, African countries need to make the maximum possible effort to strengthen industry-university linkages. While most African countries do have environmental regulations that are sufficiently detailed, they significantly lack the appropriate institutional process and structure for their enforcement. Hence, in parallel with the development of the sectoral development policy framework, they need to put in place a function of environmental compliance and enforcement mechanisms. This may include the establishment of an Environmental Court that is dedicated explicitly for adjudicating environmental complaints to be made by the public.

Physical infrastructure

Development of the necessary physical infrastructure that is required for efficient industrial operation is a fundamental prerequisite for any meaningful industrial development process. This includes energy, water, communication, transportation and environmental management infrastructure that are necessary for industrial operation. The most critical issue in this regard is to develop these infrastructures in an integrated manner with primary attention on avoiding any operational bottlenecks that could be caused by lack of delay of one of these infrastructures. One effective way of achieving such an integrated infrastructural service provision is the development of eco-industrial parks that are effectively integrated with the local and national economies. While the development of EIPs as the backbone of the industrial development strategy is essential, it will be necessary for African countries to give equal attention to the development of distributed manufacturing infrastructure as an essential vehicle for job creation and value creation at the local level. Properly designed and developed EIPs could serve as a strategic anchor for developing such distributed manufacturing networks.

Technology infrastructure

Development of dedicated technology infrastructure is of vital importance in light of the significant developments in the field of industrial resource efficiency and the critical role that existing and emerging disruptive technologies would play in industrial operation in the twenty-first centuries. Establishment of a dynamic innovation ecosystem with blended financing mechanisms would assist African countries to benefit from the state-of-the-art technologies and techniques that are emerging in connection with specific sectors. Recent developments in the application of ICT have opened enormous opportunities for industrial applications. Supporting the establishment of ICT-based innovation hubs could help African countries to gain the maximum benefit from these applications and also contain the adverse impacts from disruptive technologies. Establishing a technology registry that would be accessible to the industrial community would also enable industrial decision-makers and investors to make an informed decision about available technologies and their related benefits and impacts.

Compliance assistance to SMEs

Finally, but equally importantly, African countries need to establish a compliance assistance infrastructure that will particularly assist small- and medium-sized enterprises (SMEs). This is critical to meet the national regulatory requirement and to make them competitive in the international market. Given the capacity limitations of most of the SMEs, the compliance assistance infrastructure needs to address both the physical and technical constraints they face. Establishment

of shared environmental management services and facilities would reduce the significant financial burden for these SMEs, while providing technical support programmes on how to integrate resource efficiency in their industrial operation would enhance their profitability and enable them to comply with the environmental regulation requirement. Complementing these with a recognition scheme on industrial resource efficiency (refer to Box 4.2) would encourage and motivate these industries to become more efficient and competitive.

Box 4.2: AKOBEN: Environmental performance rating of Ghana

Some African countries have introduced annual award schemes that recognise industrial efficiency improvement at various levels. The most common award scheme that is implemented in some African countries is the awards given for energy efficiency. The environmental performance rating that has been implemented by the Environmental Protection Agency of Ghana (EPA-Ghana) is one of the unique rating systems that is performed by an environmental agency in the region. The AKOBEN programme is an environmental performance rating and disclosure initiative of EPA-Ghana. Under the AKOBEN initiative, the environmental performance of mining and manufacturing operations is assessed using a five-colour rating scheme. The five colours are GOLD, GREEN, BLUE, ORANGE and RED, indicating environmental performance ranging from excellent to poor. These ratings are annually disclosed to the public and the general media, and it aims to strengthen public awareness and participation.

AKOBEN ratings are evaluated by analysing more than a hundred performance indicators that include quantitative data as well as qualitative and visual information. These ratings measure the environmental performance of companies based on their day-to-day operations once they have successfully cleared their environmental impact assessments (EIA) and obtained their environmental permit to operate. These ratings indicate how well companies have met the commitments they made in their EIAs at the planning stage. AKOBEN, therefore, complements the EIA process and serves as a monitoring and verification programme to ensure that companies follow environmental regulations on a continuous basis. Besides creating more motivation both through peer-to-peer and public pressure by publicly disclosing the individual performance of the industries, EPA-Ghana facilitates the provision of technical support to those industries that need to improve their performance through the Ghanaian National Cleaner Production Centre (NCPC-Ghana).

(Source: EPA-Ghana, 2019)

Conclusions

Industrialising their national economy has been one of the primary preoccupations of successive African governments since the early years of liberation, and it remains to be a priority. However, despite the numerous regional and national efforts made over many decades, none of the sub-Saharan African countries was able to industrialise their economy. On the contrary, most of the African countries have been exposed to premature deindustrialisation as a result of trade liberalisation

through globalisation. Development of the manufacturing sector is at the core of industrialisation as it tends to be technologically dynamic, absorbs significant quantities of unskilled labour, and it does not face the demand constraints of a home market populated by low-income consumers as it is a tradeable sector (Rodrik, 2016). Hence, it is of paramount importance for African countries to develop their manufacturing sector. However, the development of the manufacturing sector cannot and should not follow the development path of the nineteenth and twentieth century. It cannot because no country could be sustainably competitive in the global market by following the conventional manufacturing development path. It should not because the emerging technological and knowledge trends provide it with unique opportunities to avoid the various pitfalls and drawbacks of industrialisation of the last two centuries.

This chapter highlighted the key lessons that could be drawn from experience and presented the essential tools and opportunities which African countries can utilise in promoting an inclusive and sustainable industrial development. It emphasises that developing an integrated industrial infrastructure that effectively covers the physical, institutional and human components is at the core of the success for any country. This includes the development of eco-industrial parks that are effectively integrated with the local economy, both horizontally and vertically, as the backbone of the industrialisation. Such an approach will provide a strong basis for the promotion and development of distributed economy networks that will serve as a vehicle for job creation and value addition at the local level. All these would require clarity of vision and high-level political commitment that is adequately captured and implemented through national policy and strategy frameworks. I hope the key issues highlighted and covered in this chapter will assist national governments to make an informed decision in their policy direction.

References

- Africa Progress Panel. (2012). *Africa progress report 2012: Jobs, justice and equity*. Geneva: APP.
- African Union. (2001). *New economic partnership for Africa's development*. Addis Ababa: African Union.
- Andersen, T.B. & Jensen, P.S. (2013). *Is Africa's recent growth sustainable?* Discussion Papers on Business and Economics, No. 8, Department of Business and Economics, University of Southern Denmark.
- Arbache, J.S. & Page, J. (2009). How fragile is Africa's recent growth? *Journal of African Economies* 19(1): 1–24. <https://doi.org/10.1093/jae/ejp017>
- Ayres, R.U. (1994). *Information, entropy and progress: A new evolutionary paradigm*. New York: American Institute of Physics.
- Cilliers, P. (1998). *Complexity and postmodernism: Understanding complex systems*. London: Routledge.
- Environmental Protection Agency – Ghana. (2019). AKOBEN programme. <http://www.epa.gov.gh/epa/projects/akoben> [Accessed 20 September 2019].
- International Labour Organization. (2014). *Global employment trends 2014: Risk of a jobless recovery?* Geneva: ILO.
- International Resource Panel. (2019). *Global resources outlook: Natural resources for the future we want*. Nairobi: UNEP
- Lindqvist, T. (1998). What is extended producers responsibility? In: K. Jönsson & T. Lindqvist (Eds), *Extended producer responsibility as a policy instrument: What is the knowledge in the scientific community?* Lund: Lund University.
- McCloughry, J. (1989). Preface. In: E.F. Schumacher, *Small is beautiful*. London: Harper Perennial.
- McKinsey Global Institute (2010). *Lions on the move: The progress and potential of African economies*. <https://mck.co/2qGbXhZ> [Accessed 15 September 2019].
- McKinsey Global Institute. (2016). *Lions on the move II: Realizing the potential of Africa's economies*. <https://mck.co/2NfutLS> [Accessed 15 September 2019].
- Meadows, D., Meadows, D. & Randers, J. (1992). *Beyond the limits*. London: Earthscan Publications.
- Mebratu D. (2000). *Strategies for sustainable industrial development in sub-Saharan Africa*. Lund: Lund University.
- Mosley, P., Harrigan, J. & Tague, J. (1991). *Aid and power: The World Bank and policy-based lending*. New York: Routledge.
- Muriithi T. (2005). *The African Union: Pan-Africanism peace building and development*. Burlington, VT: Ashgate Publishing.
- Organization of African Unity, Economic Commission for Africa & United Nations Industrial Development Organization. (1997). *Report of the mid-term programme evaluation of IDDA II*. Vienna: UNIDO.
- Oser, J. & Blanchfield W.C. (1975). *The evolution of economic thought*. New York: Harcourt Brace Jovanovich Inc.
- Partnership for Action on Green Economy. (2017). *Green industrial policy: Concept, policies and country experiences*. Geneva: UN Environment.
- Pearce, D.W. & Turner, R.K. (1990). *Economics of natural resources and the environment*. New York: Harvester Wheatsheaf.
- Perez C. (2010). *The financial crisis and the future of innovation: A view of technical change with the aid of history*. The Other Cannon Foundation & Tallinn University of Technology Working Papers in Technology Governance and Economic Dynamics, 28, TUT Ragnar Nurkse Department of Innovation and Governance.
- Radelet, S. & Sirleaf, E. (2010). *Emerging Africa: How 17 countries are leading the way*. Baltimore, MD: Brookings Institution Press.

- Rasheed, S. & Luke, D.F. (Eds). (1995). *Development management in Africa: Toward dynamism, empowerment, and entrepreneurship*. Boulder, CO: Westview Press. <https://doi.org/10.1111/j.1467-8268.1995.tb00076.x>
- Reed, D. (1992). *Structural adjustment and the environment*. London: Earthscan Publications.
- Rifkin, J. (2011). *The third industrial revolution: How lateral power is transforming energy, the economy and the world*. New York: St. Martin's Griffin.
- Roberts, H. & Robinson, G. (1998). *ISO 14001 EMS implementation handbook*. Oxford: Butterworth-Heinemann.
- Robertson, C., Mhango, Y. & Moran, M. (2012). *The fastest billion: The story behind Africa's economic revolution*. London: Renaissance Capital.
- Rodrik, D. (2016). Premature deindustrialisation. *Journal of Economic Growth* 21(1): 1–33. <https://bit.ly/2q06dCG> [Accessed 18 September 2019]. <https://doi.org/10.1007/s10887-015-9122-3>
- Rodrik, D. (2017). Growth without industrialisation. <https://bit.ly/2OG72uP> [Accessed 28 May 2019].
- Roszak, T. (1989). Introduction. In: E.F. Schumacher, *Small is beautiful*. New York: Harper Perennial.
- Schwab, K. (2018). *Shaping the fourth industrial revolution*. Geneva: WEF.
- Stein, H. (1998). *Globalisation, adjustment and the structural transformation of African economies*. Chicago: Roosevelt University. <https://doi.org/10.2139/ssrn.165812>
- United Nations. (1992). *A programme for the second industrial development decade for Africa (1991–2000): Self-sustained development through industrialization*. New York: United Nations.
- United Nations Conference on Trade and Development. (2012). *The new partnership for Africa's development: Performance, challenges, and the role of UNCTAD*. Geneva: UNCTAD.
- United Nations Economic Commission for Africa. (1980). *Lagos plan of action*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (1991). *The second United Nations transport and communications decade in Africa*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (1996). *Economic and social survey of Africa*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2015). *Economic report on Africa 2015: Industrializing through trade*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2016a). *Greening Africa's industrialisation*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2016b). *Transformative industrial policy for Africa*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2017). *Urbanisation and industrialisation for Africa's transformation*. Addis Ababa: UNECA.
- United Nations Environment Programme. (2001). *Environmental management of industrial estates in China*. Nairobi: UNEP.
- United Nations Environment Programme. (2002). Cleaner production: Seventh International High-level Seminar. *Industry and Environment Review* 25(3–4). Paris: UNEP.
- United Nations Environmental Programme & United Nations Industrial Development Organization. (2010). *PRE-SME – Promoting resource efficiency in small & medium sized enterprises: Industrial training handbook*. Paris: UNEP.

- United Nations Industrial Development Organization. (1982). *A programme for the industrial development decade for Africa*. Vienna: UNIDO.
- United Nations Industrial Development Organization. (2009). *Green industry for a low-carbon future*. Vienna: UNIDO.
- United Nations Industrial Development Organization. (2016). *Global assessment of eco-industrial parks in developing and emerging countries*. Vienna: UNIDO.
- van Weenen, J.C. (1997). Sustainable product development: Opportunities for developing countries. *Industry and Environment* 20(1/2): 14–20.
- World Bank. (1989). *Sub-Saharan Africa: From crisis to growth*. Washington, DC: World Bank.



5

SUSTAINABLE URBAN DEVELOPMENT IN AFRICA

Gulelat Kebede¹

Introduction

Africa is urbanising fast and is largely driven by natural growth.² Its population is young and growing. Historically, the urban transition took 100 to 150 years, but today's transition in developing countries occurs in about 30 years and is thus 'traumatic and disruptive' (Henderson, 2010). In the twenty years between 1995 and 2015, Africa's urban population nearly doubled and is projected to almost double again by 2035 (Barofsky, 2016).

Africa's urbanisation is not only rapid but is also taking place at a lower income level than the urbanisation history of other regions. A comparison with East Asia brings

1 With contributions from Ms Liz Paterson Gauntner, independent consultant, and Professor Josephine Musango, Stellenbosch University.

2 Natural growth rates of urbanisation in Africa and Asia are 3 percent and 1.7 percent respectively (UNECA, 2016).

the point home. Africa is 40 percent urbanised with a per capita income of about \$1 000.³ The figures for eastern Asia and Latin America are \$3 617 and \$1 860 when they reached the same level of urbanisation in 1994 and 1950 respectively. This reflects the relatively weak link between urbanisation and economic growth in Africa (Henderson & Kritikos, 2017). Africa's rapid urbanisation is also taking place in a context of demographic transition, pressing environmental challenges and global technological revolution. A space-blind development approach is perilous, and the conventional sectorial approach is inadequate. In this chapter, we argue for a systemic approach that leverages urbanisation for sustainable development.

According to data from *African Economic Outlook 2016: Sustainable Cities and Structural Transformation* produced jointly by the African Development Bank (AfDB), the Organization for Economic Co-operation and Development (OECD) and the United Nations Development Programme (UNDP), two-thirds of the infrastructure needed by 2050 are not yet built (AfDB, OECD & UNDP, 2016). Even with severe infrastructure deficit, African cities have already become the economic powerhouse of national economies; renewable energy is becoming increasingly cheaper and accessible; and Africa is endowed with natural resources as well as a youthful workforce that is educated and are literate in information technology (IT). These are some of the levers that underpin our argument for leveraging urbanisation for sustainability.

The chapter identifies urban resource consumption, spatial, housing, infrastructure and economic challenges and opportunities. It also highlights the policy issues related to these challenges and opportunities and closes with an illustrative list of relevant tools to support actions for transformative urbanisation.

Sustainability through an urban lens: A systemic approach

In 2001, *The Economist* portrayed Africa as 'hopeless continent', and a decade later, as a 'rising continent'. The port city of Onitsha (which elsewhere has been mentioned for its worst air pollution, slums or planning failure) was selected to portray Africa's cities as the economic powerhouse of 'rising Africa'. For the most part, the earlier African urban narrative emphasised the housing and infrastructure deficiency epitomised by growing slums. In recent times, a narrative that emphasises a growing 'middle class' and a potential youth dividend appears to be in vogue. Each perspective captures some truth but does not provide the full picture. African economies are multifaceted, as is the role of cities within them, and a more nuanced and systemic outlook is necessary to position urban Africa within its regional development agenda of economic transformation and sustainability.

³ All dollars (\$) are US dollars unless otherwise mentioned.

An urban system is complex and, as illustrated in Figure 5.1, plays a key role in resource efficiency and sustainability.

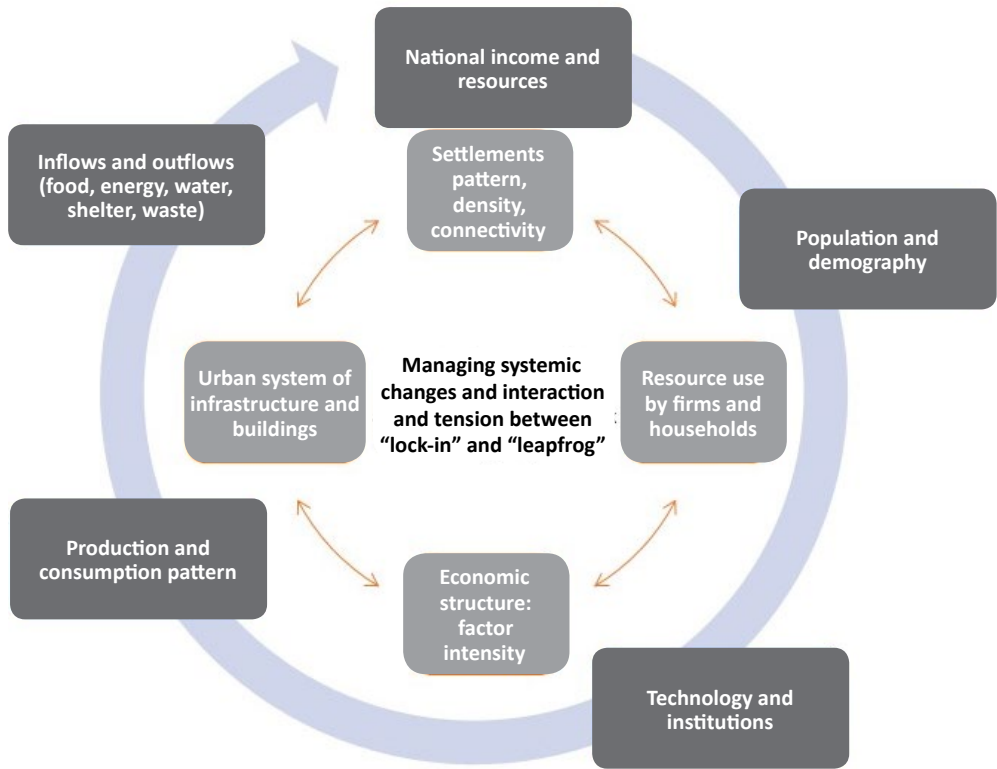


Figure 5.1 Forces shaping the sustainability of Africa's cities

At macro-level, as shown in the outer ring, demand for resources increase as the population grows and incomes rise. But the scale and intensity of demand for resources depend on the production and consumption patterns, which in turn depends on the way the economy is organised, technology is harnessed, and institutions are fashioned. As exhibited in the inner ring, resource consumption at city level depends on the size of the urban population on one hand, and the built environment on the other. The way urban streets are laid out and infrastructure is designed play a critical role.

If we consider cities as mega living organisms that consume resources and dispose of waste, their metabolic (in) efficiency hinges to a large extent on urban streets and infrastructure. Poor land use and transport systems that promote sprawl and fragmentation lock cities in unsustainable resource consumption. In contrast, smart planning and technology that capitalise on urban density and connectivity

spur cities to sustainability. As depicted at the centre of the diagram, managing the forces shaping urban form is central to achieving urban sustainability. By adopting, environment-friendly urban and infrastructure planning and by harnessing technology, African countries have the opportunity to leverage urbanisation for sustainable development.

The challenges and opportunities of urbanisation in Africa

These are some key issues concerning the challenges and opportunities of urbanisation in Africa:

1. Urban Africa is well below the global average in resource consumption, although countries differ considerably. But for many countries, the low average per capita consumption is a reflection of resource deficiency. A growing urban population is under-serviced and do not have access to energy. Many African countries are experiencing rapid urban and economic growth trajectories and Africa's resource consumption and carbon emission are likely to increase in the following decades.
2. Africa's urban space is characterised by primacy, missing middle and rapidly growing small towns, a poor economic base, and limited job creation. The urban system is imbalanced, underperforming and unsustainable.
3. Prime cities are productive but feature premature diseconomies. The urban economy is dominated by informal and less productive economic activities. There has been poor job growth and manufacturing is largely absent, however, the role of non-industrial sectors including information and communications technology (ICT) and service appear to be growing.
4. Besides providing basic shelter, housing plays an important role in economic growth, job creation, wealth distribution and resource conservation. The housing price to income ratio in Africa is exceedingly high. Slums and informality are the default option for the majority. But as income grows, and if suitable policy conditions are created, demand for housing can unleash growth and drive resource efficiency.
5. Compared to other developing countries, Africa has a low level of infrastructure. The levels of investment needed to catch up are overwhelming. The impact of the deficit on economic growth and efficiency is significant. However, although most of Africa's infrastructure needs are yet to be met, Africa offers unique opportunities to choose sustainable infrastructure design options and harness smart technologies.

Resource consumption

Based on data from satellite and aerial imagery, the growth of African cities has been characterised by fragmented or leapfrog urban development and unplanned expansion, with infill urban development accounting for a lower percentage of new urban development than in any other region except East Asia and the Pacific. Informality and peri-urbanisation, which drive urban sprawl and inequality, pose long-term challenges for the economy and the environment. Declining density and sprawl increase the costs of infrastructure. Between 2000 and 2014, African cities expanded their land coverage by an average of 4.08 percent. As shown in Figure 5.2, the average density of 16 of these cities declined by 2.48 percent, but with wide variation between cities (Lamson-Hall, Degroot, Martin, Tafesse & Angel, 2015).

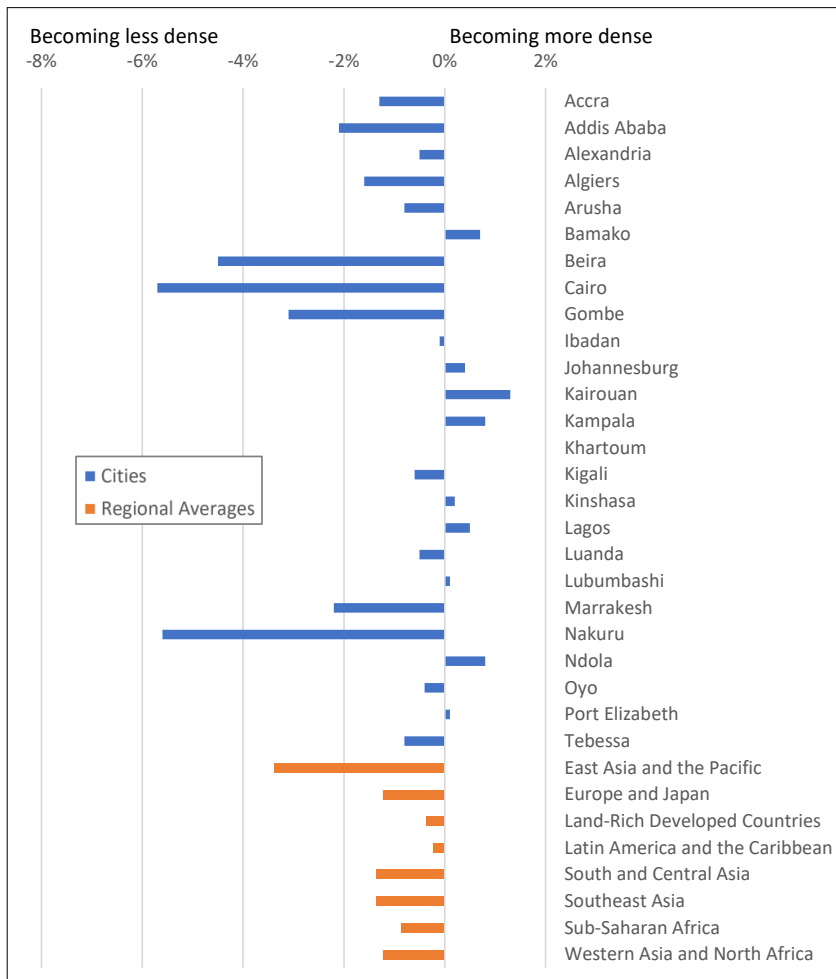


Figure 5.2 Percentage change in urban extent population density, ca. 2000 to ca. 2014: Cities and regional averages (Source: Data taken from Angel, Lamson-Hall, Madrid, Blei and Parent, 2016)

Countries with better capacity and resources are not much better in managing sprawl. According to an article in *The Economist*, ‘There are fewer people per square kilometre in Cape Town than in Woking, a commuter town in Surrey, England.’⁴ Considering a huge backlog in housing and urban services, and a rapidly growing urban population, demand for resources, including land, building materials, energy, food and water is expected to increase substantially in the coming decades.

Using national data and based on scaling relationships and country similarities in demographic, economic and climatic parameters, Currie and Musango (2017) have estimated resource consumption of 120 African cities and clustered them (Currie, 2015; Currie, Lay-Sleeper, Fernandez, Kim & Musango, 2015). The key findings of their work carried out as part of a research on urban metabolism in Africa are summarised below (Currie, 2015; Currie & Musango, 2017):

- Of the 120 cities, 71 have per capita consumption levels below 8 tonnes; 38 cities exceed 10 tonnes per capita, of which only five are over 20 tonnes per capita. These consumption levels are below the average of the global North, but the low level of consumption largely reflects resource deficiency. ‘On per capita basis, the average electricity consumption of Africa, excluding South Africa and North Africa, is 160 kWh or 1.3 percent that of the United States’ (United Nations Economic Commission for Africa [UNECA] et al., 2018:20).
- Cities in northern and southern Africa – regions with higher per capita GDP and human development index – exhibit high per capita consumption. They may have to prioritise resource efficiency and resource access.
- Cities of rapidly urbanising regions of eastern and western Africa are prominently missing from the list of relatively big resource consumers. Many of the cities in these regions will reach the range of \$2 000 to \$3 000 per capita, which is estimated as the global peaking point for emission intensity per unit of income (Stefanski, 2010). Further, the shift in the composition of GDP to non-agriculture urban sectors expected to accompany structural transformation in the coming decades will make African cities disposed to increased resource use and emission intensity.⁵
- In the broader scheme of things, trends in energy consumption, mix and intensity will play critical roles in the urban and sustainability transition of Africa. Africa is rich in energy resources but poor in access to electricity. ‘Only about a quarter of the population in Africa, excluding North Africa, has access

4 Tragedy of the commons, *The Economist*, 23 August 2018.

5 Change in structural transformation influences pollution intensity over time, and the initial effect is strictly positive (Stefanski, 2010).

to electricity, versus about half in South Asia and more than 80 percent in Latin America, the Middle East and North Africa. Only 19 percent of the African population has access to clean cooking technologies – when excluding North Africa it drops to 14 percent,’ (UNECA et al., 2018:20). Scaling up investment in electricity generation to outpace population increase is a big challenge, but the expanding possibilities to invest in renewables, which are cleaner and increasingly cheaper, is an opportunity. Currently, a third of the total primary demand in Africa is met by coal and oil. That means business-as-usual is not an option (UNECA et al., 2018).

- The region also lags in energy efficiency. Though the average per capita energy consumption and carbon emission of Africa are low in comparison to developed economies or the world average, energy intensity levels remain significantly higher than the world average. In 2015, at 7.9mJ/US\$ 2011 PPP GDP, Africa, excluding North Africa, recorded an exceptionally high energy intensity. Compared to the OECD average of 4.5 mJ/US\$ 2011 PPP GDP, this amounts to 73 percent higher. In fact, with an average of 10.5 mJ intensity, a unit of output in low-income African countries consumes about 134 percent more energy than that of OECD countries. (UNECA et al., 2018).

Resource and energy consumption increase with economic growth. However, as shown in Figure 5.3, the correlation is not simple and linear. An array of structural factors including climate, affordability and density affect resource efficiency. Economic structure and urban form play critical roles in determining the scale and intensity of resource consumption.

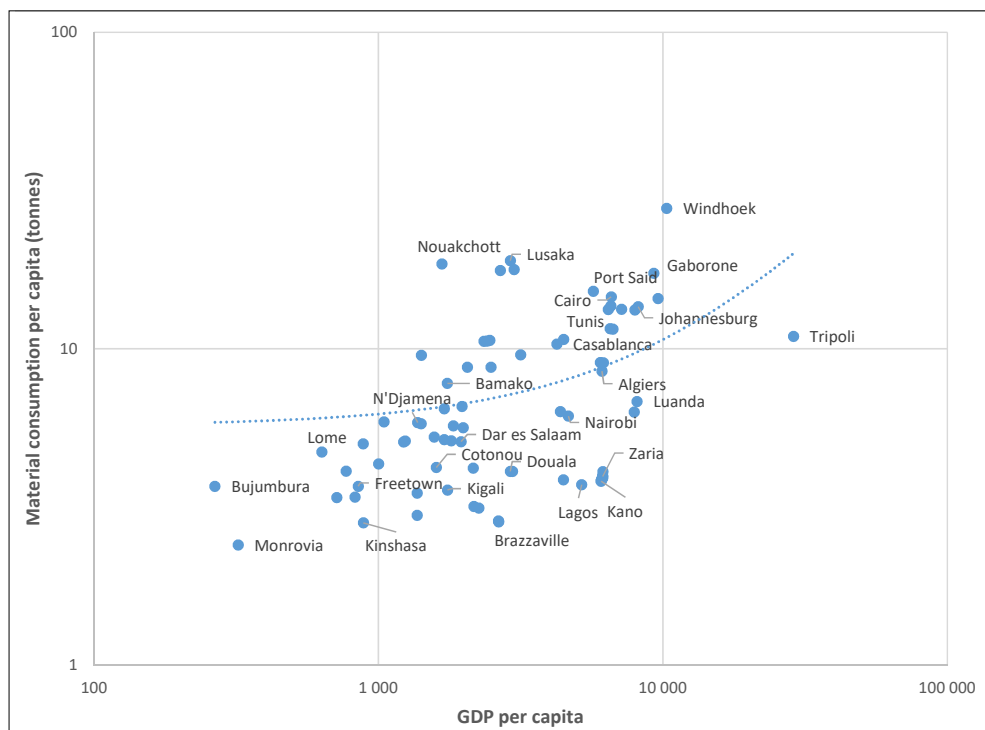


Figure 5.3 Material consumption and GDP in selected African cities, 2010
 (Source: Data taken from Currie and Musango, 2017; World Bank, 2019)

Spatial challenges and opportunities

Africa is urbanising at a rate faster than historical trends, and with and without economic growth. The contrast between the urbanisation of resource-poor Africa and that of rich and industrial Europe is remarkable (see Figure 5.4). This is borne out by the following extract:

In Europe, urbanisation accelerated with the advent of the Industrial Revolution, rising from 15 percent in 1800 to 40 percent in 1910. Both Africa and Asia reached the same rate in half the time, moving from 15 percent in 1950 to 40 percent in 2010. (Jedwab, Christiaensen & Gindelsky, 2014:1)

The challenge is that urban planning and investment has lagged urban growth for decades in Africa, resulting in chaotic urbanisation characterised by primacy, growing slums and informality. Crowding and premature diseconomies are constraining Africa’s largest cities, while secondary cities and small towns are failing to keep up economically.

Prime cities in Africa are an economic powerhouse. The 69 largest cities selected from 36 countries for a study on ‘climate economy’ in Africa contribute 36 percent of the combined national GDP while representing only 16 percent of the population (Godfrey & Zhao, 2015). However, Africa’s largest cities are facing several factors constraining their full potential. Drawing on a World Bank survey of firms, in 188 subnational locations of 45 African countries, a recent UNECA report concludes that due to weak infrastructure, first and foremost, because of constraints in electricity and transportation, African cities with a population over 1 million are underperforming. They are also hampered by institutional barriers, including inadequate density, artificial separation and rigid land uses, and residential segregation (UNECA, 2017a). Improving these institutional barriers and infrastructure constraints, if implemented within a smart and inclusive growth framework, can yield economic growth and productivity and contribute to job creation and resource efficiency.

Unfortunately, because of poor infrastructure and weak institutions, smaller cities also appear to be impacted by congestion and overcrowding, while lacking a strong economic base for sustainable growth and job creation. The result is an excessive concentration of urban populations into a single large city, which could ‘detract from national income growth as resources are squandered in oversized congested cities’ (Henderson & Kritikos, 2017:23).

Moreover, intermediate cities, which play a critical role in facilitating the development of specialised industries and linkages between small and big cities, are not growing as much. Henderson and Kritikos maintain that:

smaller cities near the bottom of the size distribution tend to be growing faster than larger secondary (but not primate) cities and seem to exist to serve agriculture and to house farmers – with their fortunes perhaps rising with improved productivity in farming in recent years. (Henderson & Kritikos, 2017:31)

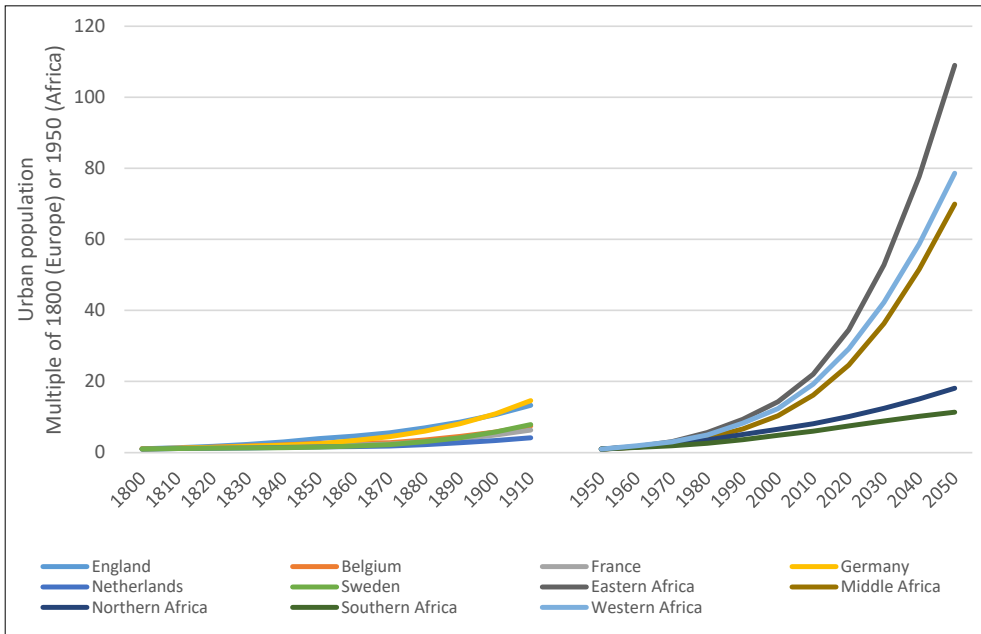


Figure 5.4 Urban population increase in selected European countries, 1800–1910 and African regions, 1950–2050 (Source: Data taken from Jedwab et al., 2014; United Nations Department of Economic and Social Affairs [UNDESA], 2018)

Housing challenges and opportunities

Housing is the engine of economic growth and social and economic wellbeing. The Asian countries of Hong Kong, Singapore, South Korea and Taiwan have used homeownership to boost economic growth, employment and government revenue. In Hong Kong, the property sector contributed about 24 percent to GDP and 7 percent of the labour force in the 1980s and 1990s. In Singapore in the 1980s and 1990s, 15 percent of expenditure was allocated to housing. This was in line with the government’s initiative of the ‘Home Ownership for the People Scheme’ established in 1964. In developing countries, 3–8 percent of GDP originates from the construction sector, and housing constitutes over a third of it. The estimates go higher if informal housing activities and their multiplier effect are considered (Harris & Arku, 2006).

Besides these economic and social benefits, housing, through efficient use of building materials and energy, can deliver a huge environmental dividend and improve the living conditions of millions. But at low-income levels, the majority in many African countries cannot afford even the cheapest housing unit.

Housing is 55 percent more expensive in urban Africa than in other developing countries of similar income levels. The typical housing price-to-income ratio in

Africa is over 10:1, compared to the global range of 3:1 to 5:1. This is way above the affordable rate, even for those with a stable job and income in the public service or the formal private sector. This signals a serious structural problem associated with the key components of housing provision: urban land, building materials and construction, and housing finance (UNECA, 2017a).

Spending on housing typically begins to increase after the per capita income level of \$3 000 (World Bank, 2015), which suggests investment in housing is expected to grow significantly in the coming decades as countries continue urbanising and become middle-income. This is a huge opportunity to spur inclusive growth and nudge urbanisation on a path to resource efficiency. Because of its small housing stock and limited lock-in forces, Africa can reap huge social, economic and environmental benefits while contributing to a reduction of global carbon emission,⁶ from its massive future investments in housing by promoting affordable and green building solutions.

Infrastructure challenges and opportunities

Urban Africa suffers a huge infrastructure deficit. ‘The region lags behind the rest of the world in access to electricity, internet penetration and access to improved water, and has large road maintenance needs’ (UNECA, 2017a:126). The World Bank estimates the annual investment need of Africa for infrastructure at \$93 billion, or approximately 15 percent of regional GDP (Foster & Briceño-Garmendia, 2010).⁷ Annual national public spending on infrastructure is exceedingly low with an average of 2 percent of GDP in 2009–2015, compared to 5.2 percent in India and 8.8 percent in China (Muggah & Hill, 2018).

The situation with electricity captures the essence of infrastructure deficiency. World development indicators show that in sub-Saharan Africa, less than half of the citizens have access to electricity, compared with 85 percent in low- and middle-income countries as a whole (World Bank, 2019). Power outages are a serious problem forcing firms to install back-up generators. It is estimated that formal and informal firms lose 6 percent and 16 percent of their sales respectively (Foster & Briceño-Garmendia, 2010). It is also estimated that the outages result in a loss of 2.5 percent of GDP to the economy, ranging from 1 percent in Niger to 4 percent in Tanzania (Eberhard, Rosnes, Shkaratan & Vennemo, 2011).

6 Cement-making and the production of steel, half of which goes to building, account for 14 percent of worlds’ carbon emission (The house made of wood, *The Economist*, 5 January 2019).

7 Yet, at 2 percent of GDP, public spending on infrastructure is exceedingly low, resulting in a 40 percent decline in firm productivity and slums (Muggah & Hill, 2018).

Besides its impact on economic productivity, urban infrastructure investment, when done cleverly, can also be a game-changer. Two-thirds of investment in African urban infrastructure needed by 2050 is yet to be made (Muggah & Hill, 2018) and three-fourths of urban areas and infrastructure needed by 2040 in Uganda, for example, is yet to be built (UNECA, 2017a). Twice as much as the existing infrastructure has to be built in one-third of the time the existing infrastructure was built (Collier, 2016).

Urban concentration lowers the unit cost of piped water, sewers and drains, and public services, however, these benefits come with challenges. Cities rely on infrastructure for the regular flow of ecological services and natural resources (food, water and biomass) needed to support urban life and economy, and thus its disruption through natural forces or due to climate change poses huge social and economic risks. Choices of urban form and infrastructure technologies and systems determine whether these risks are mitigated or exacerbated. Bad choices in urban and infrastructure systems not only increase future environmental risks, often with a higher burden on the urban poor, but also inhibit or distort productive resource use or consumption, thus exacting penalties on economic growth and efficiency.

Economic challenges and opportunities

Though many African countries have seen strong economic growth in the last two decades, for the most part, growth has been jobless.

African cities lack strong economic bases. A study that investigated sector level employment data by city size distribution (prime, secondary, tertiary, small) of 11 African countries (Ethiopia, Tanzania, Uganda, Mozambique, Ghana, Cameroon, Mali, Malawi, Zambia, Sierra Leone and Liberia) covering a population of 242 million (of which 62 million were urban) concluded that (i) over 40 percent of urban residents in the second quartile and bottom half of cities are engaged in agriculture; (ii) manufacturing and tradeable services (finance, insurance, real estate and business services) in prime and secondary cities are only around 10 to 12 percent, much lower than their agglomeration opportunities suggest; and (iii) housing and servicing ('trade') farmers are the chief economic drivers in the bottom 75 percentile of the cities and even in the upper 25 percentile of the cities outside prime cities (Henderson & Kriticos, 2017).

This, in major part, reflects the slow or weak structural transformation characterising African economies. Structural change, or the movement of labour from low-productivity sectors to higher productivity sectors, typically accompanies urbanisation and is part of the economic development process. However, African

countries have seen labour shifting into urban informal and non-tradeable sectors with low productivity, while the expansion of manufacturing and tradeable services has not kept pace with urban population growth. Though there have been some positive signs in structural change in recent years, the overall change does not mark a turning point. On the contrary, the decline in the share of manufacturing from 10.6 to 8.4 percent between 2000 and 2015 and the stubbornly high informality is troubling. Africa's urban middle class is expanding, but so are the number of Africa's urban poor (UNECA, 2017a).

The above discussion points to the need for Africa to consider an alternative path for structural transformation. Developing on the back of the export-oriented manufacturing sector, as East Asia did, may not be a viable option for all countries. Some suggest that African countries should pursue industries without smokestacks, such as tradeable services, agro-industries, horticulture and agro-business, communication technology-based services and tourism. Some signs may support this proposition. Between 2000 and 2015, Africa's service sectors' share grew from 44 percent to 55.7 percent; a leap by a historical measure. According to Newfarmer, Page and Tarp:

Service exports from Africa grew more than six times faster than merchandise exports between 1998 and 2015. In Kenya, Rwanda, Senegal, and South Africa, the ICT sector is flourishing. In Rwanda, tourism is now the single largest export activity, accounting for about 30 percent of total exports. Ethiopia, Ghana, Kenya, and Senegal are all integrated into global horticultural value chains, and Ethiopia has become a leading player in global flower exports. (Newfarmer, Page & Tarp, 2018:66)

Some of the recent revision of GDP figures following the rebasing that took place in a few African countries like Ghana, Kenya and Nigeria reflect the increasing contributions of the service industry including ICT, media and entertainment in the economy (Sy, 2015).

The role of ICT is of particular relevance for Africa. At 26 percent, mobile internet penetration is low, but it is expected to contribute \$110 billion, or the equivalent of 7.7 percent of GDP and employ approximately 3.5 million people in 2016. Penetration is expected to reach 40 percent in 2020, indicating a growing potential to accelerate leapfrog growth and transformation (Rogers & Pedros, 2017). Venture capital, which reached a \$1 billion from a modest start of \$40 million in 2012, supports African entrepreneurs starting up tech sector businesses across the region, including in Ghana, Kenya, Nigeria, Rwanda and South Africa, which is a promising sign. Some estimate that 3 500 new tech-related ventures and 200 innovation hubs are in existence.

Prime cities will continue to be important economic drivers, particularly in the case of the high-end service sector, innovation and knowledge areas, however, the emerging digital economy and service economy in large part favours economic dispersion across secondary, tertiary and small cities.

Key policy and strategic issues for African countries

This section explores some policy and strategic issues concerning African countries.

Key points

These are a few key points regarding policy and strategic issues concerning African countries:

- There is room to improve the absorptive capacity and functioning of prime cities, but this can only succeed if implemented within a policy framework of creating a balanced system of cities and human settlements.
- Making urbanisation a transformative force for economic development and sustainability requires promoting distributed economies across the continuum of human settlements. Digitisation, green and industrial revolutions can be harnessed for leapfrogging.
- The housing issue in Africa is not merely lack of it, but affordability. Investments in housing that are not connected to jobs and amenities or implemented outside an integrated planning framework are not effective or sustainable.
- Africa is infrastructure deficient and narrowing the gap in infrastructure is a key success factor in Africa's race to catch-up economically. As the majority of infrastructure in African cities is yet to be met, there is the opportunity to reap sustainability dividend by adapting compact and dense urban form and by shifting to cheaper and cleaner energy. Moving to smart urban infrastructure design and technology can be a game-changer.
- The urban policy and strategy issues critical to sustainability transition in Africa are centred on four themes: the spatial characteristics of cities, housing, infrastructure and productive urban or local economies. They are interconnected. Figure 5.5 highlights major policy issues involved within each policy theme.

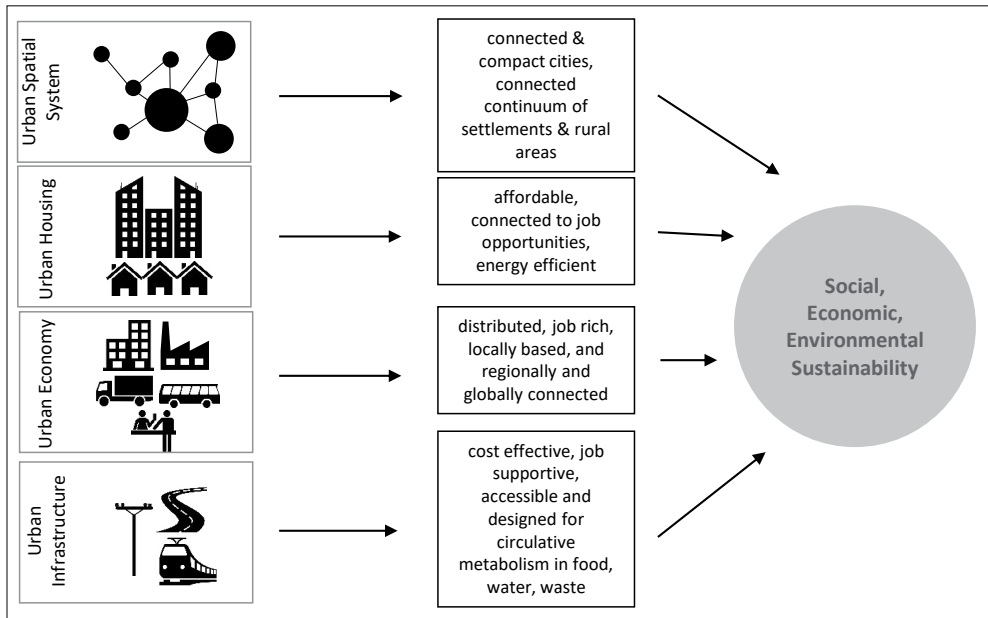


Figure 5.5 Themes and policy issues for the sustainability of Africa's cities

- Countries vary substantially in the level and rate of urbanisation and income and differ in resource endowment (see Figure 5.6). They also vary in institutions and policy thus GDP is not a sole predictor of outcomes in sustainability.⁸ Policy issues and outcomes are context-specific. We are not here proposing an all-size-fit silver bullet but outline the broad principles and themes that are universally relevant to the shift to sustainability-oriented 'leapfrog' development advocated in this book.

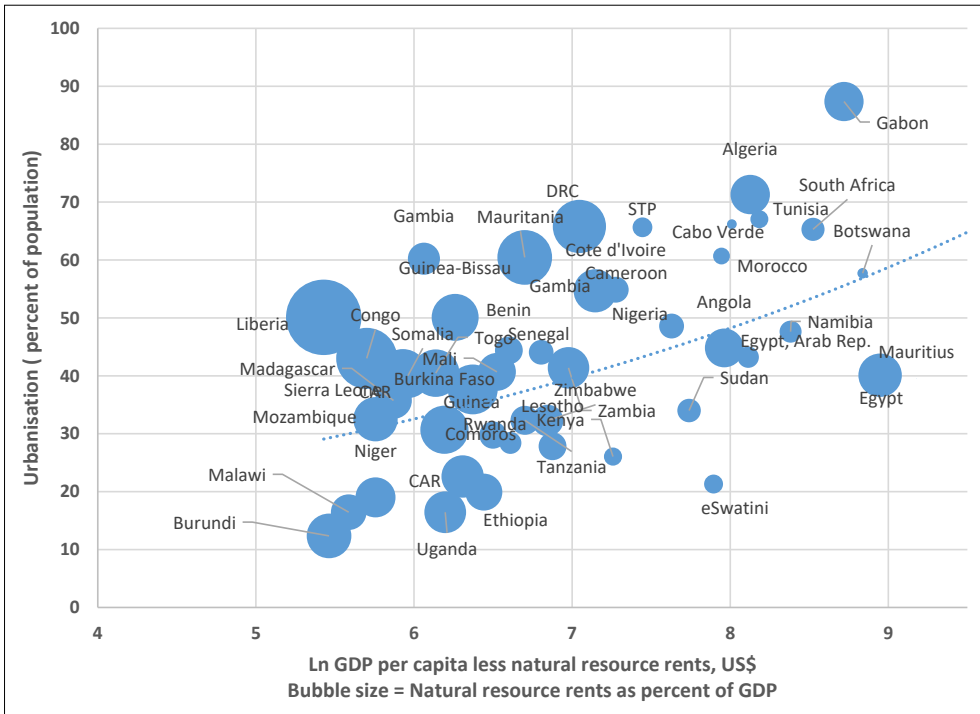


Figure 5.6 Income, urbanisation and natural resource rents, 2016
 (Source: Data taken from development indicators, World Bank, 2019)

Spatial characteristics: Promoting compact, connected development across the continuum of settlements

Urban growth in many African cities is fragmented and patchy with a flat or declining density. The growth is characterised by the rapid peri-urban expansion that concentrates the poor on the urban fringes with limited or no access to the job market and basic services. This growth is characterised by poor planning and inefficient land use on the one hand and rapid urbanisation, migration, driving sprawl and congestion on the other, especially in the low-income rapidly urbanising countries. If unchecked, the trend can harm economic and resource efficiency, and in many cases result in premature diseconomies.

There is room for improving the absorptive capacity and functioning of prime cities, but this can succeed only if implemented within a policy framework of creating a balanced system of cities and human settlements. The majority of urban populations live in small cities and towns but lack basic services and job opportunities, while those in prime cities struggle to survive in the informal economy. Thus, improving urban productivity in prime cities is a policy priority, but is also inadequate. A balanced system of cities involves decentralising economic

activities and connecting villages, towns and cities across the human settlements continuum and Africa has a long way to go in this direction. 'With a few exceptions, all countries below the Sahara have primacy rates above 30 percent and several above 50 percent (Henderson & Kritikos, 2017:23).

Second-tier cities are weakly represented in the system of cities in Africa. According to Henderson and Kritikos:

The share of Africa's population in non-primate cities with over 1 million population is only 8.5 percent, while for all low- and middle-income countries it is 26 percent. Instead, Africa has a high concentration in cities under 300 000, as well as primate cities (with Africa at 28 percent versus all low and middle-income countries at 17 percent). (Henderson & Kritikos, 2017:25)

Considering the role of large secondary cities in facilitating job creation and labour mobility from rural to urban economies, the missing middle in urban Africa is a concern (Christiaensen & Todo, 2014). Secondary cities can be pivotal in industrial development. In Nigeria, for example, the recent growth in manufacturing has shown to be driven by its mid-size cities (Aba, Ilorin, Onitsha, Kaduna and Jos) spread across the different regions. This indicates a positive sign of urban differentiation along industrial functions (Bloch, Makarem, Yunusa, Papachristodoulou & Crighton, 2015). Guiding such development through better urban and infrastructure design by considering the specialised needs of cities of different sizes and functions will have a long-term pay off in social, economic and environmental terms.

Though such forward-looking investment by countries in their urban future is generally constrained by resources, the gap appears to be fundamentally at the policy and planning levels. Across the region, it is not uncommon to see resource-intensive mega projects and industrial zones planned and implemented without adequate consideration of their urban and spatial implications (UNECA, 2017b). Though some countries, such as Ethiopia, Rwanda, and Uganda, have identified strategic secondary cities to help diversify the economy and advance balanced development, these are not always fully conceptualised or backed by strategic planning.

In low-income African economies with significant agriculture sectors fostering rural-urban linkages is most critical. The debate about the urban-rural divide is a recurring one, with some proposing a modular urban model where town-centred agro-political districts could be developed in densely populated rural and peri-urban areas to expand social and economic opportunities and tame or slow migration to cities (Friedman, 1996). Neither the sole focus on agglomeration economies nor the utopia of rural cities is realistic. Considering the large employment and

output share of agriculture and the realities of circular migration (of back-and-forth movement of people between cities and rural areas) observed in Africa,⁹ fostering the links between urban and rural economies is not an option but a priority.

Small market towns will be crucial in fostering urban-rural linkages. A study that simulated urbanisation in Ethiopia and Uganda concluded that reallocation of public investment from cities and (rural areas) to towns leads to faster poverty reduction, underscoring the role of small cities in facilitating these linkages and their impact on income (Dorosh & Thurlow, 2014).

Housing: Promoting affordability and resource efficiency

Because the majority of cities and/or their housing stock is yet to be built in Africa, housing is potentially a major economic and resource efficiency driver but is constrained by structural impediments. Policy priorities include scale, resource efficiency and affordability.

The share of the population with discretionary spending above the threshold for decent housing in low-income and/or less urbanised countries is very small. These countries may have to prioritise slum reduction and nonconventional affordable housing options, including rental housing, while building the necessary conditions (land, building regulations, competitive construction industry and housing finance) for the housing and real estate sector to flourish. The housing issue in Africa is not merely the lack of housing, but affordability. Based on typical rental rates in African cities, some estimate a housing cost of \$15 000 long-term loan interest and principal of \$500–\$800 a year as affordable to informal housing occupants. However, this is a far cry from reality (Collier & Venables, 2014).

Land use regulations and building standards play an important role in shaping affordability. Existing building standards, such as wall thickness, room size, depth of foundations, and regulation of minimum lot size, if improved, can also help affordability. The minimum legal plot size in of Nairobi and Dar es Salaam is, for example, one-sixteenth of an acre and 500 square meters respectively, which is unaffordable to ordinary households (Collier & Venables, 2014).

Technology is also part of the solution. It is estimated that implementing smart building solutions could save as much as 30 percent of water usage, 40 percent of energy usage and reduce overall building maintenance costs by 10 to 30 percent (Honeywell & Ernst and Young, 2015). There are alternative technologies and housing solutions that may be applicable even to slum upgrading. The ‘smart

9 Migration to rural areas has been observed in countries like Zambia in the 1980s and Côte d’Ivoire and Mali in the 1990s, perhaps reflecting some level of ‘counter urbanisation’ caused by the economic hardship of the urban poor (Potts, 2009).

shack' design in South Africa, which resulted from the collaboration between city authorities and a local university, is an example (Modisaatsone, 2014).

Often innovation and technology precede changes in institutions and regulations. However, low-income countries can reverse this by moving to progressive building code and planning practices in phases to take advantage of existing and in pipe technology and know-how in energy-efficient housing solutions. In the middle-income countries, the resource efficiency gains will come from new units and from retrofitting of the existing stock. These countries also have a better capacity to invest in innovative housing designs and improvement of building materials.

In countries where the majority of the population has reached a disposable income threshold and can afford the most basic shelter, the role of government should focus on creating a policy environment that encourages research and investment into affordable and resource-efficient housing options and innovations, and not on building housing units themselves. Innovations can come from local or global sources, but their uptake depends on the policy and the institutional environment. Indigenous or local knowledge of nature-friendly housing solutions can be rediscovered, improved and standardised. Pipeline technologies on building design and construction materials (cement, steel, wood) can be learned and adapted.

The prevalence of slums and informality in African cities is to some extent symptomatic of a disconnect between planning, infrastructure and housing. The current default order of housing, infrastructure and planning should be reversed to planning, infrastructure and housing (World Bank, 2015). Studies show that if the land is efficiently laid out, housing and service provision can be incrementally improved, at much less cost than retrofitting slums. Slum upgrading could cost up to 12 times more, compared to service provision in areas with sub-divided plots and blocks (Campbell, 2018). There are huge cost savings to be gained from guided urbanisation, especially for low-income rapidly urbanising countries, if settlement formation is preceded by basic planning and followed by phased investment. Middle-income countries devoting big public grants and subsidies to mega housing projects should watch the unintended consequences these projects may have, for example, on urban sprawl.

In the end, housing is a core component of good urban planning and implementation. Housing without proper planning, infrastructure and jobs, is ineffectual and spatially inefficient. The majority of urban residents in African cities live in slums, signifying the prevalent problem of 'people without housing'. But the world, including Africa, is also replete with examples of 'housing without people' where houses were built but not occupied because of planning flaws, wrong locations or a lack of jobs and opportunities. This is a clear indication of squandered resources

due to a lack of coherent policy and proper planning. It is not uncommon for subsidised mass housing projects and associated infrastructure investment targeting development on the urban edge to end up driving urban sprawl. Though cheaper land on the periphery may be the key factor driving such development, the long-term overall cost to the city resources could be much higher than anticipated. The anomaly of ‘housing without people’ and the problem of ‘people without housing’ observed in many cities are symptomatic of fundamental urban development flaws and resource inefficiencies that should be prevented or mitigated.

Infrastructure and urban services: Promoting resource efficiency and access to services

There is no question that African countries need to step up their efforts in infrastructure investment to meet the pent-up and growing demand and accelerate growth.¹⁰ Estimates suggest Africa could increase its annual GDP growth by 1.7 percent, 2.2 percent and 2.6 percent if it could close its infrastructure gap with other developing regions, Mauritius (with the region’s best infrastructure) or East Asian economies respectively (Calderón, 2009). Accounting for efficiency gains, Foster and Briceño-Garmendia (2010) estimate the funding gap of Africa at \$31 billion per year after accounting for potential efficiency gains. AfDB (2018) estimates the range between \$68 billion and \$108 billion. The funding needs of low-income, middle-income and resource-rich countries are estimated at 23 percent, 10 percent and 12 percent of GDP respectively (Foster & Briceño-Garmendia, 2010).¹¹ Urban infrastructure covers both urban-specific public utilities and services and productive infrastructure, such as energy generation and railways and highways that are national in coverage but critical to the functioning of the urban system, and are thus difficult to categorize and estimate with precision. But assuming 1/3 of the total investment to be urban, the investment gap for African cities could be anywhere between \$36 billion and \$59 billion (AfDB, 2018; Oxford Economics, 2017).

10 Countries that have achieved and sustained high economic growth had 25 percent or more of investment rate and additional investment of 7 to 8 percent of GDP in education, training and health (Commission on Growth and Development, 2008).

11 Given the backlog, population growth and economic realities, plugging the gap in infrastructure is a long-term undertaking. African countries may not have the luxury of building infrastructure first before economic activities, thus the most realistic scenario of development is one of strategic investments in key bottlenecks along with massive small-scale bottom-up investments. But for this two-prong approach to work, clear principles and standards of sustainability, efficiency and equity have to be mainstreamed to guide prioritisation, planning, financing and implementation of infrastructure investment.

But an increasing investment is one side of the problem. The way infrastructure is designed and provided will impact urban quality and sustainability, thus the policy issues involved with infrastructure and services are not simply about how to finance the gap, but how to ensure accessibility and achieve resource efficiency. Based on a study of 45 countries throughout 2000–2015, The IMF suggests that investment efficiency in sub-Saharan Africa can be increased by 35 percent (Barhoumi, Vu, Towfighian & Maino, 2018:4). There is room for improvement in project preparation and implementation. Coordination across sectors and levels of government, along all elements of the project cycle, is particularly important in the case of urban infrastructure.

At a more fundamental level, three issues are critical. Firstly, urban form and design determine the nature and configuration of infrastructure. The built environment of today's cities is the product of urban vision and design implemented generations ago; the lock-in effect of urban form is long-lasting. Secondly, considering severe resource scarcity and the long life cycle of infrastructure, project prioritisation should be considered within a strategic framework. Estimates on the return of investment in hard infrastructure give electricity generation and connectivity infrastructure the top ranking. But even within energy or connectivity sectors, there are multiple decision issues that matter, such as choice of technology or energy mix, or scale and location. Finally, in the context of sustainability transition, part of the investment decisions involve shifting to new technologies or future technologies. However, policy inertia and powerful stakeholder interest, if not countered, could hamper technological shift and increase the stock of 'stranded capital. This would make 'leapfrog' transformation increasingly difficult or costly.

The majority of infrastructure investment in low-income and less urbanised countries is yet to happen. But if sound principles of urban design and sustainability are applied, it can provide major environmental, social and economic co-benefits. Dense, compact, desegregated and connected cities are resource efficient, inclusive and productive. Urban metabolic processes – the way food, energy, water and raw materials are conveyed and consumed by households and firms, and the way air pollution, waste and sewage are disposed or recovered – have major economic, social and environmental implications. The way infrastructure is configured and managed determines the nature and size of these implications. In addition, middle-income countries, in particular, can benefit from infrastructure maintenance and rehabilitation and so reap the resource efficiency dividend accruing from good infrastructure planning and design.

A dense urban form helps to reduce the cost of network infrastructure – one of the underlying benefits of big cities. But beyond a certain size, the cost of congestion weighs more than the benefits of density. In the context of Africa, the

urban poor, due to limited access and coverage, resort to costly alternatives, while prime and large cities, due to poor planning and investment in infrastructure, prematurely experience resource inefficiency and diseconomies. The results harm both the economy and the urban poor and are unsustainable. African cities are expensive and infrastructure services are twice as expensive (Foster & Briceño-Garmendia, 2010:4).

This makes optimising the trade-offs between density, congestion and decentralisation of urban services important. There are efficiency gains from existing infrastructure, by consolidating where development is fragmented and by improving urban layout and density. But improving access and coverage in Africa, especially in low-income countries, and mitigating and reversing primacy, is untenable without a concerted effort to decentralise basic urban services. The balancing act of these forces – harnessing agglomerations and decentralising urban services – requires careful consideration of different or alternative urbanisation models and their cost implications within a long-term national development plan.

At the city and metropolitan scale, African countries, especially rapidly urbanising low-income countries, should prepare urban expansion plans while they still have time to do it. Land use and supply is a cross-cutting policy issue affecting planning, housing and infrastructure. Failing to secure public land for trunk infrastructure and transport rights of way pose a barrier to infrastructure investment and causes investment costs to escalate. Given the severe resource constraints they face, low-income African countries may not have the necessary cash to invest immediately, but by putting land, basic infrastructure and necessary regulations in place, they can signal the direction to the private sector and slowly steer development to a sustainable path.

Investing in new cities is an option, especially for resource-rich countries, but the experience so far is not very positive. New cities are costly and take decades to complete. More importantly, unless, designed and developed on the basis of a new economic and environmental vision, they may not be much different from existing cities. Decisions on new cities should be based on rigorous analysis of alternatives, including urban expansion and infill development of existing cities, and sustainability should be an overriding criterion.

Technology in renewable energy, mobility, and ICT offers new opportunities for ‘latecomer’ Africa to leapfrog. In the case of high-income countries, economic viability considerations and the existence of large stocks of capital from older technologies may warrant a delay of investment in new technologies. But for rapidly urbanising low-income Africa, this is less applicable, since the forgone output, jobs and income due to energy scarcity, for example, is very high, while the stock of

existing capital and technology is relatively small. Governments, individually and collectively, should adopt policy actions to improve the supply of capital and skills that complement and change relative prices in favour of future technologies to accelerate growth now, while reducing the cost of a future lock-in by fast-tracking the transition to sustainable options.¹²

The emerging technology for mini-grid and decentralised energy system is particularly important in the context of small cities and rural towns. Information technology applications and penetration hold promise for expanding access to urban services, even to remote rural areas and market towns. Middle-income resource-rich countries or countries with a promising economic growth trajectory can step up investment in smart cities or integrated smart systems to improve urban management and resource efficiency. How much these opportunities are to be exploited depend on institutional capacity and socio-technical conditions. Further, in the African context, technological and infrastructure transitions need to consider the co-existence of alternative solutions and heterogeneous socio-technical systems (Silver & Marvin, 2017).

Reversing subsidies to the carbon economy, especially in resource-rich countries should be a policy priority. Governments spend \$21 billion in fuel subsidies, notably in North Africa, Angola and Nigeria, straining the public budget, disincentivising investment in renewable energy and creating carbon-based stranded assets. Re-channelling subsidies to renewables can accelerate the adoption of renewable energy. The cost of renewables is declining fast and becoming competitive and affordable. According to the International Energy Agency (IEA), ‘compared with typical per kWh costs of \$0.08 for large-scale hydropower, \$0.10 for geothermal, and \$0.07 to \$0.14 for natural gas’ (Avila, Carvallo, Shaw & Kammen, 2017).

Low-income and rapidly urbanising countries will generate long-term co-benefits by investing in public transport systems that better connect workers and firms. In anticipation of long-term transport needs that accompany rapid urbanisation, African countries should leverage current urban planning and infrastructure investment to support future electrification of public transportation as well as integrating grid-edge technologies (UNECA et al., 2018). Middle-income countries can use investment in transport infrastructure to remedy poor planning legacies that may have disfranchised and segregated the urban poor. Also, these countries can improve efficiency and access to the urban poor by integrating urban services and by better targeting subsidies.

12 For a detailed review of the policy trade-offs associated with green technologies facing Africa, see Paul Collier and Anthony J. Venables, *Greening Africa? Technologies, Endowments and the Latecomer Effect* (Collier & Venables, 2012).

Productive and inclusive economy: Job creation and structural change for sustainability

The success of urbanisation as a transformative force fundamentally hinges on the ability of African countries to leverage urban advantages for job-rich growth and structural change. Understanding the links between economic and spatial development is the starting point. Urban settlements are the indirect outcome of many policies interaction with economic agents who must make locational decisions (Hamer & Linn, 1987). Macroeconomic policies and sector priorities have stronger spatial impacts than urban policies, per se. Prevailing economic structures influence the economic geography of infrastructure and the relative intensity of capital, energy and labour, and thus impact on resource efficiency and job creation simultaneously. Alignment between spatial, infrastructure and economic sector planning is the key to sustainable urban development.

Despite some positive signs of structural change since 2000, manufacturing has been largely absent and growth has not been job-rich. Africa's employment share of manufacturing and productivity in industry and services are one-third and one-half that of Asia respectively (World Bank, 2013). Some economies are resource-reliant and locked in energy- or capital-intensive economic structure. This crowds out labour-intensive sectors and hampers economic diversification and the creation of employment. Past trends suggest continuing high labour-force growth, a slow movement of output and employment into manufacturing, and slow expansion of tradeable sectors (Fox, Thomas & Haines, 2017). Informality remains high and the impact of the recent GDP growth on the share of vulnerable employment has been negligible (see Figure 5.7). This suggests a need for deliberate policies to make growth job-rich and inclusive and to explore the potential of 'non-smokestack' industry and tradeable service sectors as alternative paths for structural change.¹³

13 In recent times, researchers have suggested, with the right policy and institutional environment, non-smokestack industries including tradeable services, agro-industry, horticulture and tourism could be potential drivers of structural transformation in Africa (Coulibaly, 2019).

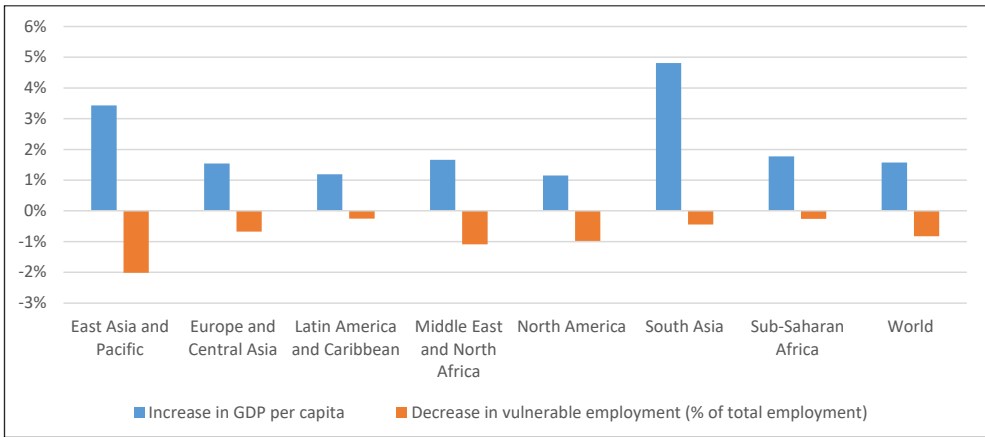


Figure 5.7 Economic growth and the decrease in the share of workers in vulnerable employment over 20 years (1998–2017) (Source: Data taken from development indicators, World Bank, 2019)

Making urbanisation a transformative force for economic development and sustainability requires promoting distributed economies across the continuum of human settlements. Sustainability and technology, if harnessed, can enable African countries to leapfrog. Figure 5.8 shows transformative forces for a new economy. As shown in the diagram, two revolutions can significantly shape economic transformation in the rapidly urbanising Africa, namely the new industrial revolution and the green revolution.

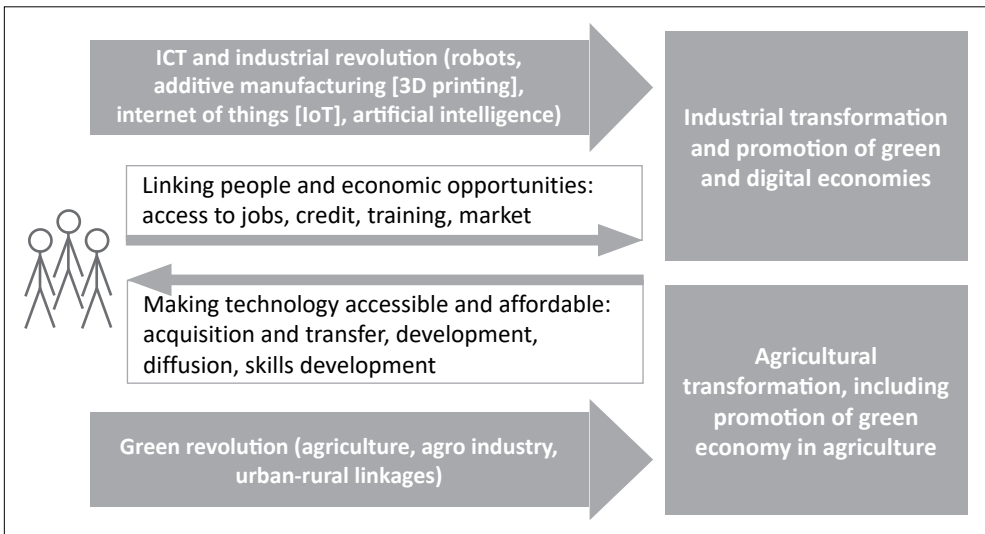


Figure 5.8 Transformative forces for a new economy

- **New industrial revolution:** Many African countries have embarked on second-generation industrial policies to reset their industrial development. This overlaps with the new industrial revolution, which includes advanced automation (robots), additive manufacturing (3D printing), the internet of things (IoT) and artificial intelligence. Africa may be lacking an industrial base to build on but going by its experience with ICT this should not necessarily exclude it from benefiting from some of the industrial applications of the new technologies. By investing in research and development,¹⁴ Africa can harness these technologies to catalyse productivity, decentralise and democratise production and innovation in a range of sectors including agriculture, food and construction, as well as tradeable service sectors. The fledgling digital and green economies, both in the rural and urban contexts, can benefit from the new industrial technologies.
- **Green revolution:** Africa is a net food importer and over 80 percent of the population in many low-income countries remains engaged in agriculture. High food prices are suggested by some as the key factor undermining the competitiveness of manufacturing in Africa. Modernising and transforming agriculture, in a policy context favouring small rural and urban producers, offers enormous job and economic opportunities and fosters urban-rural linkages, especially in low-income countries. The new twenty-first-century green revolution, in contrast to the first green revolution of the nineteenth and twentieth centuries, is not only aimed at increasing productivity and income, which remain central to combating poverty and achieving food security in Africa, but it is also aimed at fostering sustainability. It involves the use of ICT tools in a variety of ways, such as market access, weather information, and training and extension services. It also draws on agro-ecological approaches, bio-technologies, and green economy applications ranging from renewable energy to afforestation, water conservation and waste recycling.

Both low- and middle- income countries can benefit from the new industrial and green revolutions. Success hinges on the ability to harness technologies (innovation systems that links research and development, industry and finance) and the capacity to connect people and economic opportunities (access to skills, market, land, finance and infrastructure).

In recent years, the debate around whether industrial development can be a pathway for structural transformation in Africa has been intensified. Manufacturing

¹⁴ A 2018 report by UNECA on the performance of SDGs in Africa identified Kenya, Morocco, South Africa and Tunisia, among countries investing a larger share of GDP in science, technology and innovation to tap on technological opportunities (AU, UNECA, AfDB & UNDP, 2018).

production has doubled since 2000 and has been growing by 3.5 percent annually in real terms in the last decade. However, the share of manufacturing in GDP has shrunk from 18 percent in 1975 to 11 percent in 2015 and the region remains a peripheral player in global manufacturing export. But experience varies across countries, ranging from those aggressively promoted FDI in food and garment industries through special economic zones (SEZs),¹⁵ such as found in Ethiopia, to mature economies such as South Africa and Morocco, both of which promoted industrial capabilities in automobile industries. Nigeria and South Africa, followed by Kenya, Democratic Republic of Congo, Côte d’Ivoire, Ethiopia and Tanzania show a relatively strong manufacturing base, while Ethiopia shows strong growth, albeit from a low base. Garment and footwear, agro-processing, horticulture and automobiles are sighted as promising sectors. Overall, the region faces two challenges: First, competition from a new wave of Asian producers like Bangladesh, Cambodia and Viet Nam, which mostly benefit from advantages of lower wages, higher productivity or better infrastructure (Balchin et al., 2016). Second, the potential re-shoring of industry to developed countries that may stand to benefit from the fourth (new) industrial revolution.

Hence, Africa needs to narrow the digitisation gap to achieve the unconditional convergence gains of manufacturing, which will be increasingly robotised. Econometric evidence suggests a slowdown in manufacturing labour productivity in sub-Saharan Africa in 2002–2013 compared to 1991–2002. As the economy becomes more digital, the impact of technological progress on productivity increases, but again this effect is lower in LICs [low-income countries] and SSA [sub-Saharan Africa],’ (Banga & te Velde, 2018:vi). An increasing share of manufacturing in the twenty-first century will increasingly see an increased demand for products associated with higher skills, complexity and technology level.

Africa still has a window of opportunity to exploit its comparative advantages in labour-intensive industries, while speeding up narrowing the digital divide. Kenya shows the way to go. Kenya’s often-cited promising development in digitisation is a result of strategic initiatives including the introduction of mobile money (M-Pesa, 2007), the incorporation of ICT as a key pillar in the government’s

15 Special economic zones (SEZs) are designated geographical areas set aside for specifically targeted economic activities. These industrial hubs are supported through special incentives and trade laws that differ from the rest of the country. ‘They are typically established with the aim of achieving one or more of the following four policy objectives: (i) Attracting foreign direct investment (FDI); (ii) Serving as “pressure valves” to alleviate large-scale unemployment; (iii) Supporting a wider economic reform strategy; and (iv) Acting as experimental laboratories for the application of new policies and approaches’ (Farole, 2011:1). Saldanha Bay in the Western Cape and Coega in the Eastern Cape are examples of South African SEZs.

2030 vision, investment in undersea fibre-optic cables and high-speed internet (2010), and the launch of array of programmes, including the Kenya Open Data Initiative (2011), the National Broadband Strategy (2013), the National Cyber-Security Strategy (2014) and the National ICT Masterplan (2017) (Banga & te Velde, 2018). The results of these early initiatives are showing, not only in the increased general digital literacy and financial inclusion but also in the new generation of industries and capabilities. Examples include:

Proteq Automation, offering the latest in industrial automation technology and machine manufacturing; Homgenius, developing an automated bricklaying machine that can make more than 2000 interlocking building blocks per day; AB3D, acting as a one-stop-shop for 3D printing in Nairobi and offering low-cost access to 3D printers; and several cloud-based business management start-ups. (Banga & te Velde 2018:40)

Where to from here?

In this chapter, drawing on the literature, we have synthesised the growing consensus on urban realities in Africa and raised strategy policy issues for transformative urbanisation. The next sections introduce illustrative tools that can support policy actions. The key messages that came out of the policy discussion underscore that business as usual does not work and pairing urbanisation and technology offer ‘leapfrog’ opportunities to Africa. But action is needed before the window of opportunities closes. Africa may not have a large stock of capital or assets of old technology to dispose of or retrofit and thus may not have to deal with a big risk of ‘stranded assets’ or lock-in effects. However, structural factors, such as poverty, human, financial and institutional barriers and technological gaps, remain formidable challenges. This chapter does not offer a new template for urban development but highlights the broad sets of principles and levers of change.

Through the lens of these principles, African countries should assess current urban practices, programmes and initiatives at both national and subnational levels. The array of initiatives, including smart cities, tech cities and new cities offer a glimpse of the future but are neither inclusive nor scalable. Africa needs a new urban model that is inclusive and sustainable. Financial considerations may make private sector-led urban development attractive, but it is questionable whether achieving just and sustainable cities without a shared vision and rules of the game and coordination across sectors and levels of government is in the interest of the public good. Transformative urbanisation should be a priority and should be mainstreamed in the policy, investment planning and budgeting cycle.

Supporting tools for strategic decision-making and planning

As a cross-cutting phenomenon intersecting different themes, there are plenty of relevant tools supportive of sustainable urbanisation. But here we focus on illustrative and strategic tools, representing national, city and local levels or scales. These are related to national development planning, urban planning and local economic development. Figure 5.9 shows these tools at different scales.

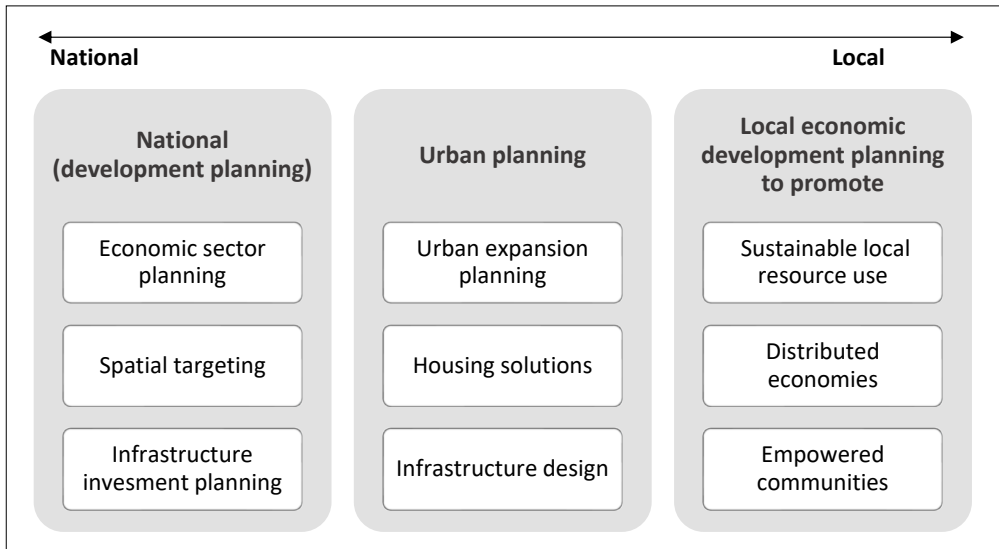


Figure 5.9 Tools at multiple scales

Integrating urbanisation into national development planning

Africa is undergoing urban, economic and demographic changes. All three are major forces impacting the nature, pace and scale of its transition to sustainability and require a concerted policy action at the national scale. National development planning provides a strategic platform to do this. Economic sector and infrastructure planning should have a spatial lens, and spatial targeting of investments should be based on economic and sustainability considerations.¹⁶ The paragraphs that follow consider some of the many reasons for the need to integrate urbanisation into national development planning.

Macro-economic and sector priorities

Macro-economic and sector priorities as defined in national development plans have strong spatial and urban implications. Sector priorities determine whether

¹⁶ Related economic, investment and spatial tools are key to planning and implementing a sustainable urban system.

growth is job-rich or job-poor and whether there is a potential shift in economic geography and economic prospects of different regions. Implicitly or explicitly, development plans influence trends in urbanisation and urban structure.

Urbanisation

Urbanisation levers growth and transformation but comes at a cost. The present and future cost of building new cities and improving existing cities and settlements should be factored into investment planning and project programming. Long-term environmental considerations and growth trajectories determine the nature and level of investment, making the cost of urbanisation vary with context and development scenarios. According to Harry Richardson, the cost of urbanisation includes:

direct investment costs (i.e., the costs of creating jobs), housing and intra-urban infrastructure costs (primarily the capital costs of urban services such as shelter, water, sanitation, electricity, social services, etc.), inter-urban (or interregional) infrastructure costs, and growth-management costs. (Richardson, 1987:564)

Urban investment

Urban investment is the total of public, private and household investment. Coordinating investment across these three sources is an essential condition for building sustainable cities. Failure to coordinate investment by the different actors leads to settlements without infrastructure or jobs, or infrastructure without firms, or vice versa. This results in dysfunctional cities, a waste of resources and the loss of positive externalities.

Public investment

Public investment is heavily directed to infrastructure. The way infrastructure is designed determines urban efficiency and sustainability. Therefore, with the huge amount of investment going to urban infrastructure in the coming years and decades, government becomes a critical lever in influencing Africa's transition to sustainability. With the right policies, technology and institutions, future cities can become productive, and at the same time resource efficient.

A multi-level governance context

In a multi-level governance context, coordination across levels of government is also extremely important in achieving sustainable urbanisation. Aligning sector and territorial priorities and linking planning and implementation capacities of different levels of government is necessary to marshal resources and action for sustainable development.

Box 5.1: Decision-making tools useful in infrastructure investment planning and prioritisation¹⁷

Alignment and prioritisation of investment is a complex process with far-reaching and long-lasting impacts. The National Research Council (2014) of the US has suggested several decision-making tools that may be useful in this process.

Benefit-costs analysis

Benefit-costs analysis (BCA) is embedded in traditional economic analysis. It is now being used more and more to analyse the social and environmental impact of decisions. Fundamentally, BCA provides a process and way to compare alternatives, and more clearly understand trade-offs. It is also important to assess the distribution of benefits and costs across different social groups arising from a decision. There may be winners and losers in the process. For example, a city may grapple with investing in poor urban areas to reduce urban poverty and social disparities or investing in a richer part of the city and achieve higher financial return or growth. Most decisions have direct and indirect effects that need to be anticipated during the planning and decision phase. Some of these effects are short term and others long term. Short-term benefits may be offset by more weighty long-term costs, which in some cases, could be irreversible and more damaging to sustainability. There also may be unintended consequences that need to be understood as actions are implemented and the cascading effects materialise. For example, the decision to invest in housing projects on the urban periphery may benefit in the short term from cheaper land costs, but over time the development contributes to sprawl, energy and transport costs.

In the context of urban development, benefits could involve multiple criteria or metrics, and therefore analysis may involve looking at the multiple impacts of each decision option. There are many critiques of BCA, especially in the context of sustainability. A common outcome of BCA analysis is an attempt to monetise as many of the benefits or costs as possible of each alternative under consideration and present the results as a single monetised result. Costs or benefits that are more difficult to monetise are either ignored, relegated to a description that is not given the same weight as the more easily measured and monetised effects or they are subject to other controversial economic techniques that attempt to 'price the priceless' (e.g., contingent valuation). Another challenge of BCA in the context of urban sustainability is related to intra- and inter-generational distributional aspects. Benefits accruing to different social groups or future generations may require assigning different weights and discount rates, respectively, and these can be controversial.

Cost-effective analysis

A related tool to BCA, cost-effective analysis (CEA) is aimed at selecting the least cost option among equally effective decision options. In the resource-scarce or deficient context of Africa, identifying the option that provides the maximum benefits with the least cost is an overriding objective in decision making. Sometimes the initial cost of intervention could appear cheaper or less, but may involve much higher long-term costs and therefore, accounting for all future costs in the decision making is critical. Some infrastructure investments may look cheap on the face of the initial cost but may end up to be much more costly when long-term social and environmental costs or operational costs are considered.

¹⁷ The tools described are adapted from the National Research Council (2014) of the US.

Life-cycle assessment

Life-cycle assessment (LCA) approaches to decision making involve considering all relevant aspects of a product or system along the different stages or phases of the life cycle. LCA helps in that the implications of decisions and their consequences are fully considered as part of a larger system, and not as isolated parts.

Risk analysis

A risk analysis (RA) is done to evaluate the relative merits of options in terms of risk management by making more explicit the likelihood and magnitude of consequences. It is particularly important in long-term decisions and uncertainties. It involves three questions: What can go wrong? What are the chances that something with serious consequences will go wrong? What are the consequences if something does go wrong? (Kaplan & Garrick, 1981). Part of the reason for involving local officials and communities in urban development and planning is to address concerns and risks stakeholders may have and to build trust and confidence.

Urban planning

Resource efficiency and urban productivity hinges on urban form, which is shaped by urban layout, density and connectivity, and infrastructure design. Urban planning is a key tool for achieving that.

Many African cities had master plans, but for the most part, the grand ideas and visions of those plans did not materialise. By the time the plans were completed, the realities on the ground had been utterly changed by the rapid forces of urbanisation. The cities are poor financially and have a weak capacity to implement, adjust, or respond. The plans remain static and rigid, while the realities constantly evolve. Big projects involving big players and resources strain local capacity, and in the meanwhile the issues and problems the cities face grow in scale and complexity, prompting a plethora of projects and bottom-up initiatives. The dynamism and ingenuity generated in bottom-up approaches, and the static and rigid planning and control interventions struggling to cope with old and new challenges, co-exist with limited interaction on the margin, resulting in chaotic urban development.

The failure of large-scale planning in African cities is manifested in the continuing growth of slums. The big developers target the rich and the upper-middle class, while the majority turn to building shacks. Under the pressure of the market forces and land encroachment by the disfranchised urban poor, the dream plans remain unfulfilled, and everyone loses. Studies from Latin America indicate that retrofit solutions or upgrading of slums are up to 12 times more costly. When land is laid out efficiently, the provision of services and incremental housing should offer a much cheaper option.

Box 5.2: When bottom-up meets top-down: Turning planning on its head

Building sustainable communities and cities demand turning the command and control top-down planning process from one of static and deterministic to enabling and generative, responsive and facilitative. The top-down planning approach that is fixated on end-states has relied on complex policies and development control tools. On the other hand, bottom-up approaches are guided by simple rules that are informed by practice, norms and traditions, but decidedly determined the urban form and development. Unlike top-down rigidity, bottom-up approaches are aligned to emergent or adaptive solutions and driven by collaborative and self-organised collective actions.

As highlighted in Figure 5.10, The key remedy to the deficiency of top-down planning lies in changing planning from place-making to condition-making. In the new approach, cities will be viewed as complex adaptive systems that evolve as living organisms and incrementally change through multiple actions of small actors. Thus urbanism is seen not as a closed set of rules, but as an open system that continuously interacts and evolves with its environment. Planning by government and the ‘emergent vernacular’ of the people overlap and interact. Planning in this context provides the essential conditions that set the boundaries and constraints within which creativity and innovation flourish to build sustainable communities. Simple and tested rules on street and blocks set the essential urban order and starter conditions. Platforms, including scalable strategies, codes, standards and regulations, provide the foundation and necessary support to accelerate change and growth. Defaults provide a typology of solutions at different scales to influence positive choices. Finally, activators focus on enabling mechanisms to build social capital in a variety of scales, catalysing collective action for change.

The range of tools for each of these planning components include an **urban expansion plan**, which is an incremental approach where the initial effort is focused on land acquisition and protection of the right of way, followed by multi-year phased investment;¹⁸ **grid-based simulation** for facilitating layouts and testing the metrics for a full range of development scenarios; **dweller adaptive building systems**, which segment actions during development and dwelling to allow fit-for-purpose uses and future changes of housing and commercial buildings, promote innovation, and balance between distinctiveness and affordability; a **parameter-based building typologies** facilitating meeting a spectrum of needs; and **citizen engagement tools** ranging from neighbourhood gaming technique to participatory budgeting geared to fostering collective actions (Campbell, 2018).

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- 18 The New York University Stern Urbanisation Project promotes a simple four-step municipal action programme that focuses on preventing the occupation of the urban fringe by formal and informal construction, prior to the necessary preparations. These preparations include (a) projecting population and urban area per capita growth 25 years out and developing maps; (b) creating a single municipal jurisdiction that can execute plans in the entire area for expansion; (c) locating an arterial road grid with a 1-kilometer spacing throughout the expansion area and transferring the rights-of-way for all roads to the municipality to prevent incursion by formal and informal developers (Lamson-Hall et al., 2015). UN-Habitat promotes similar approach, coupled with a financing plan and a supportive package of urban regulations.

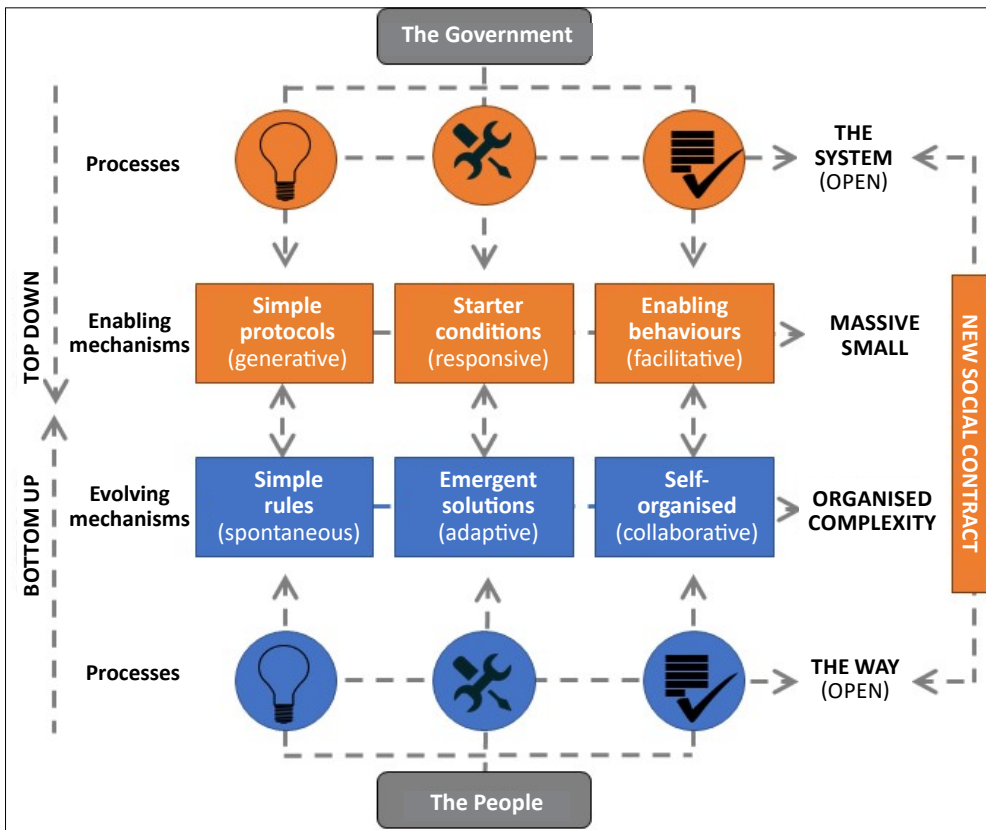


Figure 5.10 A new framework for top-down plus bottom-up planning
 (Source: Adapted from Campbell, 2018:82)

The solution lies neither in the top-down command and control system nor in the bottom-up self-development. What is needed is light-touch top-down planning to provide guidance and structure while allowing adaptation and innovation to suit diverse needs, and bottom-up initiatives that are spontaneous, adaptive and collaborative. The key is transforming the top-down planning from a system that constrains to a system that enables by moving from complex policies aimed at fixed end states to policies that provide simple and generative protocols geared to facilitating massive small changes that are adaptive, responsive and creative. The idea is making planning dynamic and accommodative by focusing on starter conditions and enabling behaviours and liberating the forces of creativity and collective actions residing in bottom-up approaches (Campbell, 2018).

Box 5.3: Financing tools

One of the central challenges African cities face is financing. Local authorities should be empowered to raise revenues and access external sources to implement urban plans. There are a host of under-utilised local revenue sources and emerging innovative financing vehicles. Two such tools are highlighted below:

Urban land value capture

Public investment in infrastructure increases land value, and in many countries, this has been an important source of local revenues for investment. By capturing part of the increased wealth and value appreciation generated through public investment, cities can expand their investment pool and sustain a virtuous link between public investment, growth and taxes. Land and property taxes, capital gain taxes, betterment fees and infrastructure exaction are some of the instruments available to capture increased land value. Due to political and administrative and technical capacity constraints, African cities fail to sufficiently exploit this important revenue source, however, there is a potential to change this.¹⁹

Green bonds

Green bonds are generally used to finance green infrastructure projects. In comparison to conventional bonds, the volume of green bonds is relatively small but growing. Out of a total of \$131 billion estimated to have been raised in 2016, only \$2.3 billion was invested in cities in developing countries (Oliver, 2016). In 2013, AfDB issued a \$500 million green bond, and over the last five years, two South African metropolitan governments, Cape Town and Johannesburg, have issued green bonds. Beyond the additional money generated for infrastructure development, green bonds provide an environmental credential that can be attractive to a new pool of investors (Duru & Nyong, 2016) and thus should be a financing instrument worth pursuing within the context of sustainable development.

Local economic development planning

Distributed economies, a critical component of sustainability in Africa, demand harnessing local capacities, resources and skills. Local economic development (LED) represents a suite of tools available for harnessing local potentialities. Local economic development is essentially inclusive because it is participatory and broad-based; it is sustainable because it balances social, economic and environmental goals; it is strategic because it forces communities to make hard choices that matter most to their long-term prosperity and sustainability. Most common local solutions, from waste recycling and home-based enterprising to time banking, resonate with the tenets of sustainability and distributed economy.

Local economic development is used by both economically vibrant and economically distressed cities, urban areas and communities. Cities with agglomeration economies use LED to leverage their spatial and natural advantages and stay economically

¹⁹ Land and property tax in Africa is estimated at 0.5 percent of GDP compared to 2 percent in developed economies (UNECA, 2019, forthcoming).

competitive, while communities in economically less productive areas use LED to improve their economic prospect by reimagining and creating new opportunities and exploiting their hitherto underutilised resources. Even in developed economies, including the US, governments target poor cities, through tax breaks and other incentives, to help them lure investment, or create and retain jobs.²⁰

Local economic development planning is a cross-cutting tool used to mobilise communities, create a shared vision and mobilise resources to achieve specific goals and objectives, such as job creation and local sustainability. The following paragraphs discuss some of the variety of tools that can be used in LED planning.

Local economic profiling

Local economy profiling applies different tools to identify and assess the economic base and drivers, as well as challenges and threats. It traces underlying changes and shifts within and between growing, declining and emerging sectors. It also assesses local resources and capacity (human, natural and physical, financial and cultural) and their sustainability.

Asset-based community development

Asset-based community development is a local sustainable development approach which draws on strength and potentials possessed by host communities. Strength could be both tangibles like location, water and land resources, or intangibles such as social capital, cultural assets, networking and leadership. Community asset mapping is used to take stock of individual assets (talents and skills), associations (cultural bodies, interest groups and religious organisations) and local institutions (business, industry, education), and other resources that can be deployed to promote economic growth and sustainability.

Capacity inventory

As a variant of asset-based community development, this tool identifies and takes stock of a range of skills (individual, community and enterprise) and also personal interests. The information helps to mobilise and exploit human capacity existing in the community for sustainable development.

Urban development LED strategy tools

Urban development LED strategy tools include a host of technical, spatial and regulatory instruments used to promote urban sustainability as a lever for economic development. Examples include pedestrian and cycling master plans with design

²⁰ The Opportunity Zone Scheme of the US which was introduced in 2017 is one such example and targets distressed communities for preferential tax treatment.

guidelines, green development guides, urban forests, climate adaptation guides, energy planning, transportation plans, urban containment boundaries, sustainability checklists, zoning bylaws; and smart neighbourhoods.

Sector-specific LED strategy tools

Sector-specific LED strategy tools include sector-specific tools deployed to leverage sustainable economic development, for example, tourism planning, agro-industrial development plans, and ICT development.

Social enterprising

Social enterprising involves processes aimed at establishing the third sector (neither public nor private) to generate solutions in areas where both the public and private actors failed or to promote a social economy as the basis for a sustainable, prosperous and inclusive society. In a digital economy, social economies can foster the power of the web and the community to create a vibrant economy that is inclusive and sustainable.

Time banking

Time banking is a mechanism connecting individual assets to foster collective action or to facilitate transaction towards meeting individual and social needs of sustainable communities. By using time as currency, people can turn their assets into economic and social goods. Sweat capital of slum dwellers in slum improvement projects or volunteers participating in green projects could also be viewed in a similar light.

Crowdsourcing

Crowdsourcing is an open system used to generate ideas and solutions or to mobilise capital and thus support building collective intelligence or unlocking financing capacity residing in the local community or beyond.

Participatory processes

Local economic development is essentially a participatory process built around shared aspirations, will and collective actions. Local leadership and demand-driven technical support are critical ingredients for success. When linked with resource allocation, the participatory process becomes a powerful tool of decision making with real consequences. Participatory budgeting which started in Port Alegre (Brazil) and adapted in many cities of both developed and developing countries is one such tool used to allocate public resources based on priorities set by communities.

Conclusion

Africa is urbanising rapidly in the context of weak industrial development and without a green revolution. A comparison with East Asia brings the point home. Africa is 40 percent urbanised with an annual per capita income of about \$1 000. The respective figures for East Asia and Latin America were \$3 617 and \$1 860 when they reached the same level of urbanisation in 1994 and 1950 respectively, reflecting the relatively weak link between urbanisation and economic growth in Africa (Henderson & Kritikos, 2017).

As a result, African cities face multiple challenges including housing and infrastructure deficits, chronic unemployment, growing informality and premature diseconomies manifested in urban sprawl, congestion and an increasing cost of living and business.

But urbanisation is inherently good for development, if well managed. Two-thirds of investment in African urban infrastructure needed by 2050 is yet to be made (Muggah & Hill, 2018), and this has huge implications for investment and job creation, and also for charting a non-conventional development path that is low-carbon, inclusive and sustainable. Considering its speed and scale, urbanisation in Africa is disruptive and traumatic, but it is also a force to be reckoned and leveraged for sustainable development. Africa does not have much time left to consummate its urban transition; an opportunity that should not be missed. The opportunities far outweigh the challenges.

The overarching policy question, therefore, is how to seize these opportunities and turn them into development conditions favourable to low-carbon, inclusive and sustainable development. The urban policy and strategy issues critical to sustainability in Africa are centred on four themes: the system of cities, housing, infrastructure and productive urban or local economies.

Africa is a huge continent and countries are diverse in their context. It is thus impossible to spell out the policy agenda suited or relevant to every case. Therefore, the policy issues discussed in the chapter are generic, though contextual specificities, such as level of income and urbanisation, are considered where appropriate. Some of the policy interventions, such as planning urban expansion, are beneficial to all countries, albeit with varying degrees of urgency. In many cases, urban policy issues cross-cut sectors, geographic scales and governance levels. Accordingly, the set of tools presented in this chapter to address the policy issues illustrate national, city and local level interventions.

Technology in renewable energy, mobility, and information and communications offer new opportunities for Africa to leapfrog. The emerging technology for mini-grid and decentralised energy systems is particularly important in the context of dispersing urban functions and promoting distributed economies. In the African context, technological and infrastructure transitions need to take into consideration the co-existence of alternative solutions and heterogeneous socio-technical systems.

References

- African Development Bank. (2018). *African economic outlook 2018*. Abidjan: AfDB.
- African Development Bank, Organization for Economic Co-operation and Development & United Nations Development Programme. (2016). *African economic outlook 2016: Sustainable cities and structural transformation*. Paris: OECD Publishing. <https://doi.org/10.1787/aec-2016-en>
- African Union, Economic Commission for Africa, African Development Bank & United Nations Development Programme. (2018). *2018 Africa sustainable development report: Towards a transformed and resilient continent*. Addis Ababa: UNECA.
- Angel, S., Lamson-Hall P., Madrid, M., Blei, A.M. & Parent, J. (2016). *Atlas of urban expansion* (Vol. 1). NYU, UN-Habitat & Lincoln Institute of Land Policy.
- Avila, N., Carvallo, J.P., Shaw, B. & Kammen, D.M. (2017). *The energy challenge in sub-Saharan Africa: A guide for advocates and policy makers: Part 1: Generating energy for sustainable and equitable development*. Oxfam Research Background series. <https://bit.ly/2kGdbd2> [Accessed 25 September 2019].
- Balchin, N., Gelb, S., Kennan, J., Martin, H., te Velde, D.W. et al. (2016). *Developing export-based manufacturing in sub-Saharan Africa*. London: ODI, SET Programmes.
- Banga, K. & te Velde, D.W. (2018). *Digitalisation and the future of manufacturing in Africa*. London: ODI, SET Programmes.
- Barhoumi, K., Vu, H., Towfighian, S.N. & Maino, R. (2018). *Public investment efficiency in sub-Saharan African countries: What lies ahead?* Washington, DC: IMF. <https://doi.org/10.5089/9781484360019.087>
- Barofsky, S.A. (2016). *Can rapid urbanisation in Africa reduce poverty? Causes, opportunities and policy recommendations*. Washington, DC: Brookings Institute.
- Bloch, R., Makarem, N., Yunusa, M., Papachristodoulou, N. & Crighton, M. (2015). *Economic development in urban Nigeria*. Urbanisation research Nigeria (URN) Research Report. London: ICF International.
- Brahmbhatt, M.B. (2016). *Africa's new climate economy: Economic transformation and social and environmental change*. Washington, DC: New Climate Economy and ODI.
- Calderón, C. (2009). *Infrastructure and growth in Africa*. Washington, DC: World Bank. <https://doi.org/10.1596/1813-9450-4914>
- Campbell, K. (2018). *Making massive small changes*. London: Chelsea Green Publishing.
- Christiaensen, L. & Todo, Y. (2013). *Poverty reduction during the rural–urban transformation: The role of the missing middle*. Washington, DC: World Bank. <https://doi.org/10.1596/1813-9450-6445>
- Collier, P. (2016). *African urbanisation: An analytic policy guide*. London: The International Growth Centre.
- Collier, P. & Venables, J.A. (2012). Greening Africa? Technologies, endowments and the latecomer effect. *Energy Economics* 34(20): 575–584. <https://doi.org/10.1016/j.eneco.2012.08.035>
- Collier, P. & Venables, J.A. (2014). *Housing and urbanisation in Africa: Unleashing a formal market process*. Washington DC: World Bank Group. <https://doi.org/10.1596/1813-9450-6871>
- Commission on Growth and Development. (2008). *The growth report: Strategies for sustained growth and inclusive development*. Washington, DC: World Bank.
- Coulibaly, B.S. (Ed.). (2019). *Foresight Africa: Top priorities for the continent in 2019*. Washington, DC: Brookings Institute.

- Currie, P. (2015). A resource flow typology of African cities. Master's thesis, Stellenbosch University, South Africa.
- Currie, P., Lay-Sleeper, E., Fernandez, J.E., Kim, J. & Musango, J.K. (2015). Towards urban resource flow estimates in data scarce environments: The case of African cities. *Journal of Environmental Protection* 6(9): 1066–1083. <https://doi.org/10.4236/jep.2015.69094>
- Currie, P. & Musango, J.K. (2017). African urbanisation: Assimilating urban metabolism into sustainability discourse and practice. *Journal of Industrial Ecology* 21(5): 1262–1276. <https://doi.org/10.1111/jiec.12517>
- Dorosh, P. & Thurlow, J. (2014). Can cities or towns drive African development? Economywide analysis for Ethiopia and Uganda. *World Development* 63: 113–123. <https://doi.org/10.1016/j.worlddev.2013.10.014>
- Duru, U. & Nyong, A. (2016). Why Africa needs green bonds. *Africa Economic Brief* 7(2): 1–8.
- Eberhard, A., Rosnes, O., Shkaratan, M. & Vennemo, H. (2011). *Africa's power infrastructure investment, integration, efficiency*. Washington, DC: World Bank. <https://doi.org/10.1596/978-0-8213-8455-8>
- Farole, T. (2011). Special economic zones: What have we learned? *Economic Premise* 64: 1–5. https://doi.org/10.1596/9780821386385_Over
- Foster, V. & Briceño-Garmendia, C. (2010). *Africa's Infrastructure: A time for transformation*. Washington, DC: World Bank. <https://doi.org/10.1596/978-0-8213-8041-3>
- Fox, L., Thomas, A. & Haines, C. (2017). *Structural transformation in employment and productivity: What can Africa hope for?* Washington, DC: IMF.
- Friedman, J. (1996). Modular cities: Beyond the rural-urban divide. *Environment and Urbanization* 8(1): 129–131. <https://doi.org/10.1177/095624789600800107>
- Godfrey, N. & Zhao, X. (2015). *The contribution of African cities to the economy and climate: Population, economic growth and carbon emission dynamics*. Technical note. London: The New Climate Economy.
- Hamer, A.M. & Linn, J.F. (1987). Urbanisation in the developing world: Patterns, issues and policies. *Handbook of Regional and Urban Economics* 2: 1255–1284. [https://doi.org/10.1016/S1574-0080\(87\)80018-4](https://doi.org/10.1016/S1574-0080(87)80018-4)
- Harris, R. & Arku, G. (2006). Housing and economic development: The evolution of an idea since 1945. *Habitat International* 30(4): 1007–1017. <https://doi.org/10.1016/j.habitatint.2005.10.003>
- Henderson, J.V. (2010). Cities and development. *Journal of Regional Science* 50 (1): 515–540. <https://doi.org/10.1111/j.1467-9787.2009.00636.x>
- Henderson, J.V. & Kritikos, S. (2017). *The development of the African system of cities*. London: London School of Economics.
- Honeywell & Ernst and Young. (2015). Smart buildings make smart cities. <https://bit.ly/2OYe8Lm> [Accessed 18 September 2019].
- Jedwab, R., Christiaensen, L. & Gindelsky, M. (2014). *Rural push, urban pull and... urban push? New historical evidence from developing countries*. Washington, DC: George Washington University.
- Kaplan, S. & Garrick, B.J. (1981). On the quantitative analysis of risk. *Risk Analysis* 1(1): 11–27.
- Lamson-Hall, P., Degroot, D., Martin, R., Tafesse, T. & Angel, S. (2015). A new plan for African cities: The Ethiopia urban expansion initiative. <https://bit.ly/31uwxxQ> [Accessed 15 September 2019].
- Modisaatsone, N. (2014, 11 April). A different kind of smart city. [Web log post]. <https://bit.ly/2Br8gCc> [Accessed 20 September 2019].

- Muggah, R. & Hill, K. (2018, 27 June). African cities will double in population by 2050. Here are 4 ways to make sure they thrive. [Web log post]. <https://bit.ly/2KcyCPb> [Accessed 20 September 2019].
- National Research Council. (2014). *Sustainability concepts in decision-making: Tools and approaches for the US Environmental Protection Agency* (2014). Washington, DC: The National Academies of Sciences, Engineering, and Medicine.
- Newfarmer, R., Page, J. & Tarp, F. (Eds). (2018). *Industries without smokestacks: Industrialization in Africa reconsidered*. WIDER Studies in Development Economics. Oxford: Oxford University Press. <https://doi.org/10.1093/oso/9780198821885.001.0001>
- Oliver, P. (2016). *Green bonds for cities: A strategic guide for city-level policymakers in developing countries*. <https://bit.ly/2MtE2F6> [Accessed 15 September 2019].
- Oxford Economics. (2017). *Global infrastructure outlook*. Oxford: Oxford Economics.
- Potts, D. (2009). The slowing of sub Saharan Africa's urbanization: Evidence and implications for urban livelihoods. *Environment and Urbanization* 21(1): 253–259. <https://doi.org/10.1177/0956247809103026>
- Richardson, H.W. (1987). The costs of urbanisation: A four-country comparison. *Economic Development and Cultural Change* 35(3): 561–580. <https://doi.org/10.1086/451604>
- Rogers, M. & Pedros, X. (2017). *Taxing mobile connectivity in sub-Saharan Africa: A review of mobile sector taxation and its impact on digital inclusion*. London: GSMA.
- Silver, J. & Marvin, S. (2017). Powering sub-Saharan Africa's urban revolution: An energy transitions approach. *Urban Studies* 54(4): 847–861. <https://doi.org/10.1177/0042098016668105>
- South Africa Cities Network. (2013). *Spatial transformation of cities: Conference report*. Braamfontein. <https://bit.ly/2BqY4tG> [Accessed 15 September 2019].
- Stefanski, R. (2010). *On the mechanics of the 'Green Solow Model'*. OxCarre Working Papers No. 47, Oxford Centre for the Analysis of Resource Rich Economies, University of Oxford.
- Sy, A. (2015). *African countries rebasing GDP in 2014: Finding evidence of structural transformation?* Washington, DC: Brookings Institute.
- United Nations Department of Economic and Social Affairs. (2018). *World urbanisation prospects 2018*. Washington, DC: UN DESA. <https://doi.org/10.18356/02486bd4-en>
- United Nations Economic Commission for Africa. (2016). *Economic report on Africa 2016: Greening Africa's industrialization*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2017a). *Economic report on Africa 2017: Urbanisation and industrialization for Africa's structural transformation*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2017b). *Urbanisation and national development planning in Africa*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2019 forthcoming). *The state of urbanisation. Financing development in Africa: The role of cities in domestic resource mobilization*. Addis Ababa: UNECA.
- World Bank. (2013). *Global monitoring report 2013: Rural-urban dynamics and the millennium development goals*. Washington, DC: World Bank.
- World Bank. (2015). *Stocktaking of the housing sector in sub-Saharan Africa: Challenges and opportunities*. Washington, DC: World Bank.
- World Bank. (2019). World development indicators. <https://bit.ly/2G6NXPo> [Accessed September 2019].



6

LIFE-CYCLE MANAGEMENT FOR SUSTAINABLE INFRASTRUCTURE PLANNING AND DEVELOPMENT IN AFRICA

Getachew Assefa and Toolseeram Ramjeawon

Introduction

The mobility of people, goods and services, and information through transport, energy, water and wastewater, and ICT infrastructure are at the heart of global and national socio-economic development. How these people, goods and services, and information are moved from one place to another and how the choice affects economic, social and environmental quality continues to be the subject of inquiry in many fields of research and practice. The type and spread of infrastructure systems in any country play a strategic role in influencing its path to sustainable development.

The global infrastructure spending between 1992 and 2013 was 3.5 percent of world GDP, and Africa spent 3.1 percent of its GDP during that period (McKinsey Global Institute, 2016). The world is expected to invest around 90 trillion USD in infrastructure over the next 15 years and developing countries will need to

nearly double the annual investment to \$1.9 trillion¹ per year between 2016 and 2030 (McKinsey Global Institute, 2016). In addition to its role in society and the economy, long operational lifetimes make infrastructure potentially impactful on the environment and vulnerable to climate variations over the many decades of its use.

According to the United Nations Environment Programme (UNEP), only 25 percent of the infrastructure that will be in place in 2050 exist today (Egler & Frazao, 2016). This provides numerous opportunities for the development of developing sustainable infrastructure systems with long lifespans. Typical lifespans of infrastructure range from 20 years for roads and petrol stations to 200 for public buildings like town halls (Wright et al., 2018).

Africa needs to ensure that its new infrastructure systems leapfrog the inefficient, sprawling and polluting systems of the past and must strive to develop systems that are sustainable, resource-efficient, low-carbon and climate-resilient. Although sustainable infrastructure could increase upfront capital costs by roughly 5 percent (Egler & Frazao, 2016), it can have lower operating costs over the life of the investment while reducing risks and negative externalities. Petit-Boix et al. (2017) identified 28 potential improvement strategies for sustainable infrastructure and urban sustainability. Most strategies point to increased process efficiency, the implementation of greener materials/designs and the integration of new technologies into the existing pool of alternatives. Sustainability and resilience must be embedded into standard planning and engineering practice to deliver infrastructure that provides a good service of the right quality, on time and at the lowest cost.

The term ‘sustainable infrastructure’ is often represented in different ways including interchangeably used with the terms ‘green’ infrastructure or ‘smart’ infrastructure. From a life-cycle perspective, we can distinguish the following typical stages of infrastructure planning and delivery: Planning, Development (outline design), Implementation (detailed design and construction), Operation and Decommissioning. In this chapter, sustainable infrastructure is used in the context of the definition used by the Inter-American Development Bank (IDB) as infrastructure that is ‘planned, designed, constructed, operated and decommissioned in a manner to ensure economic and financial, social, environmental (including climate resilience) and institutional sustainability over the entire life cycle’ (IDB, 2018:11). The definition captures a number of frameworks, principles and standards and encompasses the four major pillars of sustainability, namely economic, social, environmental and institutional.

¹ All dollars (\$) are US dollars unless otherwise mentioned.

Sustainable infrastructure systems enable a community or country to achieve a more sustainable form of economic development adaptable to global changes and the changing needs of societies. They promote inclusiveness, safety and resilience characterised by social, environmental and economic dimensions (Colombo et al., 2017; Global Infrastructure Basel Foundation, 2017; International Finance Corporation, 2017; International Institute for Sustainable Development, 2017). Creating sustainable cities strongly depends on ensuring sustainably developed and operated important infrastructure systems supported by life-cycle insights as noted by Assefa (2019). Within any one of the life-cycle stages, sustainability can be improved by what is done at each stage and particularly by what questions are asked. The biggest opportunities are often in the earlier stages of the process and also at the very start of each stage (Ainger & Fenner 2014; Braganca, Viera & Andrade, 2014; Guthrie & Konaris, 2012). A review of existing evaluation tools shows major gaps in the coverage of sustainability principles at the upstream planning stage, as most focus mainly or entirely on the design stage and stages beyond it.

Sustainable infrastructure for SDGs and Agenda 2063 in Africa

There is increasingly significant pressure on the infrastructure of African cities due to rapid population growth and urbanisation. The population has grown at an annual rate of 2.53 percent from 1950 to 2015 and is predicted to increase from 1.18 billion in 2015 to 2.44 billion in 2050 (United Nations Department of Economic and Social Affairs, 2015). At the same time, the continent is experiencing rapid urbanisation, at a rate of 3.5 percent during the period 2000 to 2015, the highest rate in the world. It is estimated that by 2030, more than 50 percent of the population in Africa will be living in cities, and this percentage is expected to increase even further and reach over 60 percent by 2050 (United Nations Human Settlements Programme [UN-Habitat] & United Nations Economic Commission for Africa [UNECA], 2015). This means that African towns and cities will host 1.26 billion people (Sow, 2015) – nearly a quarter of the world’s urban population, presenting considerable demands on infrastructure systems. Each year, an additional 14 million people join the urban population in Sub-Saharan Africa (UN-Habitat, 2010) with the vast majority (70 percent) living in ‘informal settlements’ and slums because of insufficient infrastructure and poor institutions.

Current state of infrastructure in Africa

Africa’s infrastructure lags well behind that of other developing countries (see Table 6.1). The African Development Bank (AfDB), whose strategy for 2013–2022 made infrastructure development one of its operational priorities, notes that ‘Africa

still has massive infrastructure needs, yet invests only 4 percent of its gross domestic product (GDP) in infrastructure, compared to China's 14 percent investment (AfDB, 2013).

Table 6.1 Africa's infrastructure compared to other regions, 2013

(Source: Adapted from AfDB, 2018:76)

Sector	Infrastructure	Africa	Asia	Latin America	Europe
Transport	Paved road density (km per 100 km ² of land area)	2	25	3	122
	Railway line (km)	46 380	197 610	89 002	85 986
Power	Electricity production (per capita kWh)	572	1 930	2 116	3 355
	Electricity access (percent of total population)	46	88	97	100
Water and sanitation	Improved water (percent of total population)	69	90	94	99
	Improved sanitation (percent of total population)	39	61	82	93
ICT	Fixed broadband (subscriptions per 100 population)	1	6	9	15
	Mobile cellular (subscriptions per 100 population)	73	85	115	119

Africa has 15 percent of the world's population but only 3.2 percent of world electricity-generating capacity. More than half of the world's population without electricity are Africans. According to research from the World Bank Group, 48 countries of sub-Saharan Africa (with a combined population of 800 million) generate roughly the same amount of power as Spain (with a population of 45 million). Per capita, yearly consumption of energy in sub-Saharan Africa (excluding South Africa) is 180 kWh, against 13 000 kWh in the United States and 6 500 kWh in Europe (Dethier, 2015). Energy intensity and CO₂ intensity in the continent are also very high, thus giving evidence of unclean and inefficient energy supply chain (Saghir, 2017). It is estimated that only one-third of Africans living in rural areas are within two kilometres of an all-season road, compared with two-thirds of the population in other developing regions.

The African Development Bank, based on a set of targets for 2025, estimated Africa's needs of the total investment for infrastructure at \$130 billion to \$170 billion per year between 2018 and 2025 (AfDB, 2018) with a financing gap of \$68 billion to \$108 billion. Around two-fifths of the investment need is for water and sanitation that faces an ambitious target of 100 percent access in both urban and rural Africa.

Africa also faces higher access costs for all infrastructure services compared with other developing countries. For instance, freight costs in sub-Saharan Africa per ton-kilometre are \$0.04–\$0.14 compared to \$0.01–\$0.04 in other developing regions, leaving African markets less competitive on the international level.

The situation worsens for the 16 landlocked countries in the continent where trading costs are much higher than in African coastal countries (Foster & Briceño-Garmendia, 2010). According to the World Economic Forum's Global Competitive Index for 2014–15, more than half of the 20 least competitive countries in the world are found in sub-Saharan Africa, due, in large part, to the region's deep infrastructure deficit. A World Bank study found that the deficit reduced national economic growth by two percentage points every year and cut business productivity by as much as 40 percent, making Africa – in spite of its enormous mineral and other natural resources – the region with the lowest productivity levels in the world (Foster & Briceño-Garmendia, 2010).

Among factors explaining the low infrastructure provision in Africa according to AfDB (2018) is a weakness in infrastructure planning. The continent has more countries with low population densities than other developing regions with an average population density of 70 people per km². This is lower than that of other low and lower-middle-income countries in the world with 125 and 91 people per km² respectively.

The recognition that Africa's infrastructure gap is enormous and poses a severe threat to development has led to infrastructure programmes at the national and regional levels, such as the Programme for Infrastructure Development in Africa (PIDA) that promotes regional corridors to create conditions for higher economic density and enhanced regional markets. PIDA envisages the development of highways, railways, hydroelectric power generation capacity and interconnected power lines, throughput capacity at the ports over the years leading to 2040 (PIDA, 2011).

Key to success of the UN Sustainable Development Goals and Agenda 2063

There are global and continental goals and commitments that are expected to shape the infrastructure development in Africa, such as the UN Sustainable Development Goals (SDGs) of 2015, the African Union's Agenda 2063 of 2003, the and African Development Bank's High Five Goals of 2012. The SDGs are a global set of 17 goals for all countries of the world to pursue by 2030 based on the recognition that all countries are developing countries when it comes to sustainable development. Infrastructure is directly included in SDG 9: 'Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation'. Egler and Jurik (2017), citing OECD's work on relations between infrastructure development and SDGs, noted that more than 80 percent of the SDGs are related to infrastructure in different ways.

Agenda 2063, adopted by African countries, has a forty-years long vision of criss-crossing the continent with ‘world-class infrastructure’ (African Union Commission [AUC], 2015). Africa’s common priorities outlined in Agenda 2063 are also fed into the development of Agenda 2030 through the African Common Position on SDGs. There is a strong alignment between SDG 9 and Agenda 2063 as detailed by UNECA (2017). SDG 9 has 8 targets and 12 indicators and is aligned with eight goals of Agenda 2063. SDG 9 is thus one of the most critical goals in support of Africa’s aspiration for rapid development and transformation and achieving the other SDGs and Agenda 2063 targets. Achieving the goals should be done in ways that will boost economic development, protect the environment and provide African societies with a variety of social benefits. The continental African Development Bank has also set its High Five Goals (2013–2022) namely, lighting up and powering Africa, feeding Africa, integrating Africa, industrialising Africa, and improving the quality of life for the people of Africa. All five areas are related to infrastructure development in different ways. Unless the infrastructure deficit in the continent is addressed sustainably it will continue to be a significant impediment to the achievement of the SDGs, the Agenda 2063 goals and AfDB’s High Five Goals.

Challenges and opportunities for the African infrastructure sector

The infrastructure landscape in Africa is marred by challenges such as low levels of development, coverage, access, and maintenance of existing systems. The longevity of infrastructure poses a challenge when the infrastructure is developed in a sub-optimal way as any problems associated with it will remain in place for decades as part of a broader lock-in effect. Current construction practices are far from allowing for separation of the construction materials at the end of the service life of the structures for reusing and recycling. Infrastructure systems span over large areas of land that could be used for other purposes and the systems affect flora and fauna on surrounding areas. Broader socio-economic challenges related to technology, manufacturing capability and the human resource underpin the sector. Institutional fragmentation, low efficiency and institutional instability should be overcome for better planning outcomes. Undeveloped or underdeveloped infrastructure associated with low access, low connection and poor quality of infrastructure is a challenge for social and economic development.

On the other hand, the low level of infrastructure development provides an opportunity to plan and develop new infrastructure systems sustainably. Abundant labour at a relatively low cost, the availability of land, a young population, fast economic growth, abundant renewable energy and materials resources, the potential for increased intra-Africa trade, and the presence of transnational organisations like regional economic communities, provide opportunities for transforming the

infrastructure in African countries. If resources are harnessed properly, Africa has the opportunity to do more, to do it right, to create jobs, to influence the type of economic activities to offshoot, to account for infrastructure interdependency, to consider the full life-cycle impact and to adapt to climate change.

Addressing the challenges and capitalising on the opportunities in the infrastructure sector in Africa will be critical in creating an inclusive, low-carbon, climate-resilient and resource-efficient society.

Inclusive society

Intragenerational and intergenerational equity is the cornerstone of sustainable development. The challenge in many countries, even as they grow economically close to double-digit figures, is the ensuing inequality between low-income and high-income segments of the society. The inclusiveness aspect goes beyond the income gap in capturing how the vulnerable part of society in Africa are treated. These include children, women, youth, old people, people with special needs, the poor, rural communities and pastoralists. Lack of education, health services, decent work, and social security are among the factors that create the social divide. Most, if not all, of these deprivations are associated with connectivity and access to infrastructure systems such as schools, hospitals and health centres, transport, electricity, waste and wastewater services. A robust economic growth pathway that trickles down to people at lower-income levels should be supported by infrastructure systems that decrease the social divide through job opportunities and equitable access to health services and education (Colombo et al., 2017). Infrastructure systems should be planned and developed to support African countries to overcome socio-economic vulnerabilities by seizing opportunities such as the large young population and increasing middle class in the future. Economic conditions and needs of the new generation of Africa in the next four to five decades and beyond demands new infrastructure that creates positive socio-economic dynamics (Pegram, Seddon-Daines, Reddy, Sulieman & Baletta, 2017). Filling the quantity and quality gap of infrastructure in rural and urban Africa is a step forward in building an inclusive society. Sufficient and reliable infrastructure enhances business by creating fair conditions replacing what would otherwise be skewed toward the top high-income members of the society (Colombo et al., 2017).

Low-carbon society

A carbon-constrained world following the fulfilment of the Paris Climate Agreement requires the development of new low-carbon infrastructure systems and redeveloping existing assets with a low-carbon goal (Kennedy & Corfee-Morlot, 2013). The move to a low-carbon society needs to start by targeting the high-carbon sectors of the economy in each country for redevelopment and new

development plans, such as personal and goods transport, electricity generation, agriculture, fossil fuel extraction, transport and manufacturing (e.g., cement).

A transition to a fossil fuel-free economy requires shifting to low-carbon-intensity fuels first (e.g., natural gas) as African countries transform and leapfrog to an economy powered by renewables. With improved battery technology and innovations in personal and goods transport, Africa needs to develop its transport sector to facilitate renewably-powered electric cars. Embedded infrastructure, such as solar roads where the roads are covered with solar panels to generate electricity to power vehicles, is one innovative way of utilising land for more than one infrastructure systems. In areas where there is no other productive use of land, large-scale high-efficiency and self-cleaning solar and wind farms can be developed where transmission and distribution to where the demand for electricity is viable.

In urban centres, in addition to solar roofing, which can also be applicable in rural areas, building integrated solar PV systems should be considered where the insolation and orientation allow economic feasibility. Biofuels can play a significant role in the move to a low-carbon society in Africa if it can be done without negatively affecting food availability and prices and compromising other more important uses of the biomass. The cleanest and most economical way to develop in a significantly decarbonised path is, however, to embark on broad and substantial improvements in fuel and energy utilisation efficiency at production, transmission and distribution, and consumption stages in all sectors. Economic, technical and regulatory measures should be in place to incentivise good practices and discourage bad practices of energy consumption. Measures of deep cuts in building energy use including lighting and air conditioning, the fuel consumption of transport vehicles and other types of machinery, and energy consumption in the manufacturing sector will accelerate the journey to a low-carbon economy. A new economy fuelled by solar, wind, hydro, geothermal and other renewable sources of energy can then be built on a high-energy and carbon-efficient foundation.

Climate-resilient society

The planning and development of infrastructure systems in Africa must consider the operational context beyond two or three decades in the face of new climate future. Temperature increases due to climate change in Africa will be one and half times greater than the global increase (AUC, 2015). Some areas in the continent will get much drier in the coming decades while other parts of Africa will be wetter than before. These changes will affect the technical performance and capacity of infrastructure systems and will be detrimental to social and economic development. They need to be designed beyond mean climate conditions to 'withstand more extreme weather conditions' (Kennedy & Corfee-Norlot, 2013). The cities of

Abidjan, Accra, Alexandria, Algiers, Cape Town, Durban, Casablanca, Dakar, Dar es Salaam, Djibouti, Freetown, Lagos, Libreville, Lome, Luanda, Maputo, Mombasa, Port Louis and Tunis will be severely impacted by climate change (AUC, 2015). The urban and regional infrastructure in these cities and small island states need to be developed considering resilience and adaptive capacity. The resilience of the networks of infrastructure will be undermined resulting in underperformance in face of new climate conditions different than what they are planned for (Lempert et al., 2015). Kennedy and Corfee-Norlot (2013) rightly argue for coupling the development of comprehensive strategic infrastructure plans with national climate change goals. These long-lived investments need a built-in mechanism to protect the developed infrastructure systems from the damage that would otherwise incur greater retrofit and replacement cost (Pegram et al., 2017). Adaptive capacity in many countries of the continent should be enhanced given their existing planning systems are far from accounting for changes in configuration and capacities of the infrastructure in response to future climate change projections. Accounting for an adaptation specifically is important in the planning of climate-sensitive infrastructure systems, such as water supply infrastructure, irrigation infrastructure and hydropower infrastructure.

Resource-efficient society

The economic and non-economic wellbeing of African countries depends to a large extent on biotic and abiotic resources. A massive amount of material resources is entrenched in existing infrastructure stocks and will continue to accumulate unless there is a transformational change on how infrastructure systems are planned and developed. With increased urbanisation, this material consumption is projected to grow significantly. According to a report by the International Resource Panel (IRP), domestic material consumption per capital will be around 8–17 tonnes per year which will exceed the 6–8 tonnes per capita per year required to decouple quality of life from an increase in material consumption. Domestic material consumption in urban areas in Africa will see a growth of 790 percent by 2050 relative to 2010, which is the largest in the world. The percentage growth in Africa is remotely followed by a 220 percent growth in southern Asia while the world average will be at 116 percent (IRP, 2018). A resource-efficient economy needs to identify where most resources are used and wasted: from the huge amount of resource wastage at mining sites to waste generation at processing and manufacturing of materials and products facilities. Depending on the type of product, wastage is also rampant during consumption. A large amount of resource dissipation occurs also during the end-of-life of long-lived technical systems. Sound planning and strategic decision-making around infrastructure systems play a big role in addressing these inefficiencies and advancing a resource-efficient society. Dematerialisation,

material substitution, and reuse and recycling should be part of the portfolio of solutions in infrastructure planning. Land, another important resource in relation to infrastructure planning, will also see a significant increase in urban Africa, and by 2050, will reach a size comparable to that in the highly urbanised North American region.

Planners and politicians play a role in articulating their judgements based on technical knowledge and opinions in crafting solutions that mitigate the resource challenges of infrastructure systems. During a sustainable infrastructure planning process, knowledge from different sectors should be used and appropriate tools should be utilised.

Knowledge and tools for sustainable infrastructure

The evaluation of environmental, social and economic sustainability is one of the major criteria in the assessment of strategic plans for infrastructure (Dominguez, Truffer & Gujer, 2011). The utilisation of emerging knowledge and tools that underpin the planning and development of sustainable infrastructure is important.

Knowledge on the strategic planning of sustainable infrastructure

For sustainable infrastructure planning, development and management in Africa, discipline-specific know-how should be supported by knowledge created and deployed through interdisciplinary platforms including technical and non-technical sources of innovative ways of transforming the planning process. Sound decision-making needs inputs from knowledge surrounding planning and strategic decision-making, institutions, training and capacity building, accounting, and logistics. Knowledge about climate change futures, natural infrastructure networks and deep uncertainties arm planners and decision-makers with tools that transcend conventional approaches. All these are best served through the creation and dissemination of context-specific interdisciplinary and/or transdisciplinary knowledge that can be categorised into areas of system dynamics, nature-based solutions, smart-city solutions, and integrated and distributed infrastructure (Table 6.2).

Table 6.2 Knowledge basis useful for sustainable infrastructure planning

Knowledge base	Features	Relevant infrastructure elements or aspects	Applications
System dynamics	<ul style="list-style-type: none"> Mapping and understanding systems and interactions Modelling and facilitating analysis, communication and learning about real-world problems 	<ul style="list-style-type: none"> Technical systems, social systems and environmental systems Flows of materials, wealth, energy, labour, waste and information 	Expanding boundaries of mental models, and the time horizon to see patterns of behaviour created by the underlying feedback structure, beyond most recent events
Nature-based solutions	<ul style="list-style-type: none"> Utilising natural systems like wetlands, forests, or mangroves that can substitute conventional man-made infrastructure 	<ul style="list-style-type: none"> Dams and water treatments plants, wastewater management 	Increasing the levels of sustainability and resilience of conventional infrastructure Harnessing their additional services and non-use services
'Smart-city' solutions	<ul style="list-style-type: none"> Using disruptive technologies to affect the demand side and the supply side of infrastructure Data-driven planning and management of infrastructure networks and services 	<ul style="list-style-type: none"> Transport systems, energy systems, buildings 	Understating the different elements of urban systems and their interactions Supplying information and data for better performance
Integrated and distributed infrastructure	<ul style="list-style-type: none"> Planning for infrastructure system integrated by data, function and governance An integrated system of man-made and natural infrastructure Finding the right size and location of infrastructure networks and striking an optimal infrastructure mix 	<ul style="list-style-type: none"> Transport systems, energy systems, waste management systems, wastewater treatment systems, buildings 	Capturing synergy between infrastructure systems avoiding sub-optimal solutions Addressing value conflicts between different aspects Supra-sectoral institutional arrangements for planning and managing integrated infrastructure systems

The knowledge base outlined in Table 6.2 and related concepts and guides contribute to the transformation of African infrastructure planning bodies that need to be supported in embracing discursive strategic planning instead of conventional planning (see Table 6.3).

Table 6.3 Conventional planning versus discursive planning

Type of planning	Objective	Approach	Changes	Number of alternatives	Scenario	Adaptability
Conventional planning	<ul style="list-style-type: none"> ▪ Optimising the status quo ▪ Withstanding events of high intensity based on a statistical analysis of past trends 	<ul style="list-style-type: none"> ▪ Predict-and-act; forecasting the most probable future ▪ Reactive planning 	<ul style="list-style-type: none"> ▪ Incremental 	<ul style="list-style-type: none"> ▪ Limited 	<ul style="list-style-type: none"> ▪ Future needs 	<ul style="list-style-type: none"> ▪ Less adaptable
Discursive planning	<ul style="list-style-type: none"> ▪ Performing well across a wide range of plausible future conditions 	<ul style="list-style-type: none"> ▪ Sustainability and robustness ▪ Exploration of a wide range of future uncertainties ▪ Proactive planning 	<ul style="list-style-type: none"> ▪ Transformational 	<ul style="list-style-type: none"> ▪ Broad 	<ul style="list-style-type: none"> ▪ Objectively-assessed needs and demand management strategies 	<ul style="list-style-type: none"> ▪ Adaptable to rapid changes in demand as well as external conditions ▪ Flexibility to accommodate changes in the face of future uncertainties

Tools for sustainable infrastructure

In their work on energy policy, which can be reasonably extended to other infrastructure systems, Colombo et al. (2017) argue that extending the production-based approach to a life-cycle perspective that includes a consumption/operation phase is important in understanding infrastructural links between sectors and economies. This extension spurs life-cycle management (LCM) that integrates the supply chain with the value chain in making a significant shift from the traditional focus on internal cost savings, compliance and risk management to a broader scope that links sustainability to business values and value creation (Rebitzer, 2015). The core principle of sustainable infrastructure planning and development should be to assess the benefits, impacts and costs and hence viability of an infrastructure plan on a full life-cycle basis. Infrastructure systems as long-lasting assets are one of the most suitable areas for successful utilisation of LCM insights. Life-cycle management is about managing life cycles requiring the cross-organisational collaboration of public and private actors at all life-cycle stages and enabling them to tap into the body of knowledge and resources of each other (Nilsson-Lindén, Baumann, Rosén & Diedrich, 2014). According to Harbi, Margni, Loerincik and Dettling (2015), LCM offers a ‘flexible integrated management framework of concepts, techniques and procedures’ on how to operationalise sustainable actions by, for example, helping manage ‘expectation of stakeholders’ along the life cycle. Inspired by Jensen and Remmen’s (2006) definition of product LCM from a planning perspective, LCM is defined here as the application of life-cycle thinking

to infrastructure planning practice, with the aim to manage the total life cycle of infrastructure systems towards more sustainable development and management.

Depending on the level of application, point of entry and degree of analytical content, an ecosystem of the LCM toolbox can be classified into two groups: one group containing broader qualitative LCM elements; another group containing specific quantitative LCM elements. The first group consists of LCM elements such as LCM strategies, programmes, systems, processes and concepts, while the second group includes LCM tools and techniques and LCM data, information and models (Figure 6.1). The LCM tools and techniques that can be employed for assessing and addressing different aspects of infrastructure planning are broadly divided as procedural and analytical tools.

Figure 6.1 depicts LCM elements within a decision-making framework.

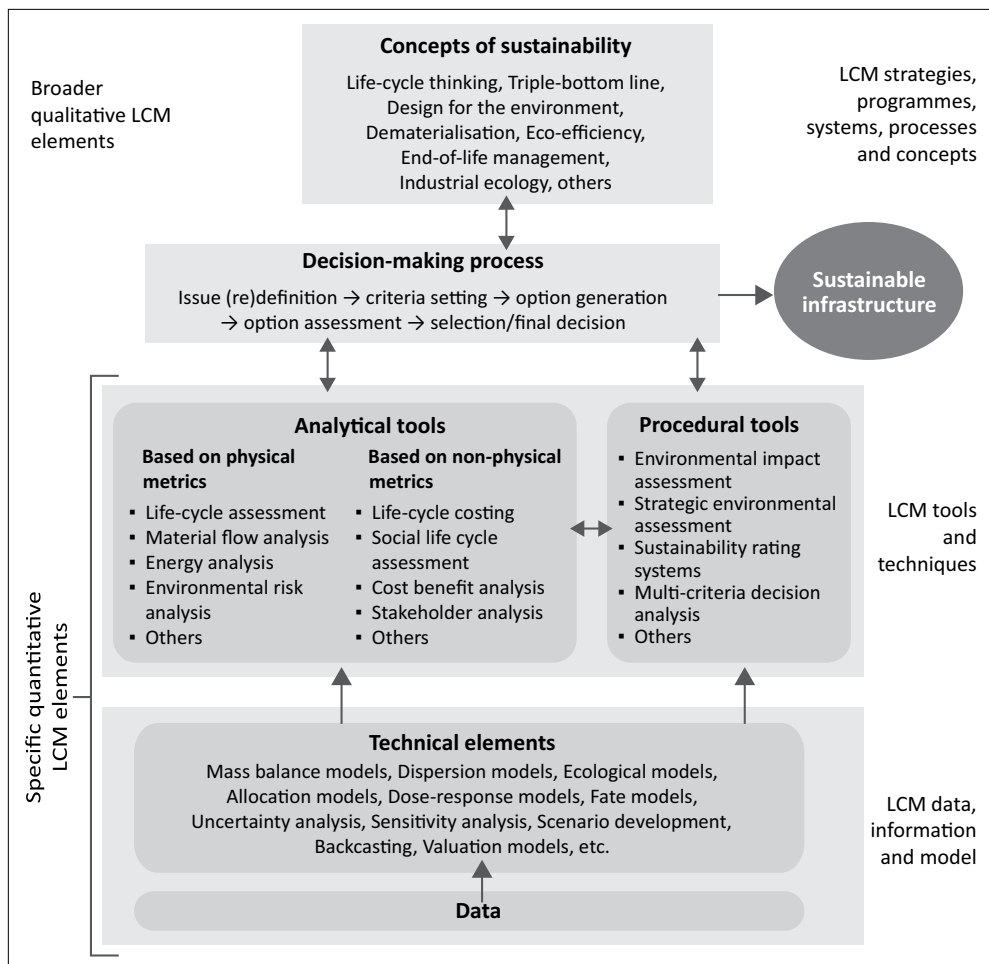


Figure 6.1 LCM elements within a decision-making framework
(Source: Diagram based on Wisberg et al., 2002:36)

The following sections present the most commonly used procedural and analytical tools for sustainability practice and those that are emerging. The discussion of the tools focuses on applicability, key issues involved and limitations.

Procedural LCM tools for sustainable infrastructure

This section discusses three procedural tools for sustainable infrastructure, namely strategic environmental assessment (SEA), sustainability rating tools and multicriteria decision-making.

Strategic environmental assessment

A strategic environmental assessment addresses sustainability issues earlier in the decision process taking the impact assessment upstream into infrastructure planning. Considering a greater scale and longer time interval, SEA focuses on policies, programmes and plans as strategic decisions points. The entry point and how SEA is deployed and for what purpose defines its strategic content and its influence on the decisions, avoiding a non-strategic application of SEA late in the process after significant decisions are made. The strategic advantage of SEA comes from its nesting into the strategic-planning and decision-making processes (Noble & Nwanekezie, 2017). Capitalising on the experience of legislated SEA in different regions of the world and the requirements of regulatory bodies and financiers in Africa, SEA should be applied beneficially in the planning and development of sustainable infrastructure systems in Africa.

Sustainability rating tools

Rating tools reward options that go beyond the legal, environmental, social and other sustainability minima to achieve distinctive sustainability performance influencing planners to consider the important issues at the most appropriate time. The rating systems are powerful planning tools that can be used to embed sustainable thinking into each decision point in the development of a plan. The tools are also helpful in communicating sustainability in a comprehensible manner to different stakeholders within and outside the planning institutions. The use of sustainability-oriented rating systems for infrastructure systems at the planning stage can be built on the experience of existing rating tools, such as the Civil Engineering Environmental Quality Assessment (UK), the Infrastructure Sustainability Rating Scheme (Australia and New Zealand) and SuRe® (Global). Some are applicable across sectors (e.g., Envision, USA) and others are sector-specific (e.g., Greenroads™, USA and international).

Africa will benefit from the dissemination and application of sustainability infrastructure rating systems adapted to the local contexts and developed through collaborations between planning institutions and universities.

Multicriteria decision-making

Planning for sustainable infrastructure that involves many aspects and variables is a subject of multicriteria decision making. Multicriteria decision analysis (MCDA) techniques help in managing decision processes typically characterised by many assessment criteria, alternatives and actions. MCDA is promoted as an appropriate tool to adopt decisions (Janic, 2003; Tudela, Akiki & Cisternas, 2006) as it provides the opportunity to integrate information about impacts and other factors with the views and opinions of stakeholders and decision-makers (Geneletti, 2005). MCDA techniques are best used as screening tools to refine a shortlist of preferred decisions and plans.

Analytical LCM tools for sustainable infrastructure

The utility of the procedural tools relies on better information and data that comes from employing analytical tools used in modelling and visualising the triple-bottom-line performance of plans and decisions enabling evidence-based decision processes that result in sustainable infrastructure. LCM has the potential to put life-cycle thinking into planning practice using relevant tools that account for the impact of infrastructure not only on the economy but also on the environment and society throughout its full life cycle (Sonnemann, Gemechu, Remmen, Frydenal & Jensen, 2015).

Some various analytical tools and methods can provide quantitative insight regarding the material and other impact aspects of infrastructure systems. Material flow analysis (MFA) and life-cycle sustainability assessment (LCSA) serve the function of analysing and appraising alternatives of infrastructure planning and development capturing the intricacies of supply chain, the operation and end-of-life management aspects. They can both be used in ‘hotspot’ analyses that help ‘identify potential solutions and prioritise actions around the most significant economic, environmental, ethical and social sustainability impacts or benefits’ of infrastructure plans (Barthel et al., 2015). Table 6.4 includes findings of life-cycle assessment (LCA) studies from the literature relevant to different types of infrastructure.

Table 6.4 Findings of life-cycle assessment (LCA) applied to infrastructure systems

Attribute	Typical environmental impact / highlights
Low population density	Impact potentials from mobility take on increased importance (Heinonen, Kyro & Junnila, 2011). Dense urban living reduces per capita transport emissions, but an increased wealth of inhabitants ultimately results in higher overall consumption and carbon footprint.
Climate variability (hot summers, cold winters)	Impacts from space conditioning take on increased importance (Goldstein, Birkved, Quitzau & Bauschild, 2013).

Attribute	Typical environmental impact / highlights
High population growth rate or economic development	Impacts from capital formation (building and infrastructure construction) take on increased importance (Goldstein et al., 2013).
Compromised waste management system	Local impacts take on increased relevance (Goldstein et al., 2013).
Significance of mobility in life-cycle assessment of buildings	To improve urban sustainability, development strategies should consider the transport infrastructure in addition to building efficiency (Bastos, Batterman & Freire, 2016).
'Smart-city' solutions at the urban system level	The importance of choosing solutions with the right focus and optimising the design to best fit the intentions (Ipsen, Zimmermann, Nielsen & Birkved, 2018).
Environmental assessment in land planning	The life-cycle assessment (LCA) framework can be adapted to environmental assessment in land planning and has the potential to provide relevant information in decision-making processes (Bistrup et al., 2015; Loiseau, Roux, Junqua, Maurel & Bellon-Maurel, 2013). Qi, Zhang, Jiang, Hou and Li (2019) adapted the existing territory LCA method to highlight regional characteristics in urban territories and applied the improved method to a Chinese city.
Sprawling and compact neighbourhoods	Occupant transportation phase plays a highly important role in neighbourhood performance. Neighbourhood development assessment should consider several variables beyond cumulative energy demand (CED) and costs (Sosa, Espinoza, Royo & Gálvez, 2017).
Sustainable buildings	Active participation by the regional government and by various authorities and institutions in the region is a key success factor in fostering a life-cycle management (LCM) approach in the building sector. Active participation by and support of industry federations and trade associations are also vital as smaller companies – a strong feature of the building sector – rely heavily on their advice and guidance. Above all, a dedicated project team is essential to start the process and then to coordinate the various actions until all partners operate with confidence with LCM (Adibi, Darul, Pasquest, Demarezt & Traisnel, 2017).
Planning of water and wastewater systems	Slagstad and Brattebø (2014) examined the system-wide life-cycle potential environmental impact of operating a city's water and wastewater system.
Waste	Landfilling is usually found in most LCA studies as the least preferred municipal solid waste management (MSWM) option. The strong dependence of each solid waste management system (SWMS) on local conditions, such as waste composition or energy system, prevents a meaningful generalisation of the LCA results as we find it in the waste hierarchy. It is recommended that stakeholders in solid waste management regard LCA as a tool, which, by its ability to capture the local specific conditions in the modelling of environmental impacts and benefits of an SWMS assists them to identify critical problems and propose improvement options adapted to the local specificities.
Roads and pavements	LCA studies that have in some way estimated the energy use due to traffic have concluded that the energy used for construction, operation and maintenance of the infrastructure only amounts to a small part of the energy use for traffic. A conclusion of this is that if the purpose is to make road transports more energy efficient it can be better to accept higher energy use for the infrastructure if it leads to lower fuel use of vehicles since it can result in lower total energy use (Carlson, 2011). A proposed GIS-based approach shows promising results for usage in LCA at an early stage of road infrastructure planning (Karlsson et al., 2017).

Attribute	Typical environmental impact / highlights
Electricity generation technologies	Direct emissions from plant operation represent the majority of the life-cycle emissions for fossil fuel technologies, whereas fuel provision represents the largest contribution for biomass technologies and nuclear power; infrastructures provided the highest impact for renewables. These data indicated that all three phases should be included for completeness and to avoid problem shifting. The most important technological aspects were identified as the energy recovery efficiency and the flue gas cleaning system for fossil fuel technologies; the electricity mix used during both the manufacturing and the construction phases for nuclear and renewable technologies; and the type, quality and origin of feedstock, as well as the amount and type of co-products, for biomass-based systems (Turconi, Boldrin & Astrup, 2013).
Renewable energy development	<ul style="list-style-type: none"> <li>▪ Renewable energy technologies show clear environmental advantages compared to fossil fuel alternatives, including a substantial decrease in life-cycle greenhouse emissions of grid electricity as well as a decrease in the extraction of fossil resources. Renewable energy substantially reduces impacts on the environment and human health, with the exception of material use (UNEP, 2015). There is a need to systematically examine end-of-life issues and ensure recycling of products, a responsibility that may fall disproportionately on local and regional authorities. <li>▪ Wind power often emerges as the renewable technology with the lowest overall environmental impact (Hertwich et al., 2015).

Material flow analysis

Infrastructure development and management play a significant role in the movement of materials and their temporary and permanent sequestration. Knowledge-driven guidance on decisions about the type, form, quantity and specific location of materials used in the construction of infrastructure systems, and what happens to the materials at the end of the lifetime of the structure is important in identifying interventions and engaging relevant life-cycle actors. In urban areas where most of the infrastructure systems are concentrated, tracking and understanding the flow and stock of materials, such as steel and concrete, is crucial for resource-efficient planning (e.g., Kennedy et al., 2015).

Material flow analysis is the earliest urban metabolism method whereby single material flows or more comprehensive lists of metabolic outflows (e.g., food, water and fuels) have been accounted for one year through cities, regions and nations. MFA should be beneficially applied at the level of the national or subnational level where the plan or the strategic decision around infrastructure is envisaged to be implemented. UNEP (2013) made the case for examining cities using material flows and recommended that cities can be restructured from a materials perspective and their infrastructure reconfigured to improve resource productivity and reduce environmental impacts. Ioppolo, Cucurachi, Salomone, Shi and Yigitcanlar (2019) proposed the integration of the mandatory procedural tool of SEA and the voluntary analytical tool of MFA, which can generate a new framework for sustainable development planning.

Life-cycle sustainability assessment

Life-cycle sustainability assessment (LCSA) is composed of environmental life-cycle assessment (LCA), economic life-cycle costing (LCC) and social life-cycle assessment (S-LCA). There is an important utility in using LCA, LCC and S-LCA elements of LCSA to capture environmental, economic and social life-cycle bottom lines throughout the life cycle of the infrastructure. The life-cycle thinking empowers the decision-makers with new opportunities of larger spans of optimisation that will, in turn, empower designers to harvest synergies and improvements by using tools and approaches of design for disassembly, design for repair, design for deconstruction and design for recycling. LCA, for example, can be employed to calculate an impact footprint of the different alternatives of planning using simplified LCA tools that generate impact results, such as global climate change, with the help of generic life-cycle inventory database to identify hotspots and trade-offs. Beyond the traditional application of LCA as a product-oriented methodology, a new LCA-based approach called 'territorial LCA' has gradually emerged to assess geographically or administratively defined systems (Loiseau et al., 2018) which would be relevant in analytical aspects of planning for sustainable infrastructure.

The economic bottom line assessed through LCC is broader than the traditional bottom line considered in current accounting systems and planning systems. Costs in LCC can be presented from the perspective of a predefined stakeholder, such as a manufacturer, a user, or society at large. Taking the societal perspective during decision making and strategic planning of infrastructure systems is both pragmatic and beneficial. LCA and S-LCA can respond in an enhanced way to the explicit requirements imposed by financiers and regulatory bodies on the environmental and social aspects of planning respectively.

Key policy and strategic issues for African countries

The megatrends of urbanisation and population growth in the African region have critical policy implications. First, as the region urbanises, policymakers must plan for resource-efficient and inclusive urban infrastructure development that can yield multiple co-benefits. Second, the African region must think strategically about urban infrastructure across a range of diverse city sizes: small, medium and large. Third, early and anticipatory infrastructure planning efforts at multiple levels of government – the national, regional and city levels – are needed to guide the sustainable development of these rapidly growing and urbanising areas from the outset to address many of the urbanisation challenges. It is becoming increasingly important to include the right sustainability and resilience aspects into the planning and development of infrastructure systems.

Infrastructure planning and development in Africa faces several constraints. These include geographical constraints, deficiencies in planning, fragmented planning, institutional inefficiencies, regulatory bottlenecks, and a lack of planning and implementation skills. Key measures to address these challenges should consist of the following elements:

- **Articulating national strategies and leadership for sustainable infrastructure:** Aligning policy goals across and within various levels of government including a clear long-term vision and targets for sustainable infrastructure.
- **Strengthening urban planning linked with integrated infrastructural planning:** Promoting and employing integrated infrastructure planning that goes beyond sectoral silos.
- **Institutional capacity building and reform:** Building human and institutional capacity and providing adequate tools to planners and designers.
- **Increasing access to LCM skills:** Creating new programmes and strengthening existing curriculums.
- **Partnerships, knowledge management and community engagement:** Encouraging collaborations and participation.

Articulating national strategies and leadership for sustainable infrastructure

There is a need for national authorities to clearly articulate a clear and comprehensive national strategy for sustainable infrastructure and embed it in an overall policy strategy for sustainable and inclusive growth and development. Ideally, a single integrated strategy for low-carbon, resource-efficient, climate-resilient and sustainable development should map to national and local planning and sector plans to guide investments. Countries need to adopt the principle of sustainable infrastructure as a national policy in all planning processes. This policy would be supported by strategies in key infrastructure sectors with clear long-term goals to incentivise the implementation of sustainability practices. Such an integrated strategic framework:

- ensures coherence across public policy actions and investments;
- facilitates coordination across sectors and levels of government; and
- provides the clarity and confidence needed by investors.

Leadership is required for the development of a long-range strategic plan for sustainable infrastructure founded on well-understood national and local aspirations and aligned with the UN SDGs and the nationally determined contributions derived

from the Paris Climate Agreement. A top-down approach to sustainable infrastructure planning maintains the focus on broader and strategic policy objectives in helping form a strategic view on where investments needs are most pressing. Providing stable long-term direction to infrastructure investment whilst retaining the flexibility needed to deal with uncertainty over long horizons is critical.

African countries need to consider setting up national bodies similar to the UK National Infrastructure Commission aimed at providing the government with independent expert advice on major infrastructure challenges and developing a strategic framework for planning major investments beyond the timeframe of electoral cycles. These national bodies can be tasked to undertake a national infrastructure assessment; make recommendations to the government and then hold the government to account on implementation; produce reports, independent of government and all stakeholders, based on rigorous evidence; and identify entry points and mechanisms to allow for the greatest impact of sustainable infrastructure.

Addressing fundamental price distortions for natural resources and infrastructure services, such as fossil fuel subsidies and the lack of carbon pricing, is also key to improving the public policy environment for sustainable infrastructure. In avoiding a bias of infrastructure investment toward high-carbon sources of energy, favouring unsustainable infrastructure and undermining efficiency in energy use, appropriate government actions are needed to address negative incentives and externalities. Tools based on life-cycle thinking are needed to integrate sustainability-related aspects into the planning and decision-making process. Governments need to ensure that such tools and standardised approaches for the implementation of the sustainable infrastructure policy are available in the public sector and utilities and understood by the private sector so that they contribute to benchmarking and create a common language among all stakeholders.

Strengthening urban planning linked with integrated infrastructural planning

Urban planning needs to guide urban expansion and the associated infrastructure should be strengthened to reduce sprawl, enhance densification and prevent development in precarious environmental zones. New urban planning aimed at lowering infrastructure costs and increasing density can help address the issue of productivity costs and can reduce the urban sprawl that is putting pressure on agricultural land and the environment.

Using the concept of a compact city, offered as an alternative to urban sprawl and adopted as policy by some countries, strategic spatial plans linked to infrastructure development can promote more compact forms of urban expansion focused around public transport (UN Habitat, 2009). An infrastructure plan is a key element of

such strategic spatial plans where transport and land-use linkages are the most important taking precedence over other forms of infrastructure such as water and sanitation trunk infrastructure that follows (UN Habitat, 2009). The integration of land use and transport planning can be improved through the earliest possible definition of land-use needs for new and future infrastructure corridors and sites, followed by adequate land-use control and acquisition. Without integrated planning that promotes sustainability principles and coordination between different infrastructure sectors, infrastructure will likely be a source of negative environmental and social impacts over the coming decades and opportunities will be lost for synergistically advancing the SDGs and sustainable economic growth. Planners could use checklists to assist them in developing proactive collaboration for infrastructure planning. Barriers to integrated infrastructure planning must be addressed. These include insufficient institutional capacity, lack of expertise, and political and cultural challenges at the national level.

Institutional capacity building and reform

The provision of ‘hard’ infrastructure can be significantly constrained by weak ‘soft’ infrastructure such as institutions and capabilities. The institutional capacity of African countries to develop robust infrastructure plans and implement them is fundamental in facilitating sustainable infrastructure investments. Deficient institutional capacity leads to wrong planning and jeopardises the achievement of commitments such as the UN SDGs and NDCs. There is a need for more awareness-raising activities on sustainable infrastructure to shift the policymakers’ mindset in understanding and embracing the sustainable infrastructure imperative, and accelerating the development and standardisation of appropriate frameworks and tools. There is also a need for institutional reform by governments as part of the efforts of building the capacity to develop and communicate long-term sustainable infrastructure plans that eventually lead to a pipeline of bankable infrastructure projects for investors.

A key challenge is to develop capacity and practice to systematically incorporate climate risks and sustainability criteria into the long-term infrastructure plans. In addition to capacity-building courses for practising planners and related professionals, efforts should also be focused on stimulating inter-agency and inter-ministerial coordination (through a supra-ministerial coordination unit) and communication in developing and implementing infrastructure plans that overcome silo thinking and reap synergies among different infrastructure plans and systems. There is a need to build institutional capacity for sustainability assessment by incorporating it into line agencies supported by in-house life-cycle management experts or by relevant independent professional associations.

Part of the institutional reform and capacity building efforts is learning from experiences in other countries with some best practices of planning. Boxes 6.1 and 6.2 provide summaries of best practices of planning from a developed country. The exemplary work from the city of Bogotá is shown in Box 6.3 as an example of best practice from the developing world.

Box 6.1: Integrated vision in brownfield development in Sweden

Hammarby Sjöstad is a district in Stockholm that has been under development for years. It is an old brownfield of industrial area that has been transformed into a sustainability model residential and commercial area visited by many local and international visitors. Its success story can be traced to the integrated view of the energy, transport and waste management infrastructure which was realised as it was considered from the outset during the planning process taking relevant stakeholders on board early. Gu, Vestbro, Wennersten and Assefa (2009) underscored how the planning dealt with conflicts of interest and multiple objectives such as technical, social, practical, economic and aesthetic objectives. Planning decisions were not left to planners from Stockholm’s office of city planning only. The planning team included people from the office of environment and those municipal entities responsible for roads and real estate, energy, water and waste (Kasioumi, 2011). The planning process is highlighted as proactive, visionary, collaborative and communication-intensive where planners were helped by national planning systems while using the neighbourhood plans to ensure attributes of ‘containments, compactness, environmentally-friendly design, green space, and public transit’ (Kasioumi, 2011). It was emphasised that an integrated vision of interrelated goals is an important starting point. As reported by Berger (2017a), Hammarby Sjöstad’s higher upfront cost associated with energy and resource-efficiency investments was justified based on the life-cycle cost analyses used to guide planning and investment decisions under the direction of Stockholm’s planning and development administration. The process behind HS involved ‘thorough analytical work, comprehensive planning, sound public policies, adequate financing, and management controls tied to specific deadlines and deliverables’ (Berger, 2017a: para. 28).

Box 6.2: Performance target and collaborative process in Sweden

The Stockholm Royal Seaport (SRS) is in another part of Stockholm that builds on the experience of planning and developing Hammarby Sjöstad. The integrated view of infrastructure has gone even further in accommodating different scenarios in the planning process. It aims at reducing the per capita carbon dioxide emission to 1.5 tonnes per person per year which is compatible with the global cap of 2°C based on the Paris Agreement. The reason for the success story of Hammarby Sjöstad, and later picked up SRS, was attributed to the development of a guiding plan or programme that from the outset outlined the vision, goals and objectives. In the SRS case, its environmental and sustainability programme contains climate-adapted and green outdoor environment, sustainable energy systems, sustainable recovery systems, sustainable water and wastewater systems, sustainable transport, environmentally-adapted residential and commercial premises, sustainable lifestyles and sustainable businesses. *(continued on next page)*

The programme was developed through a collaborative process that involved five of Stockholm city's departments (city planning, city development, planning, city environment, city traffic and local district administration), developers and construction companies, energy, water, waste service providers and academia (Holmstedt, Brandt & Robèrt, 2017).

Box 6.3: Bus Rapid Transport and land use in Colombia

Bogotá is perceived as an interesting case when considering urban issues. The positive changes experienced by this city of eight million people in just a decade have raised international interest from policymakers, researchers and multilateral institutions. The perception about Bogotá changed from an example of a failed city to an example of a sustainable and promising one. The main symbol of this change is indisputably the Bus Rapid Transit (BRT) system called TransMilenio. It is widely recognised as one of the world's best systems, with high-capacity, high-quality buses that make 1.6 million passenger-trips daily. TransMilenio has also influenced other aspects of Bogotá's structure and life, such as land use, productivity, road fatalities, and even crime and health issues. However, the mutual impacts between land use and transport in Bogotá during the past two decades have also been influenced by other elements such as the creation of a regulatory framework for urban planning that provided new public instruments, an improvement of local institutions, a transport policy that prioritised public transport over car infrastructure, and a political and economic context that promoted a dense, transit-oriented city. For a number of developing cities in a similar situation, Bogotá is an interesting example. In terms of land use/transport links, it serves as a rare and quite useful 'laboratory', as it enables the evaluation of changes after a new mass transit system was introduced in the main corridors of the city (Bocajero & Tafur, 2013:3).

Increased access to LCM skills

The use of life-cycle concepts and tools at the national level in Africa is non-existent or very limited due to the lack of a capable workforce and limited availability of databases (Machado & Cavenaghi, 2009). They are yet to be incorporated and acknowledged, through scientific research, educational programmes, business practices and national policies. There is a need to reform existing and developing new curricula in many engineering and planning schools in Africa where the education and training programmes have not kept up with challenges of supporting sustainable infrastructure planning and development. Engineering schools need to provide future engineers and technicians with the knowledge, tools and techniques that they need to design, build and manage sustainable infrastructure and to take a leadership role in making infrastructure sustainable. Courses that prepare engineers to interpret/employ life-cycle management within decision-making processes will fill the current knowledge and skills gap in professions relevant to sustainable infrastructure. Planning schools should embrace innovative planning ideas with an increased focus on skills in participatory planning, communication and negotiation,

and LCM strategies, programmes, systems, processes and concepts. There should be a more systematic approach to the education of infrastructure professionals on LCM tools and techniques and a strengthening of the research community concerning LCM. The development of LCM analysts as a new profession should be considered in training professionals with a basic understanding of infrastructure planning and development. In the interim, the necessary capacity and skillsets to influence future planners can be developed through the integration of LCM-related subjects in disciplines such as economics.

Expanding and improving technical vocational education and training (TVET) programmes in Africa can play an important role in filling the skills gap in sustainable infrastructure development in the continent. Better-quality TVET programmes with better alignment with skills demand in the sector and well-designed job placement programmes upon graduation can be used to improve the role of TVET in lowering youth unemployment while creating sustainable infrastructure. A complementary action is the strengthening of professional organisations and international professional networks to offer continuous professional development courses on sustainable infrastructure. Potential drivers for mainstreaming LCM application, such as environmental labelling schemes and green procurement, need to be developed and expanded building on lessons learned from experiences in Europe and North America.

Partnerships, knowledge management and community engagement

Efficient policy planning, design and implementation, which drives sustainable infrastructure development, should rely on integrated and participatory approaches. This implies not only alignment of the objectives of the various policies (e.g., industrial, trade and infrastructure), but also dynamic consultations between all relevant stakeholders including government agencies, the private sector, academia, local communities and regional and international partners. In tapping into the comparative advantages of each entity, better coordination and collaboration between national and regional programmes are needed for the successful development of cross-border infrastructure systems such as transport and energy corridors, aiming at fostering regional integration. Local authorities should encourage collaboration internally across departments, and externally with national government agencies.

A key to successful planning and development of sustainable infrastructure is sharing knowledge and experiences among specialists. Web-based knowledge platforms on sustainable integrated infrastructures can be developed to help promote better engagement, function as a one-stop-shop for easily accessible and

reliable information and become a forum for contributing ideas and solutions. Good infrastructure relies on and enables effective governance whereby people are informed of developments around them and are supportive of them. Visioning is an important early step in developing a holistic strategy for infrastructure planning. Visioning can provide opportunities to educate the community on how infrastructure systems work and how factors such as changing technology, climate change, and resource management affect our ability to create and maintain sustainable infrastructure systems. Community engagement is essential in identifying acceptable alternatives that reduce demand on infrastructure systems and exploring all options before spending money in planning and developing larger systems.

A framework for strategic planning of sustainable infrastructure in Africa

A framework that can create a collaborative platform for key professionals to work in an integrated manner in infrastructure planning is proposed. This framework is aimed at ensuring that sustainability is a planned outcome of an integrated approach, not a random add-on result. The framework is for use by planners, decision-makers and policymakers at the highest levels of national and subnational bodies relevant for the planning and operation of infrastructure systems. The framework is based on the following principles:

1. Forming broader long-term plans through a strategic planning approach instead of a piecemeal approach.
2. Employing a comprehensive life-cycle perspective instead of a limited perspective.
3. Adopting a shared vision of sustainable infrastructure based on a common understanding of explicitly-articulated performance criteria among stakeholders that have traditionally functioned in silos.
4. Considering nature-based solutions in the provision of infrastructure services.
5. Adapting infrastructure systems to climate change and extreme events.

The framework seeks to achieve the following objectives:

1. To involve public authorities, utility companies, planners, engineers and other affected stakeholders starting from the early stages of the planning phase.
2. To measure the value of sustainable infrastructure and its sustainability benefits throughout the planning phase.

3. To weigh the full benefits and costs of options that achieve the intended outcome over the life cycle of the infrastructure systems.
4. To create and strengthen capacity at relevant levels of government and industry and enable expertise alignment to deliver on sustainable infrastructure.
5. To create economic incentives for sustainable infrastructure that drives innovation.
6. To educate, engage and inspire public support for sustainable infrastructure.

The structure and content of the framework

The framework provides for use of the different elements of the LCM ecosystem in enabling decision making for sustainable transformation of infrastructure sectors in the face of future uncertainty and rapid changes. The LCM elements help in screening and mapping the different trade-offs faced in developing 'more sustainable' infrastructure (Truffer, Störmer, Maurer & Ruef, 2010). They facilitate transparent and reflexive communication while not covering all aspects of the overall strategy-making process. Infrastructure planning happens at several levels depending on the kind of infrastructure and the functions devolved to the different departments, national agencies and subnational spheres of government. A life-cycle approach should underpin planning and decision-making. The ability to influence the life-cycle economic, social and environmental impact is greatest during the earliest stages when sustainability goals are formulated. Figure 6.2 depicts the framework for a collaborative platform for the integration of sustainable infrastructure planning functions at national and local levels and the application of different elements of LCM detailed in Table 6.5.

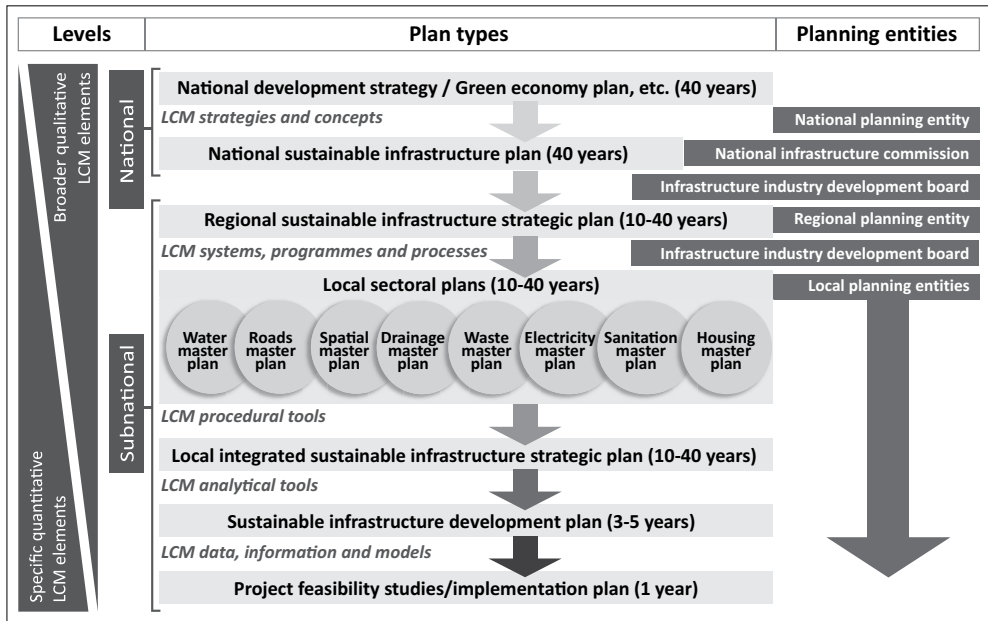


Figure 6.2 Framework of sustainable infrastructure planning and the role of LCM elements

Table 6.5 Cascading from national to local planning and LCM elements

Level of planning			Time frame	LCM elements for sustainable infrastructure
National	Macro	National development strategy/ Green economy plan	10–40 years	<ul style="list-style-type: none"> Mainly broader qualitative LCM elements Visioning Scenario planning
		National sector planning		
		National spatial development plan		
		National infrastructure commission		
Provincial	Meso	Provincial growth and development strategy		<ul style="list-style-type: none"> A mix of broader qualitative and specific quantitative LCM elements
		Provincial spatial development strategy		
		Provincial sector planning		
Local		Local development strategic plan	Ongoing	<ul style="list-style-type: none"> A mix of broader qualitative and specific quantitative LCM elements Sustainable infrastructure rating tools Planning guidelines for sustainable integrated infrastructure in cities
		Local spatial development plan		
		Local sector master plans	10–40 years	
		Local medium-term integrated development plan	5 years	
	Micro	Project feasibility studies and implementation	1 year	<ul style="list-style-type: none"> Mainly specific quantitative LCM elements Sustainable infrastructure rating tools Sustainable procurement programmes Safeguards

Applying the framework: Planning process, assessment and institutional architecture

In applying the proposed framework, there are five conditions for success that should be fulfilled by the supporting tools: (i) covering the full life cycle of infrastructure systems, (ii) covering all components of the triple bottom line, (iii) enabling the engagement of life-cycle stakeholders, (iv) accounting for important material aspects, and (v) employing rating systems. To this end, life-cycle management-oriented adaptive strategic planning process; strategic environmental assessment with a life-cycle sustainability assessment content; and life-cycle management driven institutional architecture are important.

LCM-driven adaptive strategic planning process

The first step of the process is preliminary consideration of objectives, constraints and available options with respect to the analysis of the existing situation. This step includes enumerating conditions for success and specifying desirable outcome to be included in a base plan. Then an iterative process of incorporating a series of additional targeted actions, such as ‘mitigating actions’, ‘hedging actions’, ‘seizing actions’ and ‘shaping actions’, are incorporated in refining the base plan to a final plan (Kwakkel, Walker & Marchau, 2010). These actions are included as part of the plan to proactively deal with vulnerabilities, seize opportunities and shape external forces. The iteration includes analysis of the base plan and an in-advance identification of opportunities that will improve the plan’s success and vulnerabilities that cause the plan to fail.

Table 6.6 provides an example of these drivers of actions (vulnerabilities, opportunities and external condition) for an energy plan.

Table 6.6 Actions for the refinement of a base plan: An example of an energy plan for expanding access using a modular renewable energy system based on domestically manufactured technologies

Actions	Driver	Examples of drivers	Action (example)
Mitigating action	Certain vulnerabilities	Climate change	Include climate-resilient element
Hedging actions	Uncertain vulnerabilities	Technology change	Plan element that responds to a range of changes
Seizing actions	Certain opportunities	New university programmes on renewable energy	Include actions that will utilise the graduates
Shaping actions	External conditions or events	Low level of public awareness	Increase awareness by marketing

The refined base plan should also include a list of signposts to be monitored once the plan is implemented. The purpose of the monitoring system to be included as part of the plan is to trigger ‘defensive actions’, ‘corrective actions’, ‘capitalising

actions' and 'reassessment' depending on the type of threshold of the monitored signposts reached (Kwakkel et al., 2010). Defensive and corrective measures deal with actions that can lead to keeping or adjusting the implemented plan respectively. Capitalising measures are taken to utilise opportunities that come up with the goal to further enhance the performance of the implemented plan. The monitoring system that can trigger responsive actions is put in place to make the plan an adaptive plan that consists of the planned adaptations and a triggering monitoring system.

Table 6.7 depicts an example of an energy plan with signposts that are monitored during the implementation of the plan.

Table 6.7 Actions for adapting a plan under implementation: Example of an energy plan for expanding access using a modular renewable energy system based on domestically-manufactured technologies

Actions for refinement of base plan	Signpost types	Example of signposts	Action examples (Outcome)
Defensive actions	Triggers that don't require adjusting plan	Public acceptance issues	Conduct clarification activities (plan remains unchanged)
Corrective actions	Triggers that require adjusting the plan	Change in demand pattern	Resize the system by adding or reducing modules (the plan is adjusted)
Capitalising actions	Opportunities	Better technology available at lower cost	Take advantage by using the new technology (improved performance of plan)
Reassessment	Critical analysis and assumptions behind the plan no more valid	Domestic capacity didn't develop	Consider imported technology is possible (significant change to the plan, discarded plan, new plan)

Each step of the iterative process of developing the final plan will be informed by different elements of LCM with the goal of supporting a strategic planning process that enhances the prospects for sustainable transitions in infrastructure sectors. The planning process is based on the recognition of multiple futures and multiple types and sources of uncertainty, such as demand, technological, climate change, demographic and lifestyle. The adaptive planning process that emanates from the proposed framework outlined requires close collaboration between planners and LCM analysts during the steps of analysis of characteristics of the infrastructure system (e.g., challenges), identification of key contextual factors, assessment of the scope of uncertainties of the future, iterative combination of possible future contextual conditions, identification of options for future technological and organisational configurations, assessment of the strengths and weaknesses, ranking of the options relative to specific stakeholder preferences, synthesis of resulting assessment, presentation of plans and recommendations to decision-makers and stakeholders (e.g., Truffer et al., 2010).

The participatory element of the planning process enables exposition of contradicting interests and trade-offs involved in the fulfilment of multiple sustainability objectives (Malekpour, Brown & de Haan, 2015). The overall purpose is to support greater integration of different social and natural science disciplines in a strategic planning process through multi-faceted input and engagement to be coordinated by LCM analysts.

SEA with a life-cycle sustainability assessment content

Exploring the environmental, economic and social bottom lines – collectively called the triple-bottom-line of infrastructure development – within a SEA frame using life-cycle sustainability assessment can unleash a broader range of synergies that would otherwise be left untapped. Diagnostic tools of LCSA to carry out analysis feed into operational frameworks of strategic planning and decision-making using the SEA vehicle to take the planning practice to new modes of operation. The simultaneous running of the planning process and the SEA process iteratively assesses, finds alternatives and optimises solutions that will continuously make up the final plan (Bidstrup & Hansen, 2014). SEA with a life-cycle sustainability assessment content enables the advantage of the analytical capability of the quantitative and qualitative tools in providing life-cycle insights. As outlined in Bidstrup and Hansen (2014), within the process of undertaking SEA, insights from LCA and S-LCA can, for example, be used to inform and support a significant number of the basic elements of legislated SEA.

Higher elements of LCM are more practical for use at the higher and broader level of the national planning process. The analytical tools can also be applied at the same level to broadly assess the alternatives using established databases and indicator sets. At this stage, generic LCA databases such as Ecoinvent can, for example, be used for the environmental life-cycle part, while S-LCA databases such as PSILCA can serve the same purpose for the social life-cycle impacts. Enriching the planning process with the LCM elements offers a better understanding of the material and non-material components of the infrastructure and in teasing out the different subsystems and the interactions between them. The approach that expands the system boundary beyond the conventional elements provides opportunities for understanding synergies and multiple possibilities of linkages by identifying opportunities in renovating existing infrastructure systems and in developing and implementing new plans. Red-flagging areas of concern well in advance enables planning effective and timely mitigation and adaptation measures. The approach also allows for experimenting with the implication of alternative pathways and reflexive iteration and adaptation of alternatives.

The LCM elements can be introduced in varying dosages at different entry points before and after the potential strategies are drafted (see Figure 6.3). For example, generic social and environmental databases and available off-the-shelf environmental product declarations on major products can be utilised at the stage of identifying strategic issues well before developing the strategies by screening out underperforming alternatives based on generic comparisons. This will help shape the iterative drafting and evaluation of candidate strategies through quick and dirty studies. Once a draft list of specific strategies is on the table, the generic databases can be complemented with environmental and social data that can be collected from primary sources to make a final evaluation of specific strategies.

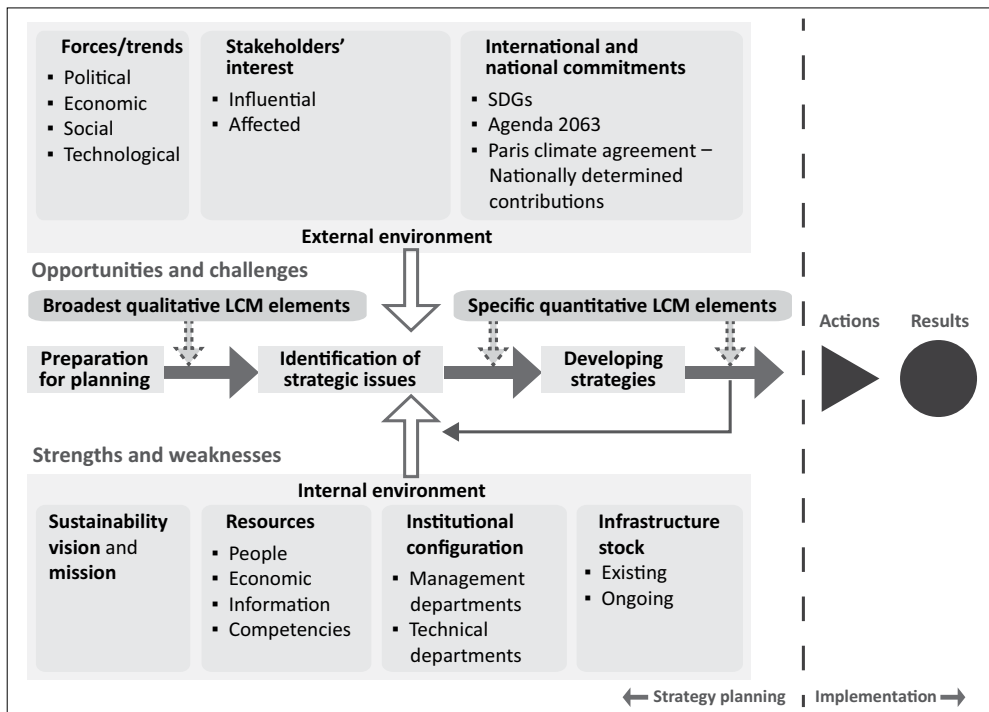


Figure 6.3 Strategic planning process (Source: Diagram adapted from Bryson, 1988:75)

LCM-driven institutional architecture

In the African national and transnational infrastructure development landscape, there are a many subnational, national and international institutional stakeholders. LCM can be applied to facilitate both technological and institutional reconfiguration in supporting new and effective institutional configurations by realigning influential and affected stakeholders. Recognising the interplay between facts and values, knowledge and opinion, there is a need for moving from conventional evaluation processes of plans to an integrated process that leads to more sustainable outcomes by positively changing the mental models of decision-makers. LCM-driven

institutional configuration brings order to the knowledge and data surrounding infrastructure systems. It opens the strategy-making and planning process and helps in communicating developed strategies. It facilitates participatory processes not only in the overall process but also in sub-processes such as modelling (Pahl-Wostl & Hare, 2004). LCM assists in structuring the participation of experts and stakeholders based on where in the life cycle of the infrastructure their impact is more pronounced. LCM analysts can coordinate infrastructure experts and stakeholders to integrate their contributions into the planning and the strategic decision-making process.

One important aspect is having a supra-ministry and inter-sectoral entity that recognises the whole of infrastructure as one system larger than what is normally handled by sectoral ministries, and the need for an independent body of expertise that supports such entity. Box 6.4 presents the National Infrastructure Commission of the UK, which is a good example of such an independent body that supports the government on strategic aspects of infrastructure systems.

Box 6.4: National Infrastructure Commission

The UK's National Infrastructure Commission (NIC) was established as an executive agency of the Treasury to provide impartial, expert advice and make independent recommendations to the government on infrastructure systems.

The NIC operates independently from the government while advising on all sectors of infrastructure: energy, transport, water and wastewater (drainage and sewerage), waste, flood risk management and digital communications. The NIC considers the potential interactions between its infrastructure recommendations and housing supply.

In carrying out its role, the NIC produces:

- a national infrastructure assessment (NIA) once in every Parliament, setting out the NIC's assessment of long-term infrastructure needs with recommendations to the government; and
- an annual monitoring report, taking stock of the government's progress in areas where it has committed to taking forward the recommendations of the NIC.

The NIC also produces specific studies on pressing infrastructure issues challenges. These are set by the government and take into account the views of the NIC and stakeholders. These studies include recommendations to the government.

The NIC takes a strategic approach, which links long-term priorities with short-term action and considers infrastructure as a system, not as a collection of silos. This approach maintains an international perspective, engages closely with leading-edge expertise and is open to new approaches and ideas.

Reports and analysis from the NIC are of the highest quality and independent of government and all vested interests. The reports make recommendations based on rigorous evidence and develop an evidence base which sets a standard in its quality and breadth.

(Source: NIC, 2017:3)

Conclusions

Sustainability of infrastructure systems is closely related to the material aspects of the structures and networks of moving people, goods and services and information. Hence, a better understanding of the use of conventional and new materials is critical. The limitation of the current practice of material choices and utilisation is the focus on traditional criteria of price and limited technical criteria. The type and quantity of materials used should be based on full knowledge of the design, construction, operation and maintenance as well as end-of-life fate of the materials fixed into the structures and networks in permanency. This environmental lens is best complemented by subscribing to the social and economic evaluation of the multiple material-related choices along the life cycle of the infrastructure systems. Good choices and decisions on how these systems are planned and developed have far-reaching impacts on other parts of the economy and society at large. Data and information from natural and social sciences and the humanities need to be purposefully utilised to avoid short-sighted and narrowly-evaluated and approved solutions.

The core principle of sustainable infrastructure planning and development is to assess the benefits, impacts and costs and hence viability of an infrastructure plan on a full life-cycle basis. To support the implementation of this principle in practice, LCM tool for environmental (LCA), economic (LCC), and social impacts (S-LCA) enable engineers, designers, and decision-makers to better understand the environmental, economic and social impacts of infrastructure and the opportunities that exist to reduce them.

Life-cycle management methodologies help in appropriately identifying and pricing sustainability-related risks and impacts of non-sustainable infrastructure and the broader long-term co-benefits of sustainable infrastructure. This makes a convincing case that sustainable infrastructure not only is better for people and the environment but also makes business sense (Global Infrastructure Basel Foundation, 2017; International Finance Corporation, 2017; International Institute for Sustainable Development, 2017). Another important principle of sustainable infrastructure development is to consider integrated needs in the early stages of planning and delivery for example, integrated approaches linking transportation, mixed-use development and the avoidance of developments in flood plains. The development planning should also encourage biodiversity in city landscapes through the creation of blue-green corridors which integrate water management functions with green infrastructure, sustainable urban drainage systems, etc.

Africa needs infrastructure systems that are planned and developed with sufficient flexibility to accommodate change. The interaction between disciplines and their

influence within a functioning intellectual ecosystem determines the success of the planning process. The presence of a strategic planning process equipped with proper analytical tools should be matched by a corresponding strategic institutional context. LCM is proposed to coordinate the organisational configuration required to advance sustainable planning, development and management of infrastructure systems in Africa. There is a need for influencing the action space of facts informed by specific quantitative LCM elements and the deliberative space of values by broader qualitative LCM elements. The implementation of the proposed approach is better done through flexible and adaptable processes recognising that planning is more than a structured and linear process.

The proposed approach is meant to contribute to efficiency, increased legitimacy and the general quality of decision making. It is best applied early in the overall strategic planning process of infrastructure systems where it can ‘take full advantage of its capacity to strategically influence the strategic direction of PPPs, or the decision-making process itself’ (Lobos & Partidario, 2014: 39). Such early positioning helps to inform the strategic dialogues, define strategic objectives, identify strategic issues and formulate strategic options around the type and size of infrastructure systems. The LCM elements help to broaden the scope of the planning life cycle to account for the full life cycle of the infrastructure system and cover a full range of opportunities and risks. Planning and strategic decision making are currently done in a fragmented way emphasising or overemphasising only part of the bigger reality the planning or the decision making seeks to change. This suboptimal departmentalised approach falls short of capturing the full range of societal benefits of maximising opportunities and minimising risks.

There is a need to look at the whole portfolio of infrastructure systems and find a way to have a low life-cycle impact portfolio by shortlisting alternatives with the best triple bottom line considering external sustainability-oriented economic environments. Whenever possible, the strategic planning needs to account for a shift from large-scale and centralised infrastructure systems to small-scale and diversified capacities. The contribution of LCM to changing the way we currently do strategic decision-making and planning is providing better information and data input to the process and improving the process of planning and decision making. The first entry point of the broadest qualitative LCM elements in the strategic planning process is the earliest stage of where the questions of ‘why’ and ‘what’ are asked at the highest level of national decision-making and planning rather than the ‘how’ questions at the middle or lower subnational level of planning. Institutions that work with this integration need to have the right level of LCM competence for use at each stage of the planning process.

There is clearly a lag between acquiring scientific knowledge and utilising the new knowledge in practice. A good starting point in dealing with this issue is a gradual trickling of relevant components of the knowledge into the different elements of the planning practice, and in the process, reconfiguring the associated organisational structure to match the new changes. In building the necessary capacity and skillsets, integration of LCM-related subjects in disciplines such as engineering and economics to influence future planners will be important.

References

- Adibi, N., Darul, M., Pasquest, V., Demaretz, C. & Trainsel, C. (2017). Life cycle management for regional development in France. Example of building sector. In: S. Massari, G. Sonnemann & F. Balkau, *Life cycle approaches to sustainable regional development*. London: Routledge.
- African Development Bank. (2013). *An integrated approach to infrastructure provision in Africa*. Tunis: AfDB.
- African Development Bank. (2018). *African economic outlook 2018*. Côte d'Ivoire: AfDB.
- African Union Commission. (2015). *Agenda 2063: The Africa we want. Framework document*. <https://bit.ly/35PLemI> [Accessed 20 September 2019].
- Ainger, C. & Fenner, R.A. (2014). *Sustainable Infrastructure – Principles into practice*. London: ICE Publishing. <https://doi.org/10.1680/sipp.57548>
- Assefa, G. (2019). Life cycle insights for creating sustainable cities. In: A. Al-Musaed & A. Almssad (Eds), *Sustainable cities: Authenticity, ambition and dream*. London: IntechOpen. <https://doi.org/10.5772/intechopen.81633>
- Barthel, M., Fava, J.A., Harnanan, C.A., Strothmann, P., Khan, S. et al. (2015). Hotspots analysis: Providing the focus for action. In: G. Sonnemann & M. Margni (Eds), *Life cycle management*. Dordrecht, Netherlands: Springer. https://doi.org/10.1007/978-94-017-7221-1_12
- Bastos, J., Batterman, S. & Freire F. (2016). Significance of mobility in the lifecycle assessment of buildings. *Building Research & Information* 44(4): 376–393. <https://doi.org/10.1080/09613218.2016.1097407>
- Berger, J.J. (2017a). Stockholm pursues climate Holy Grail: A fossil fuel-free future – Part 5: New eco-districts. <https://bit.ly/2pweyhs> [Accessed 27 February 2018].
- Berger, J.J. (2017b). Copenhagen, striving to be carbon-neutral: Part 2, the bold strategy. <https://bit.ly/2MYgpdn> [Accessed 27 February 2018].
- Bidstrup, M. & Hansen, A.M. (2014). The paradox of strategic environmental assessment. *Environmental Impact Assessment Review* 47: 29–35. <https://doi.org/10.1016/j.eiar.2014.03.005>
- Bocajero, J.P. & Tafur, L.E. (2013). *Urban land use transformation driven by an innovative transportation project, Bogotá, Colombia*. Case study prepared for the Global Report on Human Settlements 2013. <https://bit.ly/31ph8Ty> [Accessed 20 September 2019].
- Bragança, L., Vieira, S. & Andrade, A.J.B. (2014). Early stage design decisions: The way to achieve sustainable buildings at lower costs. *Scientific World Journal* 2014: 1–8. <https://doi.org/10.1155/2014/365364>
- Bryson, J.M. (1988). A strategic planning process for public and non-profit organizations. *Long Range Planning* 21(1): 73–81. [https://doi.org/10.1016/0024-6301\(88\)90061-1](https://doi.org/10.1016/0024-6301(88)90061-1)
- Carlson, A. (2011). *Life cycle assessment of roads and pavements. Studies made in Europe*. VTI report 736A. Linköping, Sweden: VTI Publications.
- Colombo, E., Leon, P., Taisch, M., Cheli, F., Pinzone, M. et al. (2017). *Toward smart and integrated infrastructure for Africa – an agenda for digitalisation, decarbonisation and mobility*. Rome: The Infrastructure Consortium for Africa (ICA).
- Dethier, J.J. (2015). Infrastructure in Africa. In: C. Monga & J. Yifu Lin (Eds), *The Oxford handbook of Africa and economics: Volume 2: Policies and practices*. Oxford, UK: Oxford University Press.
- Dominguez, D., Truffer, B. & Gujer, W. (2011). Tackling uncertainties in infrastructure sectors through strategic planning: The contribution of discursive approaches in the urban water sector. *Water Policy* 13(3), 299–316. <https://doi.org/10.2166/wp.2010.109>

- Egler, H-P. & Frazao, R. (2016). *Sustainable infrastructure and finance*. Inquiry Working Paper 16/09 June 2016. <https://bit.ly/2pxp5J8> [Accessed 20 September 2019].
- Egler, H-P. & Jurik, J. (2017). Sustainable infrastructure: A driver to achieve the sustainable development goals in Africa? *Bridges Africa* 6(2): 19–22.
- Foster, V. & Briceño-Garmendia, C. (2010). *Africa's infrastructure: a time for transformation*. Washington, DC: World Bank. <https://doi.org/10.1596/978-0-8213-8041-3>
- Geneletti, D. (2005). Multicriteria analysis to compare the impact of alternative road corridors: a case study in northern Italy. *Impact Assessment and Project Appraisal* 23(2): 135–146. <https://doi.org/10.3152/147154605781765661>
- Global Infrastructure Basel Foundation. (2017). *SuRe – the standard for sustainable and resilient infrastructure*. Basel: Global Infrastructure Basel. <https://bit.ly/2P85s4W> [Accessed 15 August 2019].
- Goldstein, B., Birkved, M., Quitzau, M. & Bauschild, M. (2013) Quantification of urban metabolism through coupling with the life cycle assessment framework: Concept development and case study. *Environmental Research Letters* 8(3): 035024. <https://doi.org/10.1088/1748-9326/8/3/035024>
- Gu, Z., Vestbro, D.U., Wennersten, R. & Assefa, G. (2009). A study of Chinese strategies for energy-efficient housing developments from an architect's perspective, combined with Swedish experiences and game theory. *Civil engineering and environmental systems* 26(4): 323–338. <https://doi.org/10.1080/10286600802151853>
- Guthrie, P. & Konaris, T. (2012). *State of the world report 2012: Sustainable infrastructure*. Geneva: International Federation of Consulting Engineers (FIDIC).
- Harbi, S., Margni, M., Loerincik, Y. & Dettling, J. (2015). Life cycle management as a way to operationalize sustainability within organizations. In: G. Sonnemann & M. Margni (Eds), *Life cycle management*. Dordrecht, Netherlands: Springer. https://doi.org/10.1007/978-94-017-7221-1_3
- Heinonen, J., Kyro, R. & Junnila, S. (2011). Dense downtown living more carbon intense due to higher consumption: A case study of Helsinki. *Environmental Research Letters* 6(3): 034034. <https://doi.org/10.1088/1748-9326/6/3/034034>
- Hertwich, E.G., Gibon, T., Bouman, E.A., Arvesen, A., Suh, S. et al. (2015). Integrated life cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies. *Proceedings of the National Academy of Sciences* 112(20): 6277–6282. <https://doi.org/10.1073/pnas.1312753111>
- Holmstedt, L., Brandt, N. & Robèrt, K.H. (2017). Can Stockholm Royal Seaport be part of the puzzle towards global sustainability?—From local to global sustainability using the same set of criteria. *Journal of Cleaner Production* 140, Part 1: 72–80. <https://doi.org/10.1016/j.jclepro.2016.07.019>
- Inter-American Development Bank. (2018). *What is sustainable infrastructure? A framework guide to sustainability across the project cycle*. Washington, DC: Inter-American Development Bank, IDB Invest. <https://doi.org/10.18235/0001043>
- International Finance Corporation. (2017). Financial valuation tool for sustainable development. <https://www.fvtool.com> [Accessed 15 August 2019].
- International Institute for Sustainable Development. (2017). Sustainable asset valuation (SAVi) tool: Helping governments and investors see the value of sustainable infrastructure. <https://bit.ly/2TUpEdG> [Accessed 20 September 2019].

- International Resource Panel. (2018). *The weight of cities: Resource requirements of future urbanization*. A Report by the International Resource Panel. Nairobi, Kenya: UNEP.
- Ioppolo, G., Cucurachi, S., Salomone, R., Shi, L. & Yigitcanlar, T. (2019). Integrating strategic environmental assessment and material flow accounting: A novel approach for moving towards sustainable urban futures. *The International Journal of Life Cycle Assessment* 24(7): 1269–1284. <https://doi.org/10.1007/s11367-018-1494-0>
- Ipsen, K.L., Zimmermann, R.K., Nielsen, P.S. & Birkved, M. (2018). Environmental assessment of smart city solutions using a coupled urban metabolism – life cycle impact assessment approach. *The International Journal of Life Cycle Assessment* 24(7): 1239–1253.
- Janic, M. (2003). Multicriteria evaluation of high-speed rail, transrapid Maglev and air passenger transport in Europe. *Transportation Planning and Technology* 26(6): 491–512.
- Jensen, A.A. & Remmen, A. (Eds). (2006). *Background report for a UNEP guide to life cycle management – A bridge to sustainable products*. Paris: Division of Technology, Industry and Economics, UNEP.
- Karlsson, C., Miliutenko, S., Björklund, A., Mörtberg, U., Olofsson, B. et al. (2017). Life cycle assessment in road infrastructure planning using spatial geological data. *The International Journal of Life Cycle Assessment* 22(8): 1302–1317. <https://doi.org/10.1007/s11367-016-1241-3>
- Kasioumi, E. (2011). Sustainable urbanism: vision and planning process through an examination of two model neighborhood developments. *Berkeley Planning Journal* 24(1): 91–114.
- Kennedy, C. & Corfee-Morlot, J. (2013). Past performance and future needs for low carbon climate resilient infrastructure – An investment perspective. *Energy Policy* 59: 773–783.
- Kennedy, C., Stewart, I., Facchini, A., Cersosimo, I., Mele, R. et al. (2015). Energy and material flows of megacities. *Proceedings of the National Academy of Sciences* 112(19): 5985–5990.
- Kwakkel, J.H., Walker, W.E. & Marchau, V.A.W.J. (2010). Adaptive airport strategic planning. *European Journal of Transport and Infrastructure Research* 10(3): 249–273.
- Lempert, R., Boehlert, B., Groves, D., Neumann, J.E., Strzepek, K.M. et al. (2015). Adaptation to climate change in infrastructure planning. In: R. Cervigni, R. Liden, J.E. Neumann & K.M. Strzepek (Eds), *Enhancing the climate resilience of Africa's infrastructure: The power and water sectors*. Washington, DC: World Bank.
- Lobos, V. & Partidario, M. (2014). Theory versus practice in strategic environmental assessment (SEA). *Environmental Impact Assessment Review* 48: 34–46.
- Loiseau, E., Aissani, L., Le Féon, S., Laurent, F., Cerceau, J. et al. (2018). Territorial life cycle assessment (LCA): What exactly is it about? A proposal towards using a common terminology and a research agenda. *Journal of Cleaner Production* 176: 474–485.
- Loiseau, E., Roux, P., Junqua, G., Maurel, P. & Bellon-Maurel, V. (2013). Adapting the LCA framework to environmental assessment in land planning. *The International Journal of Life Cycle Assessment* 18(8): 1–16.
- Machado, C.G. & Cavenaghi, V. (2009). Use of life cycle assessment in sustainable manufacturing: review of literature, analysis and trends. Paper presented at the POMS 20th Annual Conference, Orlando, Florida, USA (1–4 May).
- Malekpour, S., Brown, R.R. & de Haan, F.J. (2015). Strategic planning of urban infrastructure for environmental sustainability: understanding the past to intervene for the future. *Cities* 46: 67–75.

- McKinsey Global Institute. (2016). *Bridging global infrastructure gaps*. In collaboration with McKinsey's capital projects and infrastructure practice. McKinsey & Company.
- National Infrastructure Commission. (2017). *National Infrastructure Commission framework document*. <https://bit.ly/2KrnJm> [Accessed 3 April 2019].
- Nilsson-Lindén, H., Baumann, H., Rosén, M. & Diedrich, A. (2014). Organizing life cycle management in practice: Challenges of a multinational manufacturing corporation. *The International Journal of Life Cycle Assessment* 23(7): 1362–1382.
- Noble, B. & Nwanekezie, K. (2017). Conceptualizing strategic environmental assessment: Principles, approaches and research directions. *Environmental Impact Assessment Review* 62: 165–173.
- Pahl-Wostl, C. & Hare, M. (2004). Processes of social learning in integrated resources management. *Journal of Community & Applied Social Psychology* 14(3): 193–206.
- Pegram, G., Seddon-Daines, D., Reddy, S., Sulieman, N. & Baletta, H. (2017). *The political economy of long-lived decisions in Africa: Framework report*. <https://bit.ly/2BpdH4H> [Accessed 14 September 2019].
- Petit-Boix, A., Llorach-Massana, P., Sanjuan-Delmas, D., Sierra-Pérez, J., Vinyes, E. et al. (2017). Application of life cycle thinking towards sustainable cities: A review. *Journal of Cleaner Production* 166: 939–951.
- Programme for Infrastructure Development in Africa. (2011). *PIDA: Interconnecting, integrating, and transforming a continent The regional infrastructure that Africa needs to integrate and grow through 2040*. <https://bit.ly/2qlaelk> [Accessed 1 February 2019].
- Qi, Y., Zhang, Y., Jiang, H., Hou, H. & Li, J. (2018). Life cycle assessment in urban territories: a case study of Dalian city, China. *The International Journal of Life Cycle Assessment* 24(7): 1194–1208. <https://doi.org/10.1007/s11367-018-1465-5>
- Rebitzer, G. (2015). Introduction: Life cycle management. In: G. Sonnemann & M. Margni (Eds), *Life cycle management*. Dordrecht, Netherlands: Springer.
- Saghir, J. (2017). *Sustainable infrastructure development in sub-Saharan Africa*. Washington, DC: Centre for Strategic and International Studies.
- Slagstad, H. & Brattebø, H. (2014). Life cycle assessment of the water and wastewater system in Trondheim, Norway – A case study: Case study. *Urban Water Journal* 11(4): 323–334.
- Sonnemann, G., Gemechu, E.D., Remmen, A., Frydendal, J. & Jensen, A.S. (2015). Life cycle management: Implementing sustainability in business practice. In: G. Sonnemann & M. Margni (Eds), *Life cycle management*. Dordrecht, Netherlands: Springer.
- Sosa, R.O., Espinoza, A.H., Royo, M.G. & Gálvez, D.M. (2017). Life cycle energy and costs of sprawling and compact neighborhoods. *The International Journal of Life Cycle Assessment* 22(4): 618–627. <https://doi.org/10.1007/s11367-016-1100-2>
- Sow, M. (2015, 30 December). Foresight Africa 2016. Urbanization in the African context. [Web log post]. <https://brook.gs/2BsIcqx> [Accessed 15 September 2019].
- Truffer, B., Störmer, E., Maurer, M. & Ruef, A. (2010). Local strategic planning processes and sustainability transitions in infrastructure sectors. *Environmental Policy and Governance* 20(4): 258–269.
- Tudela, A., Akiki, N. & Cisternas, R. (2006). Comparing the output of cost benefit and multi-criteria analysis: An application to urban transport investments. *Transportation Research Part A: Policy and Practice* 40(5): 414–423.
- Turconi, R., Boldrin, A. & Astrup, T.F. (2013). Life cycle assessment (LCA) of electricity generation technologies: Overview, comparability and limitations. *Renewable and Sustainable Energy Reviews*, 28: 555–565. <https://doi.org/10.1016/j.rser.2013.08.013>

- United Nations Department of Economic and Social Affairs. (2015). *The world population prospects: 2015 revision*. <https://bit.ly/2MtQXqr> [Accessed 1 February 2019].
- United Nations Economic Commission for Africa. (2017). *Africa sustainable development report: Tracking progress on Agenda 2063 and the sustainable development goals*. Addis Ababa: UNECA.
- United Nations Environment Programme. (2013). *City-level decoupling: Urban resource flows and the governance of infrastructure transitions*. Report of the Working Group on Cities of the International Resource Panel. Nairobi, Kenya: UNEP.
- United Nations Environment Programme. (2015). *Green energy choices: The benefits, risks and trade-offs of low-carbon technologies for electricity production*. Report of the International Resource Panel. Nairobi, Kenya: UNEP.
- United Nations Human Settlements Programme. (2009). *Planning sustainable cities: Global report on human settlements*. Nairobi, Kenya: UN-Habitat.
- United Nations Human Settlements Programme. (2010). *The state of African cities 2010: Governance, inequalities and urban land markets*. Nairobi, Kenya: UN-Habitat.
- United Nations Human Settlements Programme and United Nations Economic Commission for Africa. (2015). *Towards an Africa urban agenda*. Nairobi, Kenya and Addis Ababa, Ethiopia: UN-Habitat and UNECA.
- Wright, H., Dimsdale, T., Healy, C., Orozco, D., Williamson, S. et al. (2018). *Sustainable Infrastructure and the multilateral banks: Changing the narrative*. E3G Briefing Paper, June. <https://bit.ly/2oMEcyu> [Accessed 20 September 2019].
- Wrisberg, N., Udo de Haes, H.A., Triebswetter, U., Eder, P. & Clift, R. (2002). *Analytical tools for environmental design and management in a systems perspective*. Dordrecht, Netherlands: Kluwer Academic Publishers.



7

DISTRIBUTED RENEWABLE ECONOMY FOR AFRICA AS A BASIS FOR WELLBEING ECONOMY DEVELOPMENT

Desta Mebratu

Introduction

The global economy has registered a tremendous growth rate in terms of gross domestic product (GDP) over the last few decades. This has resulted in significant improvement of human development in different parts of the world, and more particularly in developed countries and transition economies. However, more than two billion people are still deprived of the basic necessities and living in poverty. On top of this, the foundation for the global economy has been shaken over the last decades by a confluence of multiple economic, environmental and social challenges. In his book, *Shaping the Fourth Industrial Revolution*, the founder of the World Economic Forum (WEF) Klaus Schwab writes: 'The world is at a crossroads and the social and political systems that have lifted millions out of poverty and shaped our national and global policies for half a century are failing us' (Schwab, 2018:vii).

The existing situation is expected to be further aggravated with the projected increase of the global population to over nine billion by 2050. Addressing these

challenges will require a fundamental transformation of the current global production and consumption structure. Achieving incremental efficiency gains in all socio-economic activities is a necessary ongoing process of every society. However, promoting systems innovation at all levels of society is fundamental to address existing and emerging socio-economic and socio-ecological challenges adequately.

As noted by Swilling and Annecke (2012), various transitions are already underway in response to resource depletion and adverse environmental impacts, but something fundamental must change in the way that economies relate to their environments. Despite the notable progress made, there is still strong inertia that hinders the progress towards a transformational change which is urgently needed. Social transformation is inherently a complex process that involves the introduction of new thinking, products, processes and organisations that profoundly change the basic routines, resource and authority flow and beliefs of the social system. Transformational moments require challenging widely accepted logic, practices and relationships. This becomes even more complex in an increasingly globalised but fractured world as we are in today. However, these transformational moments would also provide new opportunities that could be utilised as a driver for change. Today, society is standing at a crossroad where the transition to an inclusive, low-carbon and resource-efficient economy is no more a choice but a global imperative.

Africa is the region that will face significant adverse impacts from the global environmental challenges such as climate change. In addition to addressing the environmental challenges, African countries face other key challenges that need to be addressed, such as creating jobs for its increasing percentage of young population and eradicating poverty. There is also the challenge of reducing the adverse impacts of emerging technologies, which have exponential implications, while making the best out of the opportunities they provide.

This chapter highlights some of the key drivers and opportunities which African countries need to recognise and take advantage of in developing their economies. It specifically recommends the promotion of distributed renewable economy planning in regional and local development to achieve the Sustainable Development Goals and meet the aspiration of Agenda 2063. It also highlights some of the key steps and planning tools that could be used in planning for a distributed renewable economy.

Social transformation and its transition elements

In general, the concept of societal transformation in the social sciences refers to the change in society's systemic characteristics. According to Nikolai Genov (1999),

this incorporates the replacement of existing parameters of a societal system, including technological, economic, political and cultural restructuring. More specifically:

- Such a process influences productive infrastructure which can bring about new technological changes and new patterns of participation in the division of labour. Historically, this has meant alteration of the requirements for information flows and technologies.
- Secondly, new structures of economic organisation are developing. This may imply a change in ownership rights, as well as in investments, production, distribution and supply.
- Thirdly, the distribution and use of political power take qualitatively different forms. This involves changes in the structure and performance of state institutions and other bodies of decision-making and control.
- Finally, a society's value-normative system can change, often in a way that allows the emergence and stabilisation of pluralist institutions (Genov, 1999).

Swilling and Annecke (2012) noted that besides the unviability of the old regime, which manifests itself through different forms of crisis, there have to be conscious and purposive innovations that create pathways to a new order. In this section, we look at some of the significant shifts and changes that happened over centuries and defined the transformation path taken by societies.

Social transformation as a cumulative process

Succession and mobility of plants and animals, as an essential element of the self-regulation mechanism of the biotic system, played a significant role in the co-evolution of the natural and social systems. As an integral part of the natural system, more particularly the animal kingdom, mobility governed by ecological factors has patterned the dominant lifestyle of humanity for millennia (Mebratu, 1998). The natural system has been the primary source that provided all the essential resource inputs required for all socio-economic functions. Fischer-Kowalski and Harbel (2007) identify three major socio-ecological regimes in human history:

- The hunter-gatherer socio-ecological regime that existed for at least 100 000 years before the agricultural revolution that took place some 13 000 years ago.
- The agrarian socio-ecological regime that existed until the industrial revolution nearly 250 years ago.
- The industrial socio-ecological regime that begins in the 1770s and which is currently dominant in the global economy.

About 8 000 years ago, after aeons of slow accumulation, the human population reached an enormous number of about ten million people (Meadows, Meadows & Randers, 1992). These people lived as nomadic hunter-gatherers, but their increasing numbers began to create ecological scarcity around them. To resolve the problem of dwindling wild resources, some of them intensified their migratory lifestyles, while others started to domesticate animals and cultivate plants resulting in a sedentary lifestyle. Just by staying in one place, the proto-farmers altered the face of the planet and the thought of humankind in ways they could never have foreseen (Meadows et al., 1992).

As a result of this change in human behaviour, history from 3 000 BC till the advent of the industrial revolution witnessed the development of more advanced agriculture, increasingly multiple social divisions of labour and means of exploitation. This included the creation of exclusively masculine symbols of divinity and the subjugation of women by patriarchal control over their reproductive and sexual status (Gottlieb, 1996). The agricultural transformation, as a successful response to wildlife scarcity faced by the hunter-gatherer society, resulted in slow population growth from about 10 million to about 800 million by 1750 (Meadows et al., 1992). This created new scarcities and social conflict, especially in land and energy, and led to the industrial revolution.

The industrial revolution, which started in the UK with the development of the textile industry, is said to have passed through three distinct stages of industrial revolutions (Schwab, 2018). The first industrial revolution started with the mechanisation of spinning and weaving in the textile industry. The substitution of abundant coal for vanishing biomass resulting in the introduction of the steam engine. This led to new developments in other manufacturing sectors including steel manufacturing and transportation sector. A new wave of interrelated technologies that came between 1870 to 1930 further enhanced the growth made during the first industrial revolution and created new opportunities. The technologies included new communication infrastructure driven by the power of electricity, new transportation possibilities driven by internal combustion engines, and the production of new materials, such as thermoplastics, as a result of the development in chemicals processing. The revolutionary breakthroughs that were registered in the area of digital computing and information theory since the 1950s provided the foundation for the third stage of the industrial revolution. These three stages of the industrial revolution transformed the way human beings create value, and the world was changed by the co-evolution of technologies, political systems and social institutions.

The unprecedented economic growth registered through the agricultural transformation and the successive stages of the industrial revolution led to new sets

of environmental scarcities and crises of a global proportion. These scarcities grew exponentially with the fast pace of industrialisation and globalisation that was registered during the second half of the twentieth century. The globalisation of the twentieth century did not only globalise national economies. It also globalised environment pollution and degradation which remained local for millennia resulting in global challenges such as climate change. The exponential increase in inequality between and within countries is another significant social outcome of unbridled globalisation. As reported by Vázquez Pimentel, Ayma and Lawson (2018) in an Oxfam Briefing Paper, the 26 wealthiest people on earth in 2018 had the same net worth as the poorest half of the world's population, some 3.8 billion people. These challenges are expected to be further compounded with the alarming rate of population growth that is projected to be over nine billion by 2050. In a nutshell, humanity is currently faced with a confluence of economic, social, and environmental challenges that would require a significant social transformation of equal proportion to the agricultural and industrial revolution. Africa, as a developing region, may swim through or get drowned by this transformational change depending on how it deals with the critical transition elements and drivers in the coming decades.

The transition elements

Moments of major social transformations are characterised by the dynamic interaction between the socio-ecological and socio-economic systems. These, in turn, are shaped by (i) how useful information or knowledge is processed and structured, (ii) which kind of energy systems is used as the primary driver, and (iii) how the production system is organised by using the first two as primary inputs. These factors have determined the key features of the agricultural and industrial transformations and will also determine the sustainability transformation of the twenty-first century.

Table 7.1 presents a comparative analysis of the key drivers and features of the transitions under the agricultural, industrial and sustainability transformation.

Table 7.1 Key elements of major socio-economic transformations

Principle dimensions	Knowledge systems	Dominant energy drivers	Production systems
Agricultural transformation	Philosophy and religion	Bio-energy	Subsistence production
Industrial transformation	Reductionist science	Non-renewables	Mass production
Sustainability transformation	Systems thinking	Renewables	Distributed production

The following subsections present a more detailed discussion on the key features of the transitions that were recorded in the three principal dimensions shown in Table 7.1.

The knowledge transition

The transition that should happen in our knowledge system is one of the critical prerequisites for a successful transformational process. Philosophy, as the earliest form of knowledge acquisition, and religions, by way of shaping human conscience, played a significant role in determining the path of the agricultural transformation and consolidating its gains. The industrial revolution paved the way for substantial progress made in science and technology. The classic metaphysical transplant from Newtonian physics to social reality was achieved by Adam Smith under which gravity became the market, molecules became individuals, and the constancy (and reversibility) of time became value (Swilling & Annecke, 2012). At the same time, the reductionist idea that advocates nature as a great machine which can be understood by studying the parts has become dominant through the whole of modern thought and culture. Finding a pattern of thinking about social reality which was similar to the pattern set by the natural resources gradually became the primary intellectual ambition of social scientists. This dominant thinking led to the unprecedented speed and magnitude of economic development, particularly over the last century.

However, the mismatch problem that arises from the description of a grey world with black-white scientific truth increasingly became the source of the limitation of the dominant knowledge model of the last century. As Kosko (1994) suggests, the bivalence of modern science ignores or denies or whitewashes, and black washes grey truth. On the contrary, the multivalent view says that almost all truth is grey and partial truth and it allows mathematical truths to remain black or white as extreme cases of grey. This led to the evolution of the holistic view, which asserts that natural wholes are always composed of parts under which the synthesis affects and determines the parts and, therefore, reciprocally influence and determine each other (Smuts, 1993). Under such thinking, the whole is much more than the summation of the parts.

Although nobody can deny the enormous positive effect of science and technology, it is equally true that science and engineering have been unable to keep pace with the second-order effects produced by the first-order victories (Weinberg, 1975). Numerous institutional and individual attempts were made to understand the impacts of these second-order effects and cope up with prescriptive solutions. However, these efforts were not able to adequately address the multidimensional challenges that are complex due to the inherent limitations in their epistemological foundations (Mebratu, 2000). The key determinant for our success in this process is the progress we make in developing a new framework of knowledge and thinking.

The initial response to the increasing level of the environmental crisis naturally originated within the entrenched domain of the different disciplinary sciences (Mebratu, 1998). However, the inherent limitations of these disciplinary sciences were soon recognised by the scientific community. This led to the proliferation of multidisciplinary and interdisciplinary approaches that led to various incremental progress in different fields. Nevertheless, as noted by Leroy (1997), the interdisciplinary approach primarily became a question of the transfer and integration of methods rather than the forging of substantive theories. In terms of the solution, the dominant mechanistic nature of the inclusion process results in solutions of detailed complexity, which diverts attention away from systemic causes by focusing on symptoms (Ziegler, 1997).

Recognition of these limitations gave rise to what is broadly known as 'systems thinking' which became increasingly used since the 1970s in different fields. According to Kelvin Campbell (2018), there are three common organising principles of complex adaptive systems. Firstly, self-organising systems produce intelligence only when they can process the diversity of knowledge that resides within the entire system. Secondly, counterintuitive to conventional wisdom, which believes in a comprehensive set of rules and regulation to achieve effectiveness, complex adaptive systems leave the responsibility for control and coordination with each of the individual members. Thirdly, order is not preordained before work begins but instead emerges through an interactive learning process.

A key challenge in adopting an approach of doing science with society is to develop solution-oriented, or transformative transdisciplinary research approaches that are capable of not only explaining and understanding the complex societal challenges currently being faced in the world, but also of changing or transforming these challenges (Breda & Swilling, 2018; Miller et al., 2014; Scholz, 2011; Seidl et al., 2013; Stauffacher, Walter, Lang, Wiek & Scholz, 2006; Wiek & Lang, 2016). The transdisciplinary field started to emerge from the increasing recognition of the urgent need to generate solutions based on understanding dynamic complexity (Mebratu, 2000).

The systems approach is based on the recognition that all systems are in a state of disequilibrium following an irreversible path of development and sustaining their systemic function through successive adaptation is their main *raison d'être* (Mebratu, 2000). Such an approach focuses on defining the basic principles that map out the evolutionary paths of any system within a given possibility domain rather than generating prescriptive solutions based on applying broad principles across socio-economic systems. This provides a sound basis for hybridising and cross-fertilising across knowledge systems, including indigenous knowledge systems, and promoting social innovation at the local level.

Table 7.2 shows some key features of conventional and transformational development.

Table 7.2 Features of conventional and transformational development

Key features	Conventional	Transformational
Knowledge system	Reductionist and mono-disciplinary	Systems thinking and transdisciplinary
Innovation regimes	Technological regimes	Socio-technological regimes
Social outcome	Power consolidation and increased inequality	Distributive and enhanced inclusiveness

As shown in Table 7.2, the specific knowledge system that is dominant will determine the nature of the innovation regimes and the respective social outcomes. Hence, the transition in our knowledge system is one of the fundamental prerequisites for addressing the confluence of challenges caused by the conventional development paradigm. The accumulation and evolution of knowledge through successive stages of transitions is an inherent part of social transformation processes. The challenges facing humanity today require a new framework of thinking that is guided by transdisciplinary methodologies which systematically integrate and deploy all the relevant existing knowledge through systems thinking.

The energy transition

Throughout human history, energy has been at the centre of every major social transition and transformation. The discovery of fire represented a significant turning point in the differentiation of human beings from the animal kingdom in the form of production and the use of tools. This was followed by the discovery and use of bioenergy as a result of domestication and use of animals for farming and domestic purposes. The subsequent development of watermills and windmills played a significant role in the agricultural transformation of the first and second millennia. The discovery of coal and the subsequent invention of the steam engine laid the foundation for the industrial revolution of the eighteenth and nineteenth centuries. Subsequently, the discovery and extensive utilisation of petroleum played a central role in the development of chemicals and material sciences as a basis for diversified products and as a key driver for new modes of transportation and communications.

The transition from renewable to non-renewable energy resource as the dominant energy provider of national economies also represented a significant turning point in society’s relationship with the natural environment. The unregulated discharge of greenhouse gases (GHGs) into the atmosphere, which resulted in the global challenge of climate change, led to the systemic deposition of various chemical pollutants in the natural environment. This has fundamentally changed the scale and scope of impact of human activity on the environment making it of a global proportion. Hence addressing the environmental challenges of today would require a transition of a global proportion in our energy systems as confirmed with

the Paris Agreement on Climate Change and series of scientific reports from the International Panel on Climate change (IPCC).

Decarbonising the global economy through a rapid transition of our energy systems to a renewable energy resource basis is of vital importance in light of the urgency of addressing the challenges of climate changes. This would require shifting our energy production focus from the exploitation of concentrated energy potential, which is mostly non-renewable and limited, to the harnessing of the abundant and renewable diffused energy potentials within our planetary system. Besides the global necessity of making such a transition, African countries can enjoy the following additional developmental benefits from such a transition to renewable energy systems:

- According to the International Renewable Energy Agency (IRENA), the continent's biomass, geothermal, hydropower, solar and wind energy resources are among the best in the world (IRENA, 2015). Given the abundant potential the region has, renewables can play a transformative role in the African energy mix and its socio-economic development.
- About 600 million people in Africa do not have access to electricity, and approximately 730 million people rely on traditional uses of biomass (International Energy Agency [IEA], 2014). Expanding and ensuring energy access for the majority of the population in Africa is at the centre of achieving distributional energy justice and eradicating poverty in Africa.
- The distributed nature of renewable energy resources combined with widely dispersed settlement patterns of the bulk of the population in the region makes the development of distributed energy systems more appropriate for the region.
- The development of local economic networks driven by renewable energy provides the foundation for developing distributed economic systems that add value to locally available renewable resources and creates jobs that are desperately needed in the region.

Africa is one of the regions with significant renewable energy potential, however, a very high proportion of its population suffer from energy poverty. Recent progress made in renewable energy technologies and the favourable policy environment at the global and regional level provides a unique opportunity for the energy transition in Africa. This transition could promote a significant level of distributive justice if due consideration is given to the right mix of grid- and off-grid based renewable energy systems. It could also promote broader socio-economic justice if the planning and implementation of renewable energy development are fully integrated with the development of sustainable local economies that create decent jobs and provide sustainable livelihoods through value addition to local resources.

Transition in production systems

Production is the fundamental factor that separates humankind from the animal kingdom. As such, change that happens in production systems is at the centre of all major social transformation processes. The concept of economy of scale as defined by Adam Smith, with cost per unit of output generally decreasing with increasing scale, has been the significant driver for the development of mega-production and distribution systems. Some political economists have challenged this dominant notion of economy of scale for decades. Theodore Roszak (1989) noted that there were many proponents of subterranean tradition or organic and de-centralist economics who insisted that the scale of the organisation must be treated as an independent and primary problem. However, he noted that it would be no exaggeration to call Schumacher the Keynes of post-industrial society. McClaughry (1989) noted that Schumacher's book *Small is Beautiful* published in 1989 provided a new sense of hope to a world that is faced with widening spectre of global pollution, resource-exhaustion, corporate concentration and the corresponding diminution of individual liberties.

Ayres (1994) defines an economy as an information processing system and identifies three kinds of information. These are thermodynamic information, associated with the chemical composition; morphological information, associated with shape, form and structure; and symbolic information, associated with control process and knowledge. He further argues that labour skills, capital and technology are more or less embodied or condensed forms of information of a production system. Based on this, one can conclude that all production systems are ultimately systems that process raw material, energy and information into useful products (both goods and services) consumed by society. Industrial development during the twentieth century had been mainly driven by various innovations that resulted in better management of the dynamics between the thermodynamic, morphological and symbolic information of production systems.

Considering that the thermodynamic content of any production is an input provided by the natural environment, the morphological and symbolic information become the fundamental factors that determine the distinction in production systems. As a result, the level of inventions and innovations that are witnessed at each stage of the major social transformations were a function of how the morphological and symbolic information was processed and utilised. The critical function and role of information in economic systems have taken new dimensions and proportions with the unprecedented development witnessed in the field of information and communication technology in the last couple of decades. This ranges from changing the speed and nature of financial flows, which is another form of information flow, to giving rise to new products and industrial operations.

The continued digitisation of the global economy is expected to result in fundamental changes in the design and development of production systems of the twenty-first century.

The transition in production systems starts with the evolution of new production systems within the old as a result of the germination of the seeds of change within the old production system. This provides the basis for the evolution of new production and consumption relationships that are necessitated by the fundamental socio-economic and socio-ecological drivers for change. The seeds for change concerning production systems of the twenty-first century are already sprouting in different sectors and different parts of the world. However, there are some fundamental shifts required for these changes to lead to inclusive, low-carbon and resource-efficient societies. In this context, the transition in production systems further includes broad-based transitional changes that should happen in the areas of the economy of scale and related energy and information systems.

One recent application of such an approach is the framing of the fourth industrial revolution by Klaus Schwab, who proposes that the ‘Fourth Industrial Revolution is a new chapter in human development, on par with the last three stages of industrial revolution, and once again driven by the increasing availability and interaction of a set of extraordinary technologies’ Schwab (2018:7). However, the possible impacts and benefits of the disruptive technologies of the fourth industrial revolution will mostly depend on who would have control over the use of these technologies.

Table 7.3 shows the possible outcomes of some of the key disruptive technologies depending on whether we use them for the conventional outcome of consolidating dominance by the few or for transformational outcomes that will lead to more inclusive and efficient economies.

Table 7.3 Possible socio-economic outcomes of emerging technologies

Emerging technologies	Application regimes	Conventional outcomes	Transformational outcomes
Artificial intelligence	Digitisation and robotisation	Consolidation of mass production and consumption resulting in substantial job losses and concentration of wealth	Promotion of distributed production aimed at improved productivity and empowerment of local communities
Blockchain technologies	Distributed ledger of transaction	Speculative capital accumulation through crypto-currencies	Promotion of distributed economy via efficient supply chain networks and local digital currency
Biotechnologies	Genetic engineering	A narrow application aimed at power control and consolidation in the name of human wellbeing	Systemic applications aimed at the improvement of human and ecosystem wellbeing

The battle is already on between the conventional groups that are bent on making the maximum profit and power consolidation out of the emerging disruptive technologies and the advocates for the transformational utility of these technologies

for the broader and higher benefit to humanity. Schwab outlines the following four fundamental principles that are particularly useful in defining a new leadership mindset that ensures a more favourable outcome from the fourth industrial revolution (Schwab, 2018):

- **Systems not technologies:** It is essential to focus on systems that deliver wellbeing rather than being tempted to focus on technologies themselves. With the right engagement of all stakeholders, new technologies can enable better-performing systems to be put in place, while the absence of them could make the existing systems worse.
- **Empowering not determining:** It is imperative to value human decision-making and agency and design systems that harness new technologies to give people more choice, opportunities, freedom and control over their lives.
- **By design not by default:** Society should not resign itself to the inevitability of default options. Design thinking, guided by human-centred design, as well as systems-thinking approaches can help the world to appreciate how new technologies may shift systems into new configurations.
- **Values as a feature, not a bug:** We should recognise that all technologies implicitly have values baked in them from the initial idea to how they are developed and deployed and hence we need to debate values at all stages of innovation rather than reacting after the damage has been caused.

In general, the twenty-first century will be registered as the century of the most significant social transformation in human history. This transformation is of global proportion and would have a significant immediate impact on Africa's opportunity to develop its economy. As was shown in the chapter on leapfrogging, Africa has a unique opportunity to be a significant beneficiary of this transformation. However, for Africa to reduce the adverse impact of this transformation on its people and maximise its benefit, it has to come out of its passive recipient status and prepare itself to be an active player of this transformation by seizing the available opportunities. The emerging disruptive technologies, which are inherently distributive, provide excellent opportunities for the economic empowerment of people provided that these technologies are utilised innovatively. One of the strategic approaches for this is to commit to an inclusive, low-carbon and resource-efficient bottom-up economic development process through the promotion of a distributed renewable economy, which is discussed in the following section.

Distributed renewable economy

As it was presented in the other chapters of this book, given their early stages of development, African countries have great opportunities to build a more sustainable

socio-economic infrastructure that facilitate the transition to inclusive, low-carbon and resource-efficient economies. Such a transition could only be successful if it is complemented with a bottom-up process of developing distributed economy networks that create productive and decent jobs and secure economic livelihood to local communities. The following subsection highlights the conceptual and practical basis for the development of a distributed renewable economy.

The conceptual basis of a distributed economy

The discussion on distributed economy as a strategy that guides industrial development towards a more sustainable development path started towards the end of the twentieth century and the beginning of the twenty-first century. The discussion was mainly triggered by the recognition of the limitations of technical innovations in the field of pollution prevention and cleaner production in addressing the growing resource and environmental challenges. It also recognised the need to question the purpose and structure of the dominant production systems and ultimately transform them. According to Johansson, Kisch and Mirata (2005), distributed economy promotes economies of scale through networking, and offers an approach by which different strategies can be pursued in different regions and similar or complementary development schemes can be brought together into networks providing the advantages of scale without the drawbacks of inflexibility. It also optimises resource flows that take place within and across regional boundaries through the development of regions where a diverse range of activities are organised in the form of small-scale, flexible units that are synergistically connected and prioritise quality in their production. Under such circumstances, industrial symbiosis becomes more than mere coexistence.

The International Institute for Industrial Environmental Economics noted that the dominant economic system of today has mostly been driven by the concept of 'economies of scale' that is based on the principle that production costs per unit output decline as output increases, thus making larger industrial production more attractive and profitable (Van den Dool et al., 2009). The belief in this approach has created an industrial production system largely dominated by mass production and concentrated industrial cores. However, the 'economies of scale' that is widely applied in the dominant economic model is at best partial and static and thereby inefficient. According to Van den Dool et al., the concept of distributed economy does not go against the principle of economies of scale. On the contrary, it argues that there are many cases where distributed production systems would meet the requirement for economies of scale more holistically and dynamically provided that the production costs take into account all environmental and social costs and benefits associated with it (Van den Dool et al., 2009).

Another major limitation of the conventional economic model is its assertion of the direct correlation between economic growth and wellbeing improvement. The persistence of poverty and widening inequality both within and between countries despite the fastest global economic growth pose significant barriers to the advancement of human wellbeing. It has been claimed for decades that economic growth and technological innovation offer the best possibilities to overcome these barriers. However, this seems to have failed, resulting in increasing public discontent and disappointment in all parts of the world. Furthermore, the dominant ways of measuring economic progress in the form of growth of GDP are not only misleading but are also misleading and ineffective, to say the least (Lorenzo, 2017). As pointed out by Ayres (1999), the major part of statistical growth amounts to running faster and faster to stay in the same place – wheel-spinning – rather than actual wealth creation. In this context, Johansson et al. (2005) suggest the following major areas of concern that distributed economy attempts to address:

- **Wealth creation for a larger number of people:** The purpose of economic development is to allow people to lead a meaningful life under which many basic needs have to be fulfilled and options for individual choices are provided.
- **Heterarchies and open innovations:** A centralised and hierarchical production system is poorly suited for coping with this new era of open innovation. With distributed economy, we are talking about heterarchies under which knowledge is distributed and the organisation of diversity becomes crucial.
- **Flexible and small-scale production systems:** Flexible and small-scale production systems have inherent advantages to receive relevant market signals and to devise and implement innovative solutions that satisfy the dynamically changing demands. This will be increasingly important and determinant for survival in future economies.
- **Symbiotic relationships:** Real value is to appreciate the importance of both competitive and non-competitive processes and find a balance between the two. The interaction between different entities combines in such a way that the system as a whole performs better and is more robust than the performance of the individual entity.
- **Diversity as a prerequisite:** Distributed economies have a high performance, not because of the competitive nature of individuals or even because of the direct cooperation but because of the diverse elements in the economy.
- **New producer-consumer relationships:** Today, relatively small actors can have both local and global **presence** at an affordable cost. In particular, information technology has provided us with the possibility of having a global presence and satisfying the need of being large or dominant.

- **Social and ecological capital as an advantage:** In distributed economies, there is a clear emphasis on using social and ecological capital as an advantage. This is a form of a natural asset that can deliver unique values in a unique mix if it is wisely designed and utilised.
- **A renewed balance of scale:** Distributed economies does not advocate abandoning large-scale production systems as a whole. On the contrary, there will undoubtedly be a need for efficient ways of producing commodities and bulk goods. However, new forms of symbiosis and coexistence could bring about benefits to both systems.

The notion of distributed economies generally promotes small-scale, flexible networks of local socio-economic actors using local resources according to local needs in the spirit of sustainable development (Kohtala, 2015). Besides its direct economic and environmental benefits, it provides a robust socio-economic basis for the empowerment of women and the broad participation of local communities in development management. It also provides a fertile ground for socio-technical innovations that are driven by local needs and conditions. Thus, the promotion of networks of local economies that create more jobs and add more value to local economies need to be at the centre of promoting sustainable development in Africa.

Technological drivers for a distributed economy

As noted in the preceding chapter, technological invention and innovation have been central to all major socio-economic transformations that are recorded in human history. This includes the agricultural revolution and the various stages of industrial revolutions. However, the impact of technological innovations of the twenty-first century that are mainly driven by digitisation and the transition in our energy and production systems are of exponential proportion. Some of these are referred to as exponential technologies owing to their significantly higher outcome and impacts compared to their conventional counterparts. In the context of this chapter, three major technological innovations determine the path of social transformation in the twenty-first century. These are:

- the digitisation of the global economy;
- the development of renewable energy technologies; and
- the expansion of distributed manufacturing systems.

The digitisation of the global economy

The increasing digitisation of the global economy as a result of exponential development in the field of information and communication technology is one of the most defining drivers of the global economy in the twenty-first century. Most of the

key technologies behind the fourth industrial revolution (Industry 4.0), including artificial intelligence, robotics, additive manufacturing and augmented reality, are driven by the innovation, development and the application of information and communication technology (ICT) for digital innovation. The foundation for most of the development in the ICT sector, including the development of the internet and world-wide-web, is driven by the concept of distributed systems. This concept is applied widely in the ICT field. The term 'distributed' had its roots in computing and communication networks when a more robust network that has distributed nodes rather than centralising hubs or switches was developed (Baran, 1964).

Schwab identified two categories of technologies that would determine the nature of the fourth industrial revolution. The first group of technologies are those technologies that are aimed at extending the benefits from the digital revolution of the third industrial revolution that brought us general computing, software development, personal computers and connectivity. These include new computing technologies, blockchain and distributed ledger technologies and the internet of things (IoT). The second group of technologies are the technologies that provide the materials of our living environment and interact with both industrial and social spaces using the digital infrastructure of the twenty-first century as a foundation. These include artificial intelligence (AI) and robotics, advanced materials and additive manufacturing (Schwab, 2018).

The distributive nature of the development over the last couple of decades in ICT has led to improving efficiency and enhancing the empowerment of individuals. The enormous power of influence that has been created by the widespread use of social media with its attendant social hazard is a clear testimony of this distributive power. The transition to the digital economy is expected to come with a mix of challenges and opportunities. The success of every nation in the twenty-first century will depend largely on its ability to effectively manage the challenges, harness the opportunities and master the impact of this transition.

Distributed renewable energy systems

Another technological revolution is taking place between energy supply and demand, powered by information, computing, communications and control technologies. This is transforming the ability to manage a dynamic electricity system that integrates decentralised and variable clean, renewable supply with demand (Cooper, 2016). The techno-economic viability of renewable energy options has registered significant progress over the last decade owing to the favourable policy and investment conditions created at the global, regional and national levels. This ranges from various forms of policy and regulatory reforms at regional and national levels which are favourable for renewable energy development to direct and indirect economic incentives provided by national governments.

Most African rural communities are characterised by low population densities and dispersed settlement patterns, resulting in high connection costs. Smaller hybrid energy plants closer to the end-user consisting of multiple energy sources are emerging as an alternative to large energy and distribution power plants with competitive price and improved reliability and security (Raji & Kahn, 2012). Distributed energy resources could be both conventional and nonconventional energy sources connected to the primary feeder or secondary feeder of a distribution system (Alanne & Saari, 2006). The International Renewable Energy Agency describes Africa as the continent of opportunity because of the significant potential it has both in terms of the renewable energy resource it has and the existing energy gap that needs to be addressed (IRENA, 2013).

Distributed renewable energy (DRE) systems offer unprecedented opportunities to accelerate the transition to modern energy services in remote and rural areas and also provide various co-benefits. According to the *Renewables 2017 Global Status Report* (REN21, 2017), the major benefits include: (i) cost savings when compared to the grid in many markets; (ii) fuel availability and/or stability and predictability of prices; (iii) modularity, flexibility and rapid construction times; (iv) faster technological learning curves and rates of improvement compared to fossil fuels; (v) enhanced reliability and resilience; (vi) improved health through reductions in indoor air pollution; (vii) contribution to climate change mitigation; (viii) reductions in deforestation and environmental degradation; (ix) positive effects on women's empowerment, and (x) reductions of poverty among vulnerable groups (REN21, 2017:97). The report also maintains that 'the old paradigm of energy access through grid extension alone is becoming obsolete as bottom-up customer demand is motivating hundreds of millions of households to generate their own modern energy services through off-grid units or community-scale mini-grids' (REN21, 2017:24).

As mentioned previously, Africa has a substantial potential for renewable energy, but at the same time, a large percentage of its population suffers from energy poverty. If current African development trends continue, almost 600 million people in rural areas will still lack access to electricity in 2030, and an even more significant number will require access to clean cooking facilities. According to the regional decomposition analysis carried out by Mundaca, Markandya and Nørgaard (2013), Africa appears to be the only region that showed signs of grabbing the low-carbon economy opportunity. Besides facilitating energy access, the development of local economic networks driven by renewable energy provides the foundation for developing distributed economic systems that are based on the efficient utilisation of locally-available renewable resources and hence leapfrogging to the low-carbon economy. However, realising this potential would require taking

some critical measures aimed at creating the necessary framework for the effective deployment of the required physical and institutional infrastructure.

Recent progress made in renewable energy technologies and the favourable policy environment at the global and regional levels provides unique opportunities for the energy transition in Africa. This transition could promote a significant level of distributive justice if due consideration is given to the right mix of grid- and off-grid based renewable energy systems. It could also promote broader socio-economic justice if the planning and implementation of renewable energy development are fully integrated with the development of sustainable local economies that create decent jobs and provide sustainable livelihoods through value addition to local resources. All of the above major drivers indicate that we are at a moment of a significant social transformation process that will require all countries to revisit their development planning process fundamentally. The promotion of distributed renewable economy as a development planning tool is one key element of this transition that responds to all the major drivers highlighted above.

Distributed manufacturing systems

The notion of distributed production is a conceptualisation of a shift in consumption and production patterns away from the conventional mass production paradigm with its centralising tendencies. This transition also poses a challenge to the notion of having strict intellectual property (IP) regimes as the foundation for technological innovation. Based on empirical data from the United States, Dafermos (2015) points out that the dramatic increase in the number of patents registered in the United States from 1973 to 2010 has not been paralleled by an increase in productivity or technological innovation. On the contrary, based on two case studies, he illustrates how innovation in the twenty-first century thrives on openness and free sharing of knowledge and presents an alternative model of economic and technological development enabled by inclusive IP regimes founded on the open knowledge commons. Bauwens and Kostakis (2015) emphasise the need for recomposing productive infrastructures for commons-oriented development.

Distributed production is enabled especially by advances in digital manufacturing technologies and the internet and is often referred to as distributed manufacturing (DM) or personal manufacturing. However, distributed manufacturing goes beyond the introduction of intelligent and autonomous systems that are driven by digitisation and smart machines. It also includes new societal considerations of a highly participative form of decentralised manufacturing that requires participation across the manufacturing value chains, including end-users, from design to potential production (Srai et al., 2016). Furthermore, DM entails a

deviation from conventional mass production, not only in terms of scale and location but also in terms of the consumer-producer relationships (Kohtala, 2015). The implication here is a shift from the long, linear supply chain, economies of scale and centralisation tendencies, towards more distributed production models (Srai et al., 2016). The user interface is also changing, with the blurring of the boundary between consumers and producers leading to higher product personalisation and customisation.

At the firm level, DM comprises a category of manufacturing systems characterised by autonomy, flexibility, adaptability, agility and decentralisation (Leitao, 2009). At the economy level, DM fits into distributed economies that feature different regions pursuing different innovative development strategies according to local needs and further characterised by flexible networks of diverse actors (Kohtala, 2015). Srai et al. (2016) identified the following major characteristics of distributed manufacturing based on a cross-case analysis done on different sectors:

- **Digitalisation:** A relatively new, pervasive and disruptive phenomenon in manufacturing which mainly permits a product to exist perpetually in a virtual form ready to be rendered at any time.
- **Localisation:** Products can be potentially produced anywhere, and possibly nearer to the end-user, given the local availability of resources and access to new production technologies.
- **Enabling technologies:** Technologies that can operate at a small scale and are agile. This permits their proliferation in many production sites with less restriction on where they might be located.
- **Personalisation:** The enhanced interactive role for consumers resulting in better customisation of goods and services through collaborative production.

Distributed manufacturing systems (DMS) already provide several benefits in comparison to traditional centralised production concepts (Seidenstricker, Rauch & Battistella, 2017). Megatrends such as sustainability, the democratisation of design, open innovation, regionalism and authenticity, and instant availability can be provided by DMS and drive the change to modern organisationally decentralised production (Matt, Rauch & Dallasaga, 2015; Putnik et al., 2013). Seidenstricker et al. (2017) conclude that the connectivity and achievements in the IoT will drive forward the decentralised concepts and will enable other planning and control systems in manufacturing based on DMS thinking.

The United Nations Industrial Development Organization (UNIDO) and the World Economic Forum identified DMS among the key emerging trends in global manufacturing industries. In a website article, *Top 10 Emerging Technologies 2015*,

Bernard Meyerson (2015) asserts that ‘distributed manufacturing turns on its head the way we make and distribute products’ by decentralising raw materials and fabrication and final products manufactured close to the final customer. The UNIDO report *Emerging Trends in Global Manufacturing Industries* argues that long-term industrial competitiveness may depend on countries’ ability to build and upgrade production-related industrial capabilities and to address existing technology gaps. This would require African countries to develop their national manufacturing development strategies by taking into account emerging technologies and trends such as distributed manufacturing systems (UNIDO, 2013).

Precursors of a distributed renewable economy

Throughout human history, there have been communities that have been living in harmony with nature, albeit on a more subsistence basis. This was and still is the case with hunter-gatherer societies that utilise mobility as a critical regulating factor for their relationship with nature. The fundamental organising principle of these communities over the millennia has been to live within the limit of the carrying and assimilative capacity of their natural environment. This, however, started to change with the onset of the agricultural transformation, which resulted in a new set of property ownership and production systems. Except for a few cases that led to the downfall of major civilisation, the agricultural society mainly adhered to the overall principle of keeping within the limit of the carrying capacity. This is primarily due to the local nature of most of the environmental impact caused by the agricultural society and its limits within the assimilative and regenerative capacity of local ecosystems.

However, the localised nature of environmental impacts started to fundamentally change with the industrial revolution, which was based on the total disregard of the principle of living within the carrying capacity of nature and was driven by the desire to have complete control over natural systems. The drive for full domination and exploitation of nature, driven by unchecked industrialisation led to a significant depletion and degradation of the natural ecosystems that provide the necessary ecosystem services for the whole economy and society. This led to an unbearable situation in the second half of the twentieth century – a situation that gave governments in industrialised countries a wake-up call. The increasing scientific knowledge about the impact of industrialisation on the environment combined with the pressure from civil societies and the general public led to the convening of the Stockholm Conference on Human Environment in 1972. This was followed by the United Nations Conference on Environment and Development (UNCED) in 1992 as the environmental challenge became more of a global proportion.

Since the adoption of Agenda 21 at UNCED in 1992, we have seen thousands of initiatives that were aimed at reconciling the environment and development goals at the local level. The following subsections consider some of these initiatives that could be considered as precursors for a distributed renewable economy.

Sustainable communities

This section covers the guiding principles of the numerous local initiatives on establishing sustainable communities as part of the implementation of Agenda 21 on sustainable development at the local level.

In general, sustainable communities are regarded as those communities that meet the economic needs of the community residents, enhance and protect their environment and promote more humane local societies. The main focus is on increasing local economic diversity that is self-reliant driven by the development of local markets, local production and greater cooperation among local economic entities. This is all coupled with an emphasis on reduction in the use of energy and the careful management and recycling of waste products (Oloyede, 2017). Over the last few decades, there have been thousands of local initiatives aimed at creating sustainable communities that strive to maintain harmony with their natural surrounds while at the same time promoting social inclusivity. Out of the many principles developed by different groups, the list that follows describes some of the key sustainable community development planning principles established by the South African Government, and in particular those in the Nelson Mandela Bay Municipal area (NMBM):

- Poverty alleviation and satisfaction of basic needs with a particular focus on communities with special needs and gender equality is necessary for any planning intervention for sustainable community development.
- Emphasising the environment as a planning principle involves incorporation of environmental aspects with the purpose of protection as well as sustainable utilisation and management of resources.
- Public participation is a general principle in planning that has specific significance at the sustainable community unit level. While the Spatial Development Framework deals with vision, long-term strategies and metro-level planning, sustainable community planning enable communities to participate in and influence planning for development in their area in concrete ways.
- Local economic development is crucial to achieve improved living conditions and promote sustainability. At the sustainable communities' level, local economic development is particularly important as it contributes to local income earning, local markets and improvement of informal businesses.

- Mixed-use development is a planning principle that directly provides for functional and social integration. The location of different uses in proximity to each other facilitates access and promotes efficient urban development. It promotes sustainability through more efficient use of resources and infrastructure.
- Variation and flexibility involve urban design aspects in the form of different types of housing, heights, densities and land use, and provision for different land tenure options within a community area. Furthermore, the principle allows for changes over time to accommodate a growing or shrinking households and alternative economic activities.
- Limiting urban sprawl is closely linked to densification and creation of compact urban structures. It is, therefore, an essential aspect of integration and sustainability and crucial for efficient infrastructure provision.

Smart urbanism

Smart urbanism poses the view that the solution to building a better urban society lies in mobilising people's latent creativity. As an antidote to bigness, it looks to harness the collective power of many small, bottom-up ideas and actions to shape the urban neighbourhood. It is mainly guided by the principles of radical incrementalism, which is a deliberate strategy through which a series of small changes are enacted one after the other resulting in radical cumulative changes in the formation of a neighbourhood. It is iterative, and adaptive learning at its best as the feedback you get along the way will initiate, accelerate and modify next actions (Campbell, 2018). Based on insights and lessons gained from various local initiatives on urban development, Campbell (2018) further identified the following key principles:

- We must shift our centralised system from its top-down, command-and-control process to operating in a more enabling role while at the same time dovetailing this with an evolving distributed system.
- We need to embrace complexity and see the city in the context of a complex adaptive system rather than using traditional planning techniques that do not have the flexibility needed to address multifaceted and rapidly-paced urban change.
- Urban design must be a generative process, from which a form will emerge and one that must incorporate the decisions and needs of local stakeholders not as a matter of fairness only but also of the intrinsic quality of the result.

- Urban neighbourhood development needs to shift from a ‘bigness’ model that is characterised by large-scale neighbourhood schemes that are driven by top-down capital accumulation to a ‘massive small’ model that is characterised by bottom-up land management model which promote diversity of provisions.
- Putting the sustainability agenda which is guided by ‘thinking globally while acting locally’ together with the viability agenda, which is guided by ‘thinking locally and acting locally’, together gives a powerful signal across the full spectrum of local to global and enables the abstract model to work with an agent-based model for real difference.

Regenerative economies

Contrary to the conventional economic thinking, which presumes economic vigour as a function of the rate of gross national product growth, regenerative economies recognise ‘economic vigour as a product of human and societal vitality, rooted in ecological health and the inclusive development of human capabilities and potential’ (Fullerton, 2015:40). The following are the key and interconnected principles that determine systemic health under regenerative economies, as highlighted by Fullerton (2015:44-79):

- **In right relationship:** Humanity is an integral part of an interconnected web of life in which there is no real separation between ‘us’ and ‘it’ and the scale of the human economy matters in relation to the biosphere in which it is embedded.
- **Views wealth holistically:** Real wealth must be defined and managed in terms of the wellbeing of the whole, achieved through the harmonisation of multiple kinds of wealth or capital, including social, cultural, living and experiential. The whole is only as strong as the weakest link.
- **Innovative, adaptive, and responsive:** In a world in which change is both ever-present and accelerating, the qualities of innovation and adaptability are critical to health. To use the Darwinian expression the most ‘fit’ is the one that is most adaptable to a changing environment.
- **Empowered participation:** In an interdependent system, fitness comes from contributing in some way to the health of the whole. The quality of empowered participation means that all parts must be ‘in a relationship’ with the larger whole in ways that not only empower them to negotiate for their own needs but also enable them to add their unique contribution towards the health and well-being of the larger wholes in which they are embedded.

- **Honours community and place:** Each human community consists of a mosaic of peoples, traditions, beliefs and institutions uniquely shaped by long-term pressures of geography, human history, culture, local environment and changing human needs.
- **Edge effect abundance:** Creativity and abundance flourish synergistically at the 'edges' of systems, where the bonds holding the dominant pattern in place are weakest. Working collaboratively across edges is transformative for both the communities and individuals involved.
- **Robust circulatory flow:** Just as human health depends on the healthy circulation of oxygen and nutrients, so too does economic health depend on robust circulatory flows of money, information, resources, and goods and services to support exchange, flush toxins and nourish every cell at every level of our human networks.
- **Seeks balance:** Being in balance is more than just an excellent way to be as it is essential to systemic health. A regenerative economy seeks to balance efficiency and resilience; collaboration and competition; diversity and coherence; and small, medium, and large organisations and needs.

The tens of thousands of local initiatives that have been developed and implemented across the globe under these and other similar initiatives have led to a massive volume of empirical knowledge on how to plan and implement bottom-up initiatives that are driven by communities. African countries can gain valuable practical insights from these initiatives, which are also happening in their localities, and use them as a pilot basis for the development of distributed economy networks.

Development of a distributed renewable economy

Planning for a distributed renewable economy is aimed at creating a local, sustainable economy network as a foundation for developing a wellbeing economy that continuously fulfils the needs and aspirations of its people while ensuring the wellbeing of the natural ecosystem. Figure 7.1 presents the key development objectives of a wellbeing economy under human wellbeing and ecosystems wellbeing. The fundamental objective of the Wellbeing Economy in relation to human wellbeing is fulfilling the basic needs and aspirations of its people while continuously enhancing the productive capacity of the community. A wellbeing economy recognises that these fundamental objectives of human wellbeing could only be achieved by ensuring the wellbeing of the ecosystem which provides the primary ecosystem services input within the limits of its regenerative and assimilative capacity.

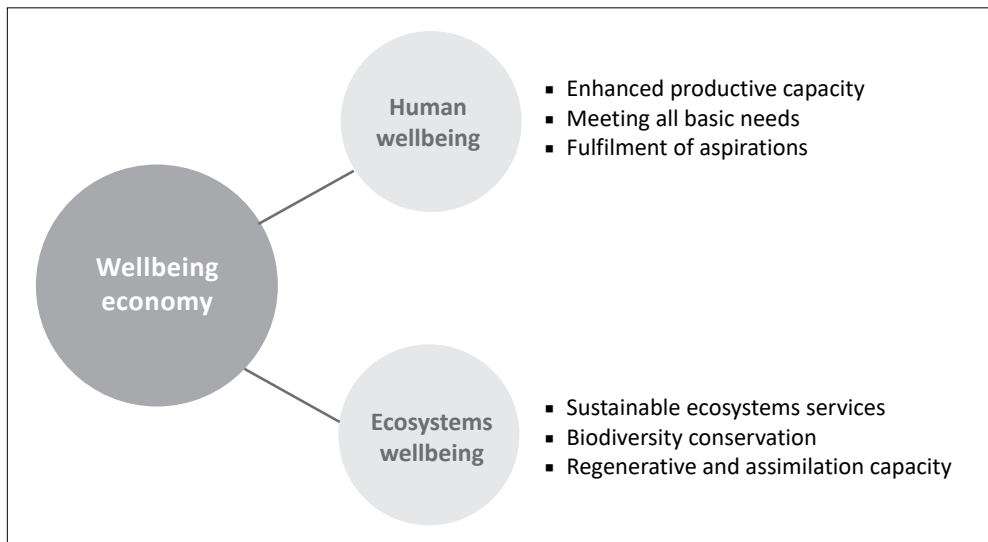


Figure 7.1 Key objectives of a wellbeing economy

Distributed renewable economy is a planning tool that will enable countries to reconcile the above two fundamental objectives at the local level. Based on case studies conducted in different countries, Van den Dool et al. (2009) identified the following as the potential benefits attributed to a distributed economy:

- Increased local use of renewable resources and wealth creation for more people.
- Decreased pollutant emissions and waste generation at the local and regional levels.
- Added value benefits maintained within the region.
- Increased share of non-material inputs (e.g., information, local know-how) and higher added value to local materials.
- Diversity and flexibility of economic activities and increased diversity and intensity of communication.
- Enhanced collaboration between regional activities.

The basis for a distributed renewable economy

As noted by Fioramonti (2017), the shift towards quality jobs and distributed production and consumption require dismantling the vertical approach of the growth economy to support a horizontal network across an economy. The distributed renewable economy development model is about building the foundation for the transition to an inclusive, low-carbon and resource-efficient society through a

bottom-up process that is built upon dynamic interaction between sustainable local economy networks. The following are the major theoretical and empirical premises that serve as the basis for the development of a distributed renewable economy:

- The current dominant notion of economy of scale, which favours concentration and consolidation of the productive capacity of society around a limited number of players and actors, is fundamentally constrained to create a sufficient number of jobs and promote social inclusion as stated in Agenda 2030 on SDGs and the aspiration of Agenda 2063.
- The significant progress made in the areas of renewable energy technology, information technology and distributed (modular) manufacturing systems in recent decades has also made the dominant economy of scale, which is characterised by large scale mass production, increasingly obsolete. This provides the basis for distributed economies consisted of dynamic local economic networks.
- The enormous potential that African countries have in terms of renewable energy resources coupled with its natural resources provide a significant opportunity for African countries to develop more sustainable local economies that are mainly driven by distributed renewable energy systems.
- As much as it may have its own threats, recent developments in ICT and the increasing digitisation of the global economy open new empowerment opportunities for African countries provided that they proactively manage and use them in a transformative way. The development of such local economy networks in the region would make a significant contribution towards job creation and value addition at the local level. This will, in turn, provide the basis for a profound social transformation towards a sustainable society.
- Developing and promoting distributed renewable economies that are driven by distributed renewable energy systems which utilise the abundant renewable energy resource that Africa has, and maintaining the ecological foundation of African economies are fundamental for promoting economic development and social transformation in the region.

Development framework for distributed renewable economy

Distributed renewable economy is being developed as a planning model that reinforces the ongoing work of reorienting macro-economic policies at the national level with a bottom-up process that demonstrates the contribution of the development process to poverty eradication and sustainable development. As a planning tool, distributed renewable economy facilitates the operationalisation of the transition to a sustainable economy through efficient management and

utilisation of the available resources within a given region or locality. As such, it does not come with a ready-made blueprint in the form of 'one-size-fits-all' approach. It instead provides a methodological framework to assist and guide local communities and development partners to develop and implement their own inclusive, low-carbon and resource-efficient economy which will dynamically evolve. It also provides an operational framework through which maximum synergy could be promoted between various initiatives aimed at promoting sustainable development and thereby promoting effective resource utilisation.

The distributed renewable economy process is guided by key systems and evolutionary principles of which the following could be cited as the major ones:

- **Incremental efficiency gains and systems innovation:** The sustainability transition requires promoting incremental efficiency gains contributing to resource decoupling supported with broader systems innovation aimed at impact decoupling.
- **Technological innovation coupled with social innovation:** The systems innovation that is required for the sustainability transition would require reinforcing the ongoing technological innovation with social innovation systems at all levels.
- **Self-organising systems through symbiotic relationships:** The development of a more stable and sustainable economic system that operates as a self-organising socio-economic system following the principles of industrial symbiosis is at the core of a distributed renewable economy.
- **Adaptive and inclusive governance:** The development and implementation of the distributed renewable economy at any level requires the innovative engagement of all sectors of the society guided by the principles of adaptive and inclusive governance.

Some fundamental shifts need to happen in the overall framing and implementation of the planning process to make progress in developing a distributed economy. Based on the above principles and the key concepts and empirical lessons covered in earlier sections, the following planning framework is proposed as a generic framework that could be modified and adapted to local contexts. As shown in Figure 7.2, the framework consists of three stages that have nine key steps altogether.

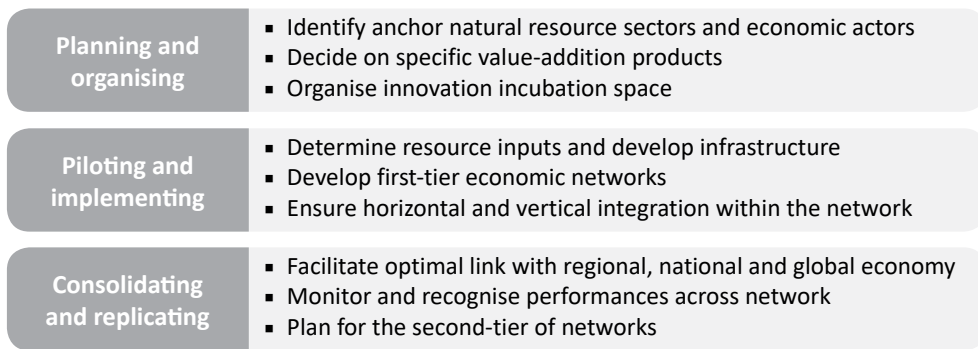


Figure 7.2 Development framework for distributed renewable economy

The first stage of the framework covers the planning and organising steps as the foundation of the process. The crucial first step of the whole process is to identify a natural resource sector and or an economic actor which could be used as an anchor for the development of the distributed economy network. The next step is to organise an innovation incubation space to identify the specific economic activity that may lead to higher value addition and job creation for the local economy.

The second stage is the piloting and implementation stage which focuses on the actual development of the distributed economy network around the selected resource sector or economic actor. Depending on the level of preparedness and the possible success rate, this stage can start with a piloting phase to be followed with full-scale implementation. The critical step in this stage is the definition and development of the resource input required with a particular focus on the provision of energy, knowledge and financial inputs. This would require making the best use of the available knowledge, technological and financial resources that are highlighted in this section. The initial focus of this stage is on the development of the first tier of the economic network around the most promising resource and economic actors by ensuring an optimal vertical and horizontal integration across the value chain.

The third stage focuses on further consolidating and possibly replicating the economic network into a second tier of economic activities. The critical step in this stage is the facilitation of an optimal and efficient link of the local economic network with the national and global economic system. It is critical to continuously monitor the effectiveness of the economic actors in the network with the purpose of feeding back the lessons into the process and encourage competition by giving recognition to the best-performing actors and stakeholders.

Each of the steps in the development framework needs to be guided by the key principles highlighted in this section and supported by the relevant tools that are available in connection with local development planning processes.

Conclusion

Creation of jobs to the youth population that is growing at an alarming rate, eradication of poverty, and gender empowerment are three of the most common and critical development priorities that are cited in almost all of the continental and national development visions, policies and strategies. Evidence from the past couple of decades has clearly shown that challenges of job creation and social inclusivity continued to be further aggravated across the world, but more severely in Africa. The fourth industrial revolution, driven by inappropriate application and utilisation of exponentially disruptive technologies is feared to increase the number of vulnerable jobs by putting more people out of jobs. It is also expected to widen the wealth gap significantly by further reinforcing the concentration of wealth in few hands. Fortunately, most of the disruptive technologies of the twenty-first century also have significant potential to promote distributional justice by empowering people and enhancing the overall socio-ecological efficiency of the global economic system.

One of the major areas where the disruptive technologies of the twenty-first century would have significant transformation outcomes is in the field of promoting distributed economy networks that are aimed at creating more jobs and adding multiple values at the local level. Even if this could apply to almost all countries, Africa has a unique opportunity to gain the maximum benefit from such a strategic approach. A systematic application of distributed economy networks development could also assist countries to overcome the limitation and save wastage from the fragmented and isolated implementation of development programmes, which is an Achilles heel of most development programmes in African countries. Finally, it is worth noting that an Africa that is at peace with itself and with its natural environment; an Africa that is inclusive, low-carbon and resource-efficient; and an Africa that is free of poverty and unemployment makes a critical contribution to global security and sustainability. Supporting the proliferation of distributed economy networks across the region is one sure way of achieving the 'Africa We Want' of Agenda 2063 and the 'Future We Want' of Agenda 2030.

References

- Alanne, K. & Saari, A. (2006). Distributed energy generation and sustainable development. *Renewable and Sustainable Energy Reviews* 10(6): 539–558. <https://doi.org/10.1016/j.rser.2004.11.004>
- Ayres, R.U. (1994). *Information, entropy, and progress: A new evolutionary paradigm*. New York: American Institute of Physics Press.
- Baran, P. (1964). *On distributed communications network*. Reprinted from the *IEEE Transactions on Communications Systems* CS-12(1), March. <https://bit.ly/2MamttJ> [Accessed 20 September 2019]. <https://doi.org/10.1109/TCOM.1964.1088883>
- Bauwens, M. & Kostakis, V. (2015). *Towards a new reconfiguration among the state, civil society and the market*. <https://bit.ly/2B666b9> [Accessed 24 May 2018]. <https://doi.org/10.21721/p2p.2014v1n1.p1-24>
- Breda, J.V. & Swilling, M. (2018). The guiding logic and principles for designing emergent transdisciplinary research processes. *Sustainability Science* 13(42): 1–19. <https://doi.org/10.1007/s11625-018-0606-x>
- Campbell, K. (2018). *Making massive small change: Building the urban society we want*. London: Chelsea Green Publishing.
- Cooper, M. (2016). Renewables and distributed resources in a post-Paris low carbon future: The key role and political economy of sustainable electricity. *Energy Research & Social Science* 19: 66–93. <https://doi.org/10.1016/j.erss.2016.05.008>
- Dafermos, G. (2015). *Transforming the productive base of the economy through the open design commons and distributed manufacturing*. <https://bit.ly/2B743DC> [Accessed 16 May 2016].
- Fioramonti, L. (2017). *Wellbeing economy: Success in a world without growth*. Johannesburg: Macmillan.
- Fischer-Kowalski, M. & Harbel, H. (2007). *Socioecological transitions and global change: Trajectories of social metabolism and land use*. Cheltenham, UK: Edward Elgar Publishing. <https://doi.org/10.4337/9781847209436>
- Fullerton, J. (2015). *Regenerative capitalism: How universal principles and patterns will shape our new economy*. <https://bit.ly/1bDuUrY> [Accessed 15 September 2019].
- Genov, N. (1999). *Managing transformations in Eastern Europe*. Paris: UNESCO-MOST.
- Gottlieb, R.S. (Ed.). (1996). *This Sacred earth: Religion, nature and environment*. New York: Routledge.
- International Energy Agency. (2014). *Africa energy outlook*. Paris: IEA. <https://doi.org/10.1787/weo-2014-en>
- International Renewable Energy Agency. (2013). *Africa's renewable future: The path to sustainable growth*. Abu Dhabi, UAE: IRENA. <https://doi.org/10.4324/9781315074436>
- International Renewable Energy Agency. (2015). *Africa 2030: A roadmap for renewable energy future*. Abu Dhabi, UAE: IRENA.
- Johansson, A., Kisch, P. & Mirata, M. (2005). Distributed economies – A new engine for innovation. *Journal of Cleaner Production* 3(10/11): 971–979. <https://doi.org/10.1016/j.jclepro.2004.12.015>
- Kohtala, C. (2015). Addressing sustainability in research on distributed production: An integrated literature review. *Journal of Cleaner Production* 106(1): 654–668. <https://doi.org/10.1016/j.jclepro.2014.09.039>
- Kosko, B. (1994). *Fuzzy thinking: The new science of fuzzy logic*. London: Flamingo Publishers.

- Leitao, P. (2009). Agent-based distributed manufacturing control: A state-of-the-art survey. *Engineering Applications of Artificial Intelligence* 22(7): 979–991. <https://doi.org/10.1016/j.engappai.2008.09.005>
- Leroy, P. (1997). Interdisciplinarity within Dutch environmental science(s). *Proceedings of the Conference on Science for Sustainability: Integrating Natural and Social Sciences*. Roskilde: Roskilde University.
- Lorenzo, F. (2017). *Wellbeing economy: Success in a world without growth*. Johannesburg: Macmillan.
- Matt, D.T., Rauch E. & Dallasaga, P. (2015). Trends towards distributed manufacturing systems and modern forms for their design. *Procedia CIRP* 33: 185–190. <https://doi.org/10.1016/j.procir.2015.06.034>
- McClaghry, J. (1989). Preface. In: E.F. Schumacher, *Small is beautiful*. London: Harper Perennial.
- Meadows, D., Meadows, D. & Randers, J. (1992). *Beyond the limits* (1st edition). London: Chelsea Green Publishing.
- Mebratu, D. (1998). Sustainability and sustainable development: Historical and conceptual review. *Environmental Impact Assessment Review* 18(6): 493–520. [https://doi.org/10.1016/S0195-9255\(98\)00019-5](https://doi.org/10.1016/S0195-9255(98)00019-5)
- Mebratu, D. (2000). *Strategies for sustainable industrial development in sub-Saharan Africa*. Lund, Sweden: Lund University.
- Meyerson, B. (2015). Top 10 emerging technologies of 2015. <https://www.weforum.org/agenda/2015/03/top-10-emerging-technologies-of-2015-2/> [Accessed 20 September 2019].
- Miller, T.R., Wiek, A., Sarewitz, D., Robinson, J., Olsson, L. et al. (2014). The future of sustainability science: A solutions-oriented research agenda. *Sustainability Science* 9(2): 239–246. <https://doi.org/10.1007/s11625-013-0228-2>
- Mundaca, L., Markandya, A. & Nørgaard, J. (2013). Walking away from a low carbon economy? Recent and historical trends using a regional decomposition analysis. *Energy Policy* 61: 1471–1480. <https://doi.org/10.1016/j.enpol.2013.04.083>
- Nelson Mandela Bay Municipality. (2007). *Sustainable community planning guide*. <https://bit.ly/2B8aXZe> [Accessed 10 September 2019].
- Oloyede, O. (2009) Developing sustainable communities in Africa: Components for a Framework. *Identity, Culture and Politics: An Afro-Asian Dialogue* 10(2): 56–64. <https://bit.ly/316iZww> [Accessed 2 May 2017].
- Putnik, G., Sluga, A., Elmaraghy H., Teti, R., Koren, Y. et al. (2013). Scalability in manufacturing systems design and operation: State of the art and future developments roadmap. *CIRP Annals – Manufacturing Technology* 62(2): 751–774. <https://doi.org/10.1016/j.cirp.2013.05.002>
- Raji, A. & Kahn, M.T. (2012). Analysis of distributed energy resources for domestic electricity users. *Journal of Energy in Southern Africa* 23(2): 50–55. <https://doi.org/10.17159/2413-3051/2012/v23i2a3163>
- REN21. (2017). *Renewables 2017 global status report*. Paris: REN 21 Secretariat.
- Roszak, T. (1989). Introduction. In: E.F. Schumacher, *Small is beautiful*. New York: Harper Perennial.
- Scholz, R.W. (2011). *Environmental literacy in science and society: From knowledge to decisions*. Cambridge, UK: Cambridge University Press. <https://doi.org/10.1017/CBO9780511921520>
- Schwab, K. (2018). *Shaping the fourth industrial revolution*. Geneva: World Economic Forum.
- Seidenstricker, S., Rauch, E., & Battistella, C. (2017). Business model engineering for distributed manufacturing systems. *Procedia CIRP* 62: 135–140. <https://doi.org/10.1016/j.procir.2016.06.112>

- Seidl, R., Brand, F.S., Stauffacher, M., Krütli, P., Le, Q.B. et al. (2013). Science with society in the anthropocene. *Ambio* 42(1): 5–12. <https://doi.org/10.1007/s13280-012-0363-5>
- Smuts, J. (1993). Holism and evolution. In: J.J. Clarke (Ed.), *Nature in question: An anthology of ideas*. London: Earthscan Publications.
- Srai, J.S., Mukesh, K., Graham, G., Philips, W., Tooze, J. et al. (2016). Distributed manufacturing: scope, challenges and opportunities. *International Journal of Production Research* 54(23): 6917–6935. <https://doi.org/10.1080/00207543.2016.1192302>
- Stauffacher, M., Walter, A.I., Lang, D.J., Wiek, A. & Scholz, R.W. (2006). Learning to research environmental problems from a functional socio-cultural constructivism perspective: The transdisciplinary case study approach. *International Journal of Sustainability in Higher Education* 7(3): 252–275. <https://doi.org/10.1108/14676370610677838>
- Swilling, M. & Annecke, E. (2012). *Just transitions: Explorations of sustainability in an unfair world*. Tokyo: United Nations University.
- United Nations Industrial Development Organization. (2013). *Emerging trends in global manufacturing industries*. Vienna: UNIDO.
- van den Dool, A., Marchington, E., Ripken, R., Hsieh, A., Petrasova, M. et al. (2009). *The future is distributed: A vision for sustainable economies*. Lund, Sweden: Lund University.
- Vázquez Pimentel, D.A., Ayma, I.M. & Lawson, M. (2018). *Reward work not wealth*. Oxfam Briefing paper, January. Cowley, UK: Oxfam GB. <https://bit.ly/2q8ejcD> [Accessed 13 March 2019].
- Weinberg, M.G. (1975). *An introduction to general systems thinking*. New York: Wiley-Interscience Publications. <https://doi.org/10.1080/03081077508960832>
- Wiek, A. & Lang, D.J. (2016). Transformational sustainability research methodology. In: H. Heinrichs, P. Martens, G. Michelsen & A. Wiek (Eds), *Sustainability science*. Dordrecht, Netherlands: Springer. https://doi.org/10.1007/978-94-017-7242-6_3
- Ziegler, H. (1997). Statement at the final panel of the conference. Conference of Science for Sustainability: Integrating Natural and Social Sciences. Roskilde University, Denmark (October).



8

INCLUSIVE GOVERNANCE FOR SUSTAINABLE DEVELOPMENT IN AFRICA

Mark Swilling

Introduction

Since the onset of the global economic crisis in 2007/2008, two key trends converged in ways that require a new discussion about the connection between ‘development’ and ‘sustainability transitions’: the rise of the so-called ‘BRICS-plus’¹ economies as most of the traditional Organization for Economic Co-operation and Development (OECD) economies plunged into a prolonged depressive malaise (Bogdan, Hurduzeu, Josan & Vlasceanu, 2011; Pant, 2013; Van Agtmael, 2012), and the emergence of a global narrative that started with the ‘green economy’ discourse in 2009 (Death, 2014; Geels, 2013) followed soon after by the adoption of the Sustainable Development Goals (SDGs) in 2015. The primary implication

1 BRICS is an association of emerging/developing countries namely Brazil, Russia, India, China and South Africa. The BRICS-plus initiative is aimed at developing the outreach activities of the BRICS countries with the global South and building wider partnership with emerging markets and developing countries.

of the convergence of these trends over nearly a decade is the need to rethink the relationship between development and sustainability transition. Although Scoones, Leach and Newell (2015) make a significant contribution in this regard the focus in this chapter is not on the development-sustainability nexus in general. Instead, the focus is more on sustainability transitions and ‘developmental states’ – the latter usually regarded as having a historic mission to accelerate the development and modernisation processes in the spirit of ‘catch up’ (Evans, 2010).

Building on earlier work with similar aims (see Swilling and Annecke, 2012, Chapter 5), this chapter argues that we need to draw on the well-established literature on the developmental state (DS) and sustainability transitions (ST) in order to better understand the challenge of combining development strategies and commitments to ecological sustainability that many states in Africa now face since the adoption of the SDGs. This synthesis, in turn, needs to be brought into conversation with the African literature on ‘governance for development’.

Given the contested nature of the term ‘development’, it is necessary to declare a specific point of departure. For this purpose, I favour the following definition of development by Castells and Himanen:

Development ... is the self-defined social process by which humans enhance their well-being and assert their dignity while creating the structural conditions for the sustainability of the process of development itself. (Castells & Himanen, 2014:29)

This definition is useful because wellbeing rather than gross domestic product (GDP) per capita is at the centre. Following Sen (1999), this definition of development is not derived from an abstract categorical imperative but from the everyday processes of ‘self-definition’ via dialogical engagement, which are of course context-specific. However, these acts of becoming are inseparable from the wider process of structural change to ensure the longer-term sustainability of development processes. But the former is not conditioned by the latter – instead, the latter is the emergent outcome of the continuous struggles over the terms of the development process itself. Of course, this is not how ‘Development’ (with a big ‘D’) is usually officially defined in mainstream narratives (Nederveen-Pieterse, 2000). Nevertheless, this is, most certainly, ‘development’ (with a small ‘d’) as a process of mutual flourishing within communities of human and non-human beings. For some, this takes us into what is referred to in the Latin American literature as ‘postdevelopment’ (Escobar, 2015), while for others it implies ‘degrowth’ (D’Alisa, Demaria & Kallis, 2015) or ‘alternative development’ (Nederveen-Pieterse, 2000). Either way, wellbeing and a relational perspective seem to be what is common across nearly all perspectives that break with ‘Development’ (big ‘D’).

Following this perspective,² a ‘just transition’ can be defined as a set of complex highly contested socio-political processes that result in (i) significant improvements in wellbeing for all (including the eradication of poverty and reduced inequalities, in particular asset inequality); and (ii) decarbonisation, the simultaneous restoration of degraded ecosystems, and radical improvements in resource efficiency. Achieving both via a just transition would require – and result in – far-reaching structural transformations that are arguably implied by the commitments embedded within the SDGs. An exclusive focus on the former will leave planetary systems to collapse resulting in rising prices of increasingly scarce resources, starting with the most sensitive which is food, but also water, energy and other extracted materials. No matter how progressive the government of the day may be, in a highly unequal world, the poor will suffer the most and the rich will be able to buy up a shrinking pool of resources. Conversely, strategies that only focus on the ecological sustainability of the planetary systems will tend to neglect what is needed to build the capabilities of the poor to define their own solutions and the capabilities of the state to intervene where required. Where the fusion of these goals becomes most explicit is in the idea of a just transition expressed most concretely in the call for energy democracy as a way of reorienting the directionality of the global renewable energy revolution (Burke & Stephens, 2018).

The problem, however, is that the literature on developmental states and sustainability transitions have evolved in parallel without much cross-over (for a key exception and seminal contribution see Johnstone and Newell, 2018). This is an opportune moment to synthesise this literature in order to conceptualise in a more detailed way the dimensions of a sustainability-oriented polity that holds in balance the developmental and sustainability agendas (in a way that avoids the usual ‘trade-off’ narrative introduced by the ‘triple bottom line’ approach).

While the DS literature has been widely used to address the development challenges of industrialising economies in the global South (Bagchi, 2000; Chang, 2007; Chibber, 2002; Edigheji, 2010; Evans, 2010; Jayasuriya, 2001; Kohli, 2006; Leftwich, 1995, 2000; Mkandawire, 2001; Noman, Botchwey, Stein & Stiglitz, 2011; Rodrik, Subramanian & Trebbi, 2004; Swilling, 2008; Swilling, Musango & Wakeford, 2015; Thompson, n.d.), this literature has generally neglected to deal with environmental challenges in general and STs in particular. The ST literature generally has ignored development (with exceptions such as Scoones, Leach and Newell, 2015; Swilling and Annecke, 2012;), but there is an emerging literature

2 This definition fuses together various strands in development studies, including Sen’s capability perspective, the writing on wellbeing, traditional concerns with structure in development economics, and ecological and institutional sustainability thinking.

that has started to be used to address this lacuna, with a significant body of work already done on East Asian economies (Angel & Rock, 2009; Berkhout, Angel & Wieczorek, 2009; Rock, Murphy, Rasiah, Van Seters & Managi, 2009) and now also starting to be applied in the South African context (Baker, 2015; Baker, Newell & Philips, 2014; Lawhon & Murphy, 2011; Swilling & Anneck, 2012).

Scoones et al. (2015) have achieved a significant synthesis of the development economics and ST/transformation literature, with specific reference to the 'politics of green transformations'. In a subsequent publication, Johnstone and Newell (2018) build on this foundation and offer a perspective on sustainability transitions that draws on rich traditions in radical political economy. This chapter builds on these works, the ST literature on East Asia plus my previous work on synthesising development, institutional and ecological economics to theorise the 'greening' of the developmental; Swilling, Musango & Wakeford, 2016). The resultant synthesis is then brought into conversation with the debates about the African developmental state, in particular, the contributions in a volume edited by Noman et al. (2011).

As already noted, the DS and ST literature agree on the need for deep structural transformation, but with two different ends in mind: for the DS literature, the end is accelerated economic 'Development' (big 'D') that substantially raises the average GDP per capita with a focus on industrialisation and urbanisation; while for the ST literature the end is a socio-technical transition that results in a low-carbon resource-efficient economy. Johnstone and Newell (referred to later) go a long way towards achieving such a synthesis, but like most work in the political economy field, they neglect the institutional context. I will argue that the synthesis of this literature needs, rather, to open up a space for a more detailed discussion about governance for a just transition, with special reference to how we deepen our understanding of the dynamics of the polity in African governance systems.

Developmental states

The defining feature of DSs is that they are primarily concerned with the structural transformation of modernising economies (Evans, 1995; Kohli, 2006; Noman et al., 2011). The legitimisation of DSs is derived primarily from their ability to promote sustained growth and development via aggressive industrialisation (Chibber, 2002). In practice, the underlying economic rationale for DSs has been an acceptance that markets left to their own devices will tend towards disequilibrium in unequal developing economies and therefore state intervention is a necessity. However, at the ideological level, DSs were excellent at extolling the virtues of capitalism and even, when it suited them, the logics of neo-classical economics. As summarised by Khan (2008), they promoted sustained growth and development by deploying several unique abilities. These included the ability to extract and

deploy capital productively, generate and implement national and sectoral plans and effect dynamic egalitarian and productivity-enhancing development programmes in land, education and training, small enterprise, infrastructure and housing sectors. In addition, DSs have been able to manipulate private access to scarce resources through, among others, financial sector re-engineering, subsidies, taxes, concessions and high levels of lending.

An authoritarian form of governance was often pursued by states that were determined to tightly manage and cultivate a state-dependent national business class. The cultivation of close and productive relationships with business on terms set by the political elite and enforced via state institutions was the norm. Interest groups were managed using corporatist arrangements, often in authoritarian top-down ways to impose the state's agenda versus the more consensual type of social corporatism that was pursued in South Africa after 1994. Thus the East Asian DS was characterised by a capacity to coordinate the efforts of individual businesses by encouraging the emergence and growth of private economic institutions, target specific industrial projects and sectors, resist political pressure from popular forces and, at times, also brutally suppress them. These DSs often mediated and/or insulated domestic economies from (extensive) foreign capital penetration during the early stages and, most importantly, sustained and implemented a project of productivity improvement, technological upgrading and increased market share that broke them out of a path-dependent low-growth economic trajectory (Chang, 2007).

The institutionalisation of the polity of the developmental state has received much attention since the 1990s. In a seminal contribution, Leftwich (1995) summarised what many regard as the key institutional characteristics of the typical polity of the typical DS as follows:

- a 'determined developmental elite' committed to the modernisation project;
- 'relative autonomy' from major capitalist economic interests who are always keen to capture the state;
- 'a powerful, competent and insulated economic bureaucracy' that enjoys the highest possible political support but operates without too much political interference;
- a 'weak and subordinated civil society' which means there are no rival centres of alternative policy formation;
- the 'effective management of non-state economic interests' via formal structured compacts, incentives and penalties; and
- accessible and usable institutions of 'repression, legitimacy and performance'.

What is distinctive about the literature on developmental statism in Africa is whether these characteristics – derived from the East Asian context - are applicable in the African context (Mkandawire, 2001), especially in light of the pervasiveness of neo-patrimonial modes of governance in post-independence Africa (Booth & Golooba-Mutebi, 2012; Kelsall, 2013; Pitcher, Moran & Johnston, 2009). Originating in Fanon's classic narrative on the weakness of the 'national bourgeoisie' in post-colonial Africa (Fanon, 1963), the core questions asked in this literature are about whether it really is possible to talk about a 'developmental elite' acting 'relatively autonomously' from capitalist interests by way of a 'competent bureaucracy' that 'effectively managed' developmental compacts with non-state actors. Or whether it is preferable to talk about 'developmental neo-patrimonialism'. But before addressing this African debate, the wider conceptual framework needs to be put in place.

Once East Asian DSs had consolidated an industrial base through technological capacity building, institutional functionality and human developmental capabilities, their focus shifted from the late 1990s onwards from massive investments in the material conditions of modernisation to establishing the conditions required by the emergent knowledge economy created by the information revolution (Evans, 2012). Three new tasks emerged with major implications for the structures and logics of the polities that drove the initial phases of development. Together, these three tasks clearly defined the slightly more consensual modes of governance that emerged during the transition from accelerated heavy industrialisation/urbanisation to an emphasis on quality and greening – a process often associated with 'de-nationalisation' of the 'commanding heights' of the economy (except for the China case).

Firstly, if institutions are accepted as key to an environment that fosters innovation (following the logic of the new mainstream institutional economics – see Rodrik et al. 2004), then the main challenge becomes the building of networks and new value chains as the drivers of growth, the development of leadership capabilities to build effective institutions and, more importantly, the facilitation of networks of institutions that span multiple sectors of the economy. This new kind of political leadership has to strike a very delicate balance between regulation of shared norms/values (e.g., a patriotic or nationalist commitment to national development) and self-managed implementation (especially important for fostering innovation). As will be argued, this depended on the political will to re-organise the various dimensions of the polity (including political re-alignments), and in some cases, this meant using repressive force.

Secondly, no one disputes that knowledge and innovation matter. However, these are emergent properties that stem from dense networks of people, working together across institutional boundaries within quite well-defined institutional

eco-systems, unconstrained by outdated (usually hierarchically organised) norms or an atmosphere of fear and conformity (that often prevailed during the earlier years of 'forced march' industrialisation/urbanisation). The private sector always under-invests in human capital and innovation networks because the direct returns to the investor are impossible to predict. Without state-led investment in these sectors, facilitated by an appropriately configured socio-political regime via universities, NGOs and developmental partnerships/compacts, knowledge-based, innovation-led economic development in the era of the network society may be impossible (Castells & Himanen, 2014; Mazzucato, 2011). Indeed, the key constituency that gets included in the broadening out of 'collibratory' governance to support innovation and experimentation are a wide range of knowledge workers – entrepreneurs, researchers, inventors, innovators, venture capitalists, impact investors, NGOs, consultants, and so on.

Thirdly, embeddedness for the twenty-first-century DS might mean building a polity that broadens out developmental partnering with networks of civil society formations and smaller entrepreneurs rather than focusing only on the investment strategies of large corporates (as was the case during the early years when the focus was on the construction of a heavy industrial base). This kind of broad more consensual mode of governance may be particularly appropriate where the national business class is strong. A weak national bourgeoisie has traditionally been a good reason for developmentally-oriented states to get involved during the early stages of economic development to weld together local business elites into effective drivers of national investment-led development. But in situations where the national bourgeoisie is fully consolidated, the state has more freedom to integrate a wider set of class alliances. This may entail a multiplicity of smallish interventions, rather than a few, massive, physical infrastructure investments that satisfy the need for capital deepening but do little to redefine the institutional context for the circulation of the benefits. This, however, is only possible if there is sufficient capacity to handle these transaction costs.

Sustainability transitions

The multi-level perspective (MLP) is the most influential approach in the ST literature. In summary, the MLP makes a distinction between landscape pressures, socio-technical regimes, and innovation niches (Grin, Rotmans & Schot, 2010). Landscape pressures are longer-term transformative socio-structural conditions such as demographic change, climate change, digitalisation, rising levels of education over time, ageing, resource depletion and cultural change. Socio-technical regimes are specific configurations of technologies, markets, regulations, institutions, human capabilities and routines that make it possible to reproduce societal systems such as energy provision, mobility, market-based property

development, food systems, industrial agriculture, water provision and waste management. Regimes display a high degree of obduracy in the face of landscape pressures. Niche innovations emerge when networks of innovators (technological financial, institutional) respond to landscape pressures by collaborating to develop potentially new emergent socio-technical regimes (e.g., renewable energy, or organic food) that can either replace old regimes or get absorbed by those regimes that realise they need to adapt to landscape pressures.

Transition researchers characterise socio-technical regime change – or structural transformation – as being predicated on the ways in which shifting landscape pressures impinge on a regime and the extent to which responses to these pressures are coordinated, both from inside and outside the regime to accommodate or resist these pressures (Smith, Stirling & Berkhout, 2005). In this way, the ST literature opens up the issue of governance interventions to facilitate regime transformation, but for some this has not hitherto been taken far enough (Geels, 2014; Hess, 2014; Johnstone & Newell, 2018; Meadowcroft, 2011). It is not only the objective reality of these pressures that matters, but more importantly, the adaptive capacity, or the relationships, resources and their levels of coordination within the polity that shapes responses to these pressures. This can be the outcome of historical processes (e.g., a gradual shift in consumer choices or evolution of new technologies) or purposively informed by a strategically aligned polity with a shared vision and capacity to implement a coherent set of policies. The ST literature is critical of the neo-liberal assumptions about the virtues of the market, hence the constant insistence on a role for the state. As Johnstone and Newell suggest:

In short, within sustainability transitions literatures ‘the state’ has been an assumed but underconceptualised, secondary aspect in explorations of socio-technical transitions and niche development. (Johnstone & Newell, 2018:74)

Johnstone and Newell identify five implicit assumptions about the nature and role of the state in the ST literature (Johnstone & Newell, 2018:74–76). Firstly, there is rising awareness of the key role of state institutions in accelerating transitions. The supportive role of state institutions in the rapid rise of renewable energy across all world regions is a case in point (Mazzucato, 2015). Secondly, there is growing recognition of the political role played by coalitions of incumbents that resist STs. They can use state institutions, and equally state institutions can be used against them. Thirdly, it is becoming increasingly clear that state institutions will be required to actively destabilise and discontinue unsustainable socio-technical regimes (e.g., oil-based motor vehicle engines) – they are unlikely to simply wither away in the face of landscape pressures and niche innovations. Fourthly, the rising number of case studies of STs reveals how significant each context is. Regimes, niches and transition pathways are profoundly embedded within – and shaped

by – the dynamics of each specific context. How these dynamics pan out in South Africa will be very different in South Korea, or Europe, or Brazil. Fifthly, despite the foregoing four trends, when the state is discussed in the ST literature there is little recognition of its relational nature. Instead, ‘[s]trict dividing lines often persist in relation to “state”, “market” and “civil society”’, and as a result the ‘processual and dynamic nature of the state in configuring geometries of power between different actors ... remains largely unexplored’ (Johnstone & Newell, 2018:75).

Rethinking governance

Drawing from cutting-edge thinking in contemporary political economy, Johnstone and Newell proceed to suggest five particular ‘dimensions of state power’ (Johnstone & Newell, 2018:75) that align closely with Jessop’s strategic-relational approach. Firstly, the assemblages of state institutions evolved *historically* in ways that are specific to each regional and national context. This is why an understanding of the dynamics of STs cannot be simplistically derived from global dynamics. Contextual specificity matters. The role of the ‘mineral-energy-complex’ in the South African case is a case in point (Jaglin & Dubresson, 2016). Secondly, the political economy of energy is such that there are *global geo-strategic interdependencies* that can enhance or constrain energy transitions at the national and local levels. For example, states use commercial and military means to secure and protect access to fossil fuel supplies in global markets in ways that can constrain the expansion of renewables at the national level. The former South African president’s determination to procure a Russian nuclear power plant is a good example. But the drastic drop in prices of renewables in South Africa due to subsidies in other jurisdictions has the opposite effect. Thirdly, there are always *multiple centres of power* in any state system. This is why it is often meaningless to talk about ‘the state’ as if it exists in reality as a single unified entity. It can exist as an idea or political project, but in reality, it is an assemblage of diverse institutions. Fourthly, a *relational approach to governance* means accepting there are no neat dividing lines between polities and societies. State institutions reflect and refract particular sets of interests, sometimes in contradictory ways. This often renders references to ‘the state’ as distinct from ‘the market’ and ‘civil society’ somewhat meaningless. The dependence of economic growth on affordable energy supplies, for example, often gives large energy providers a privileged place in the polity which they use to protect their positions and systems. Again, this is reflected in the way the South Africa polity has worked. Fifthly, there is ‘insufficient attention to the *material implications of certain technologies* in shaping institutional routines and practices that may influence the directionality of sustainability transitions’ (Johnstone & Newell, 2018:78, emphasis added). In short, as in the South Africa case, the dominance of the ‘mineral-energy-complex’ not only retards the

diversification of the economy and reinforces social exclusion; it is also premised on the 'normalisation' of a particular set of technological practices that get inscribed into policies, laws and regulatory regimes that serve to (wittingly and unwittingly) exclude potentially more productive and inclusionary alternatives.

Whether or not the directionality of the transition to more sustainable modes of production and consumption (SDG 12) is oriented towards a just transition (SDGs 1 and 10) will depend on power dynamics within the polity. With Johnstone and Newell's framework in mind, according to Jessop, the polity is:

the institutional matrix that establishes a distinctive terrain, realm, domain, field, or region of specifically political actions. ... Further, while the polity offers a rather static, spatial referent, politics is inherently dynamic, open-ended, and heterogeneous. (Jessop, 2016:17)

Jessop's 'strategic-relational approach' is useful for understanding the contemporary state in both the developed and developing world contexts (Jessop, 2016). He argues that from the 1970s onwards there has been a gradual 'de-centering' of the polity as the state 'retreated' (to use the word Strange used in the 1990s (see Strange, 1996) as the primary driver of the policies that shape the future. The result is the emergence of a polity that is far more complex than what existed in the old state-centric polities. Polities have evolved into complex semi-institutionalised partner-based assemblages and dynamic sets of transactions. In the academic and policy literature, the notion of 'governance' emerged to capture this shift away from state-centric conceptions of the polity (Hajer, 2009; Jessop, 2003; Kooiman, 1993; Offe, 2009). Research agendas also moved away from a preoccupation with structures of government to the relational dynamics of governance. Out of these emerged what Schot and colleagues refer to as 'frame 3' policy-making: a multi-stakeholder, multi-goal process that requires a far more complex set of institutions and leadership skills (Schot & Steinmuller, 2016). Governance, however, is less about the long-term directionality of the polity, and more about relational and dialogical management of complexity over the short term (Offe, 2009). It is, in short, the outcome of political weakening and has, unsurprisingly, generated a reaction. Jessop argues there is a counter-trend initiated by forward-looking political leaders with long-term visions who are interested in the 'governance of governance', which is what he refers to as 'collibration'. This consists of a new set of intermediary public institutions that have the capacity and mandate to set the terms of governance so that the directionality of the relational polity is determined politically rather than through a constellation of negotiated deals.

Jessop's notion of 'collibration' is useful because it addresses a dilemma at the centre of the African literature on developmental statism, namely the tension between complexity and directionality. For those committed to social democracy, socialism

or inclusive development, a return to state-centric polities is essential for achieving this kind of long-term directionality (Mitchell & Fazi, 2017; Zenawi, 2011). For former Ethiopian prime minister Meles Zenawi, contra neoliberal economics, the 'activist developmental state' must be autonomous – but necessarily democratic – in order to catalyse accelerated development (Zenawi, 2011). However, this assumes that complexity can be rolled back. Under conditions of increasing complexity in a globalised digitalised information-rich world, directionality is unlikely to be achieved by returning to state-centric polities. The alternative lies in Jessop's notion of 'collibration' – the emergence of a new generation of meta-governance institutions mandated to foster the 'governance of governance'. The core skill required for this is process facilitation.

Drawing on a synthesis of Jessop's conceptions of the polity and Wilson's 'policy regime' theory, a more nuanced conception of the polity starts to emerge (Wilson, 2000). This is useful for making sense of the kinds of 'sustainability-oriented polities' that would be required in the African context to drive a just transition.

The polity can be understood as the space or arena that demarcates a specific constellation of political and quasi-political actors engaged in a defined set of contestations to influence policy outcomes and the actual roles of particular state apparatuses. This constellation of actors usually share a sufficient consensus about a set of ground rules for conducting the business of everyday politics within and outside the formal institutions of the state apparatus. These actors (interests) subscribe to certain underlying beliefs about the legitimacy of the system, how institutions are controlled in various ways, and the way cooperation and opposition work. They get organised into competing factions or alliances – and related policy networks – to secure advantages in the policy-making space and the wider polity. In other words, a polity goes beyond the governing elite and the state apparatuses that the DS literature has tended to focus on.

The nature and character of the polity demarcate the space within which the political game is conducted across various arenas (parliament, executive, media, civil society, judiciary, local/regional space-economies, organised business, policy networks, personal networks and business sectors). Within this space, all the key actors operate in ways that more or less reproduce the overall stability of the political system. Their differences are contestations over the direction of policy in ways that do not subvert the overall coherence of that political system. Some actors, however, operate within the polity on these terms, but also either directly or indirectly act via proxies outside and against the polity and the way it is configured. These political hybrids have demands that could be revolutionary in nature (i.e. replacement of the polity by a completely different configuration of political and institutional arrangements), or reformist (i.e. for the reconfiguration

of one or more fundamental dimensions of the polity, such as, for example, reduced influence of big business or constitutional reform to reduce the powers of the head of state). This approach can help understand the dynamics of political instability in African polities. Without a sufficiently broad consensus across political elites that the polity is an appropriate space within which to engage in political competition, the result is episodic political instability. This has been a common phenomenon across different African regions.

Policy regime theory suggests that the polity has four dimensions (Wilson, 2000). The first of these is where *power relations* are played out and reproduced within the polity. This refers to how political power is constituted, distributed and maintained by the 'power elite' (Wright Mills, 1956). This applies in particular to the governing party and its allies within and outside government. Second, there is usually a shared underlying *policy paradigm*, in particular at the sectoral level (e.g., coal-based energy generation) but also at the macro-economic level (e.g., a belief in neoclassical approaches to fiscal discipline and monetary policy). A policy paradigm incorporates a specific set of beliefs/assumptions which, in turn, determines how policy problems are defined (e.g., a faith in markets, or a commitment to the SDGs). A shared policy paradigm is understood and narrated by the different policy actors who engage in the everyday business of politics, which is why a shared language emerges to enter into dialogue and negotiation.

Thirdly, there is the way *government and state institutions are organised and legitimised*. Although this reflects the underlying power relations and paradigm commitments, these power relations do not always determine how a government is organised. Organising principles get institutionalised and can have a relative autonomy and constitutional fixity that can be at odds at times with the underlying power dynamics. This happened in South Africa during Jacob Zuma's presidency (2011–2017) when the Constitution came to be regarded as an obstacle in the way of 'radical economic transformation'. Arguably this is also what is happening as the Trump presidency acts against a wide range of constitutional norms. Fourthly, there is the *policy content* of the policies themselves that are debated and adopted by policy actors within a given polity – this being the traditional focus of policy analysis.

This four-dimensional conception of the polity is useful for revealing how fundamental policy change (fourth dimension) cannot take place without changes in the three dimensions of the policy that the fourth depends on: if power relations and the policy paradigm do not change, how can we expect the real substance of policy content to change?

The rise of governance since the 1970s is essentially about the organisation and outward expansion of the polity to incorporate policy actors that were previously excluded from having any influence on policy. Much of this was to compensate for the weakening of the state as complexities mounted. However, collibration is the counter-trend, referring to the way key actors within the polity seek – with varying degrees of success – to harness and mobilise governance and, indeed, complexity more generally. It is this kind of ‘governance of governance’ that has the potential to guide and shape long-term structural transformation.

The key contribution made by policy regime theory is that it helps explain policy ‘lock in’ by referring to the complex interaction between all four dimensions of the polity, without assuming *a priori* that any one dimension determines any of the others. Determination, after all, is context-specific. This goes way beyond the traditional purview of the policy analysis community which is essentially locked into dimension 4 (policy content) and to some extent dimension 3 (organisation of government). However, the experience of policymakers and a considerable body of research suggests that policies do in fact reflect underlying power dynamics (dimension 1) and paradigm commitments (dimension 2), and therefore unless these are changed, changes in dimensions 3 and 4 will be unlikely. Each context, however, will be different. In some instances, policy change (dimension 4) can drive changes in the other dimensions (especially policy shifts driven by global dynamics or local crises), while in other contexts nothing changes until the underlying power dynamics (dimension 1) change, or the policy paradigm shifts in response to cultural or knowledge-related trends (e.g., the impact of environmental thinking).

In reality, polities tend to change in response to ‘stressors’ and ‘enablers’ (Wilson, 2000), often represented by some kind of external shock to the system (e.g., an ‘upset’ election, corruption scandal, economic crash, violent conflict, assassination, re-alignment of political forces in the governing party, mass uprisings, constitutional crisis or warfare). Stressors can emerge when new power players emerge and/or external dynamics force policy changes. Examples of enablers would be a paradigm shift, such as the gradual realisation that climate change needs to be addressed in some way. As a consequence of a shock (or series of shocks) and the nature of the enablers and stressors, the dynamics and character of the polity will change through some contextually specific combination of power shifts (dimension 1), paradigm shifts (dimension 2), a legitimacy crisis (dimension 3), and organisational and policy change (dimension 4). A re-alignment of forces and dynamics within the polity can emerge from any one of these dimensions, although dimension 1 is where the most significant shifts will most often originate.

As will be shown below, developmentally-oriented polities at the heart of DSs reflected the underlying constellation of forces (dimension 1) that were united behind a particular developmental paradigm (dimension 2). Government was re-organised from time to time (including successive phases of nationalisation and de-nationalisation of industries), and long-term policies were crafted and implemented by relatively strong bureaucratic elites. STs would require a similar alignment to sustain a long-term commitment to structural transformation via a just transition, but to date, there is no equivalent stable pattern for STs as in the case of the DSs. As will be shown, East Asian DSs were forced to adopt environmental policies (dimension 4) because of external pressures (environmental regulations adopted by trading partners) that caused a paradigm shift of sorts (dimension 2). The introduction of feed-in tariffs in Germany that triggered the renewable energy transition in that country was a policy change (dimension 4) (Debor, 2018), but reflected a deeper shift in power as the greens and the environmental movement got stronger (dimension 1) and an environmental paradigm shift took place that transcended party-political divisions (dimension 2).

Structural transformation, just transitions and the shaping of the polity

The purpose of the existing DSs was to drive the long-term structural transformation process of economic development (most commonly via industrialisation and urbanisation) in order to achieve a high level of human wellbeing with respect to income, education and health. Building on the ST literature, an ST can only be envisaged if a specific combination of state apparatuses facilitates a long-term structural transformation process that results in socio-technical transitions to more sustainable modes of production and consumption, with special reference to decarbonisation, resource efficiency and ecosystem restoration. When these two conceptual frameworks and associated goals are combined, it becomes possible to imagine a just transition.

A DS, however, is not merely defined by the goals it is committed to. The DS literature has paid considerable attention to the capacity of the state to instigate transformative developmental processes, paying special attention to the emergence of a (sufficiently uncorrupted) developmental bureaucracy and a well-entrenched policy management system. In short, this is about the way political leadership went about constructing and organising a developmentally-oriented polity and, in particular, quite an authoritarian mode of collibration. In many African countries, including South Africa, a developmentally-oriented form of collibration morphed into neo-patrimonialism (Chipkin & Swilling, 2018; Khan, 2004; Pitcher et al., 2009).

In contrast, the emphasis in the ST literature (and the transition management literature in particular) on collaborative stakeholder engagement reflects quite a sanguine view of governance. There is little appreciation of politics and practice collibration – the ‘governance of governance’ – as a specific responsibility of purpose-built state institutions mandated to set the goals and rules of the game for achieving long-term structural transformation via a just transition. Broadening out governance to improve stakeholder participation for its own sake ultimately makes little real difference other than creating an illusion of legitimation.

The ST literature on East Asia, is, however, somewhat different. Angel and Rock show how the considerable governance capacity of the East Asian DSs to drive development in ways that contradicted the neo-liberal script (because it was so interventionist) has become very useful for driving STs in response to environmental landscape pressures, in particular those globalisation dynamics that require East Asian economies to be ‘greened’ (Angel & Rock, 2009; Rock et al., 2009). However, they correctly point out that landscape pressures, in general, are too diffuse and contradictory to be useful for isolating ‘landscape variables in directing transition processes’ (Rock et al., 2009:242). As a solution, they proffer the notion of a ‘socio-political landscape’ to refer to the ‘institutions, values and regulations broadly guiding an economy’ (Rock et al., 2009:242). This seems similar to the notion of the ‘polity’ as deployed in this chapter. However, given that the defining feature of landscape pressures is that they are long term and slow-moving, calling this a ‘landscape’ seems like a misnomer – the strategic coalitioning and political actions needed to guide structural transformation via a just transition are by no means slow-moving and are not nearly as long term as socio-technical landscape pressures like climate change, demographic change, resource depletion and values change. It, therefore, makes sense to retain the notion of the polity that recognises the highly contingent nature of power dynamics and political action.

The conception of the polity advocated in this chapter addresses the challenge faced by the ST literature to conceptualise the role of politics and state, and it goes beyond the narrow institutionalist perspective that tends to pervade most accounts of the DS in the DS literature. This analysis makes it possible to suggest that a just transition becomes a realistic outcome if a developmental sustainability-oriented polity emerges. This would entail agreement within the polity that the overall goal of development is human wellbeing (income, education and health) within a sustainable world (decarbonisation, resource efficiency and ecosystem restoration). For this integrated goal to shape the direction of development, broader socio-technical and social-ecological landscape pressures would have to be seen by key actors within the polity as nudging historical processes in a way that reinforces the normative claims of these goal statements. Game-changing dynamics emerging

from niche innovations and experiments should also be coalescing around viable future alternatives and coalescing into alternative socio-technical regimes (Avelino et al., 2014). However, the structural transformations needed for a just transition (at all four levels of transition) will only be achieved when there is a developmental sustainability-oriented polity led by a strategic coalition of interests that shares this paradigm, uses state institutions to drive a just transition and adopts an appropriate policy and legislative programme that is aligned with the overall goal.

Sustainability-oriented development trajectories in Africa?

The front page of an edition of *The Economist* magazine in 2000 depicted Africa as ‘the hopeless continent’. In its 3 December 2011 edition just over a decade later Africa was depicted as ‘the hopeful continent’ and has since waxed lyrical about ‘Africa Rising’. For eight out of the ten years to 2011, economic growth rates in sub-Saharan Africa were higher than in East Asia, and six of the ten fastest-growing economies by 2015 were African. This kind of upbeat hype about African growth was also reflected in a spate of reports by leading consulting companies (Ernst & Young, 2011; McKinsey Global Institute, 2010; Monitor, 2009) and financial institutions (International Monetary Fund [IMF], 2011; World Bank, 2011) that provided extensive data to back up their optimism.

However, at an African Union summit of Ministers of Finance and Economics in Abuja 27–31 March 2014, there were repeated warnings that this economic boom is too dependent on the extraction and export of primary resources.³ Primary resources still make up 86 percent of exports into non-African markets (United Nations Economic Commission for Africa [UNECA] & African Union [AU], 2014:17). There seemed to be complete consensus at this summit that unless Africa implements what was repeatedly referred to as ‘structural transformation’, the economic fortunes of African economies will be determined by the notoriously unstable global commodity markets. Furthermore, extractive industries are seen to benefit only a narrow band of employees and shareholders with limited backward and forward linkages within the domestic economies.

The challenge, therefore, is how new political coalitions can emerge within African polities who realise the need to ensure that resource rents from the extractive sector are re-invested in the diversification of African economies to ensure sustained long-term economic growth. It is this process of change that is referred to in African discussions as ‘structural transformation’. However, as Paul Collier has argued, the more dependent an economy becomes on the exploitation of natural endowments, the less incentive it has to diversify (Collier, 2010). This, in essence, is what the ‘resource curse’ is all about. Key consequences are state failure and resource

3 Personal observations by Mark Swilling, who attended the AU Summit.

wars resulting from entrenched corporate and elite practices that prevent the re-investment of resource rents (Swilling, 2013).

No other region has had to face the challenge of development by paying attention to the resource requirements, carbon emissions and biodiversity impacts of development. Ignoring this challenge will mean that the African Union Vision 2063 will not be realised. More significantly, not tackling this challenge will mean ignoring the aspirations of Africa's youth majority, many of whom are now concentrated in Africa's cities which is where the third wave of African uprisings is taking place (Branch & Mampilly, 2015). The first wave got rid of colonialism in the late 1950s/early 1960s; the second got rid of the dictatorships (and apartheid) in the 1980s/90s. In August 2016, 272 activists from the movements driving the third wave of uprisings met in Arusha, Tanzania, and issued the Kilimanjaro Declaration. One of the six 'declarations' were as follows:

Africa is a rich continent. That wealth belongs to all our People, not to a narrow political and economic elite. We need to fight for economic development that is just and embraces social inclusion and environmental care. We have a right to the 'better life' our governments have promised. (Africans Rising, 2016)

The United Nations Economic Commission for Africa, which has traditionally ignored the need to consider sustainability issues, completely changed its tune in its 2016 Report (UNECA, 2016), which built on the United Nations Conference on Trade and Development (UNCTAD) call for 'sustainable structural transformation' (UNCTAD, 2012). UNECA recognised in this report the significance of the adoption of the SDGs and the Paris Agreement on climate in 2015.

The starting point for UNECA is the argument it has mounted for many years now: 'high rates of growth over the past decade have not translated into the structural transformation of the economy. Manufacturing, also, has not made the expected contribution to aggregate output, trade or gross domestic product' (UNECA, 2016:53). Indeed, manufacturing now contributes less in percentage terms to GDP than it did 30 years ago! In its previous three reports, UNECA emphasised building state capabilities for fostering industrial policies, with a focus on commodities, trade and dynamic interventionist policy management. In its 2016 report, UNECA goes beyond this economic focus and follows thinking that has emerged from the International Resource Panel (Swilling, 2016b) by recognising that 'decoupling of growth from resource use' (UNECA, 2016:59) provides a major opportunity for African economies to 'be among the leaders in designing the new global low-carbon economy' (UNECA, 2016:55). A three-pronged rationale for this conclusion is provided: decoupling will spur 'structural transformation' (echoing the UNCTAD report), 'increase knowledge intensity in production', and 'sustain global competitiveness' in a world committed to decarbonisation (UNECA, 2016:55).

Significantly, by industrialisation UNECA does not simply mean manufacturing – instead it can be defined as ‘promoting higher-productivity growth’ across the whole economic system by making sure that governments develop ‘capabilities to enable their enterprises to compete in global value chains, promote technical and economic innovation, develop new sectors (such as green industries), and diffuse new technologies (renewables, for example)’ (UNECA, 2016:63). UNECA concluded that African governments ‘need to understand how they can launch and sustain a holistic process of economic transformation, which greens the entire system, and drive the economy in a different manner from business as usual’ (UNECA, 2016:65).

UNECA describes three strategies for achieving this, namely ‘transitioning out of brown industries; greening existing industries by increasing resource productivity, cutting pollution, and managing chemicals more safely; and creating new green enterprises, such as producing green capital goods, generating renewable energy and providing environmental advisory services’ (UNECA, 2016:69). Significantly, the UNECA report repeatedly emphasises that greening includes but is not limited to decarbonisation – it is, rather, primarily about resource productivity. This is why both are seen as sources of growth driven by innovation, a way of improving trade balances, fostering regional integration through cooperation to support innovation, stimulating resource efficiency, catalysing knowledge intensity, reducing pollution, and restoring ecosystems. Understood in this way, ‘green industrialisation can contribute to faster, more equitable and more sustainable patterns of growth.’ This is a long-term commitment, and ‘[s]trategic vision and leadership at the highest level are thus critical to inclusive green industrialisation’ (UNECA, 2016:70–71). These normative policy prescriptions are all well and good, but the UNECA document and similar perspectives lack an adequate theory of governance that takes politics, power and the limits of governance seriously enough.

Rethinking governance for development in Africa

The implications of the argument thus far for the African literature on developmental states and governance are as follows:

- in the SDG era, the traditional debate about African developmental states must now engage the literature on sustainability transitions in order to conceptualise sustainability-oriented developmental states;
- given increasing complexity in a globalised digitised world, the desire to rebuild state-centric polities (‘developmental states’) seems unlikely to succeed because it of necessity will entail the reduction rather than expansion of complexity;

- yet, at the same time, the need for purposive directionality to tackle the great African challenges of inequality and unsustainability has never been greater;
- hence the usefulness of the notion of collibratory governance – it is a notion that makes it possible to reconcile the reality of increasing complexity and the normative strategic need for directionality;
- collibratory governance in practice is about building a new generation of meta-governance institutions with a mandate and capabilities to facilitate new modes of partnering within reconfigured more inclusive polities;
- polities, however, are not merely black boxes – analysis must address the four dimensions of the polity that interact in context-specific ways, namely power relations, paradigms, organisation/institutionalisation and policy content.

The African debates will be revisited from this perspective: how do we rethink African polities in light of the need to transition to sustainability-oriented developmental states with requisite capabilities for fostering sustainable infrastructure development?

The eloquent contributions to a remarkable online edited collection by the most respected analysts of African governance (Noman et al., 2011) provide a conceptually sophisticated and empirically-rich body of scholarship about the trajectories of African governance since decolonisation. The primary argument made in different ways across the chapters is that widespread adoption of neo-liberal economic theory by Western governments, development aid institutions, development finance institutions and most economists (academics and consultancies) from the late 1970s onwards resulted in the introduction of a raft of governance reforms across Africa that failed empirically, not least because they were theoretically misguided. The alternative they collectively propose is what Khan refers to as ‘growth-enhancing governance’ (Khan, 2011).

In line with the DS literature already discussed, the overall consensus of the contributors the volume edited by Noman et al. (2011) is that economic growth is the ultimate end and that state-coordinated structural transformation is the means. Without in any way opposing the need for markets of all kinds, they disagree with the dominant view that minimising the role of the state will automatically result in market efficiencies in African economies. Their alternative is fairly obvious: because each context is unique, there cannot be a blueprint applicable to all contexts. Instead, institution-building in Africa must be about experimentation and incrementalism: experimentation to craft through trial-and-error what works in specific contexts, and to incrementally build institutions over time in accordance with actually existing capabilities rather than pursuing the delusions of ‘big bangery’

thinking. Concluding his critique of neo-liberal ‘institutional monocropping and monotasking’, Mkandawire writes:

One costly feature of the lost decades was the reduction in the space for experimentation within Africa and the one-size-fits-all institution-building tradition has produced a size that seems to fit no one. (Mkandawire, 2011:28)

Unfortunately, unlike the authors of the UNECA report referred to in the previous section, the contributors to the volume edited by Noman et al. (2011) do not refer to sustainability challenges. Economic growth is the overriding and exclusive goal. This is profoundly ironic: for a group that vehemently insists that context matters, it provides an analysis that ignores the profound contextual challenges – and opportunities – arising from degraded soils, biodiversity loss, depleted water resources, resource inefficiencies and the extra-ordinary opportunities in Africa for leapfrogging over fossil-fuel-based energy systems (Africa Progress Panel [APP], 2015). Indeed, repairing the future may well be Africa’s most significant business opportunity in the twenty-first century. It may also hold the key to escaping the resource curse. But for this to happen, African conceptions of context-specific governance must engage with the literature on sustainability transitions. Without this, strategically significant African positions like those articulated in the UNECA and APP reports, as well as alignment with the SDGs, will remain unsubstantiated by an appropriately rigorous re-conceptualisation of African developmental governance.

Following the logic of the argument thus far, this engagement must address three issues: what a sustainability-oriented developmental state means in the African context; why collibratory rather than state-centric governance makes sense; and how to rethink the form and content of African polities.

As the UNECA and APP reports acknowledge, Africa’s opportunity to mount authentic context-specific development strategies occurs at precisely the historic moment when it is generally accepted that all future development has to occur within ‘planetary boundaries’ (Rockström et al., 2009). No other major world region has faced the development challenge within a carbon- and resource-constrained world. Ignoring this reality could result in the subversion of development strategies focused exclusively on growth. This can, however, be a major developmental opportunity if the transition to an ecologically more sustainable world is conceptualised as an intrinsic part of the overall commitment to inclusive development in Africa. For this purpose, the conceptual distinctions between landscape pressures, socio-technical regimes and innovation niches offered by the ST literature can help orient the experimental and incrementalist institution-building modalities advocated by Noman et al. (2011). This is illustrated here by some brief examples.

The continent-wide commitment to accelerated infrastructure investments will propel African economies into the twenty-first century. Infrastructures are long-lasting and play a key role in conducting resource flows through modern socio-economic systems (Hoornweg & Freire, 2013; Swilling, Robinson, Marvin & Hodson, 2013; World Business Council for Sustainable Development, 2014). As the APP report reveals, electrical generation capacity in sub-Saharan Africa is equal to what exists in Spain! If Africa energises using fossil fuels, none of the climate targets agreed in Paris will be achieved. The world has an interest in Africa energising using renewables. And renewables are now cheaper than fossil fuels and arguably more technologically robust in countries with weak national grids. In short, with climate change and associated global agreements as landscape pressures, African developmental states could target renewables as the primary energy regimes of African economies. This would open up a myriad of niche-level innovation opportunities. Indeed, for countries like South Africa with a manufacturing base, such a strategic decision could drive a massive manufacturing boom. There are many similar examples with respect, for example, to food systems and agro-ecological farming to restore the degraded soils, new modes of sustainable water governance appropriate for water constrained countries, and radically different approaches to urban planning aimed at limiting suburban sprawl and maximising the use of public transit (Swilling, 2016a; Swilling et al., 2016).

It is remarkable that while the contributors to the volume by Noman et al. (2011) continuously emphasise learning, context-specific institution-building, experimentation and incrementalism, they say virtually nothing about *how* this gets done in practice. Furthermore, they also emphasise the importance of collaboration between sectors and stakeholders, rather than assuming that for-profit private sector organisations are the only viable agents of change (see Zenawi's discussion of state-aided growth-oriented 'rent creation', Khan's discussion of state-supported emerging entrepreneurs and Zalk's conception of industrial policies (Khan, 2011; Zalk, 2011; Zenawi, 2011). Again, no reference is made to *how* these relationships are formed and sustained, or who does this work. This neglect of the *how of governance* is all-pervasive in the African literature on governance.

The argument between state-centric and minimal state positions suffers from a failure to distinguish between what Jessop calls the 'idea of the state' and the 'reality of the state' (Jessop, 2016). The 'idea of the state' is a legitimate political project, thus making it the subject of debates on the role 'it' plays vis-à-vis the market and civil society. However, 'the state' does not exist in reality. The 'reality of the state' is a ramshackle assemblage of a range of quite different institutions, from national government departments, to subnational governments, parastatals, development finance institutions, regulatory and enforcement agencies (like the police). To assume

they all form part of a single unified 'it' that acts out in a specific way (as implied by phrases like 'role of the state' or even 'state intervention') is a complete misnomer. Furthermore, in reality there are no clear boundary lines between 'the state', the 'market' and 'civil society'. From the perspective of Jessop's 'strategic-relational approach', in reality, state institutions enrol a vast range of actors from within and outside the polity and, as such, cannot be assumed a priori to exist in a coherent form. They need to get built and specific people need to be the institution-builders.

State institutions are generally responsible for one or two of the five primary governance functions, namely policy formulation (departments, legislatures), regulation (departments, special purpose agencies), enforcement (police, tax authorities), implementation (departments, subnational governments) and evaluation (departments, legislatures, independent agencies). Collibratory governance is about recognising the need for a fourth function, namely facilitation. To reconcile directionality and complexity (especially if sustainability-oriented development becomes the goal) without returning to state-centric polities, it will be necessary to build a new set of institutions with facilitation capabilities. These become the institution-builders and maintainers. An excellent example is the Economic Development Partnership (EDP) in South Africa's Western Cape Province. Set up by government, the EDP comprises 25 professionals whose exclusive role is the facilitation of partnerships between, in the first instance, government departments across different spheres of government, and then also between government and non-state organisations in the private and non-profit sectors.

Finally, it is necessary to move away from a 'black box' approach to the African polity. Following the argument made earlier in this chapter, detailed granular analyses of the inner dynamics of the polity will be necessary. This will need to include, firstly, an understanding of the underlying power relations at the very heart of the polity (for a good example see Chipkin and Swilling, 2018). Without this, facilitated collibratory governance to widen stakeholder involvement in the polity will be impossible. Secondly, an understanding of the potential and limitations of the (sometimes even contradictory) paradigm(s) shared by key actors within the polity will be required. Without this, learning and innovation will be difficult to achieve. Thirdly, how state/government institutions are organised, funded and operated will be necessary. This is where 'lock-in' and path dependency sets in, often conditioning constrained parameters within which policy alternatives are considered. Effective collibratory governance may entail reconfiguring and reassembling these institutions. Finally, if policy formulation includes taking into account all four dimensions of the polity, the chances are much greater that viable and implementable policies will be adopted.

Conclusions

This chapter addressed the question of how best to understand the relationship between developmental processes and STs in Africa, with special reference to the political dynamics of developmental states. This has become an especially important challenge in light of resource-induced economic growth in many African economies. These countries want to implement a twentieth-century conception of accelerated development inspired by the East Asian industrialisers, but now in a climate- and resource-constrained world. Most important of all, after the publication of the UN SDGs in August 2015, the global discourse is shifting from the old 'MDGs-plus-green economy' framework to the globally approved SDG framework that firmly and irrevocably inserts the 'people-planet-prosperity-peace-partnership' paradigm into official definitions of sustainable development at global and national levels.

Both the DS and ST literature acknowledge that structural transformation is needed, but each with respect to the hitherto separated goals of human wellbeing (and more narrowly economic development) and sustainability (and more narrowly environmental improvements). Building on the emerging literature on East Asia and South Africa that attempts to fuse these separate research trajectories, it was argued that an integrated conception of structural transformation will be needed that is driven by a commitment to both the goals of human wellbeing and sustainability. However, the expected just transition this could give rise to will not happen simply because there is a shared normative commitment, as is now reflected in the adoption of the SDGs. Nor will much progress be made by formulating bland managerialist policy prescriptions that ignore underlying power dynamics and paradigm differences. An adequate fusion of the core body of concepts in the DS and ST literature will need to make space for an understanding of the political dynamics of the polity. The polity is a space of policy-related action and engagement by a wide range of actors within and outside the formal political system that operates in four dimensions: power dynamics, paradigm commitments, state organisation and policy programmes. The sustainability-oriented effects (and their counter-vailing tendencies) at landscape, regime and niche levels are played out within the polity, resulting in changes over time in power dynamics, paradigms shifts, state organisation adaptations and the adoption of new policies.

In light of the adoption of the SDGs and the circulation of the UNECA and APP reports, it will be necessary to conduct many more case studies in the African context where developmental and sustainability goals need to be reconciled in order to achieve the just transition envisaged by these initiatives. This chapter has contributed an approach that could guide this kind of future research.

References

- Africa Progress Panel. (2015). *Power people planet: Seizing Africa's energy and climate opportunities*. Geneva: APP.
- Africans Rising. (2016). The Kilimanjaro Declaration, Arusha, Tanzania, 23–24 August. <https://www.africans-rising.org/the-kilimanjaro-declaration/> [Accessed 30 September 2019].
- Angel, D. & Rock, M.T. (2009). Environmental rationalities and the development state in East Asia: Prospects for a sustainability transition. *Technological Forecasting and Social Change* 76(2): 229–240. <https://doi.org/10.1016/j.techfore.2008.01.004>
- Avelino, F., Wittmayer, J.M., O'Riordan, A., Haxeltine, A., Weaver, P. et al. (2014). *Game-changers and transformative social innovation: The case of the economic crisis and the new economy*. TRANSIT working paper 1, TRANSIT: EU SSH 2013.3.2-1 Grant agreement no. 613169, Rotterdam: DRIFT.
- Bagchi, A.K. (2000). The past and the future of the developmental state. *Journal of World-Systems Research* 1(2): 398–442. <https://doi.org/10.5195/JWSR.2000.216>
- Baker, L. (2015). The evolving role of finance in South Africa's renewable energy sector. *GeoForum*, 64: 146–156. <https://doi.org/10.1016/j.geoforum.2015.06.017>
- Baker, L., Newell, P. & Philips, J. (2014). The political economy of energy transitions: The case of South Africa. *New Political Economy* 19(6): 791–818. <https://doi.org/10.1080/13563467.2013.849674>
- Berkhout, F., Angel, D. & Wieczorek, A.J. (2009). Asian development pathways and sustainable socio-technical regimes. *Technological Forecasting and Social Change* 76(2): 218–228. <https://doi.org/10.1016/j.techfore.2008.03.017>
- Bogdan, L., Hurduzeu, G., Josan, A. & Vlasceanu, G. (2011). The rise of BRIC, the 21st century geopolitics and the future of the consumer society. *Romanian Review on Political Geography / Revista Romana de Geografie Politica* 13(1): 48–62.
- Booth, D. & Golooba-Mutebi, F. (2012). Developmental patrimonialism? The case of Rwanda. *African Affairs* 111(444): 379–403. <https://doi.org/10.1093/afraf/ads026>
- Branch, A. & Mampilly, Z. (2015). *African uprising: Popular protest and political change*. London: Zed.
- Burke, M.J. & Stephens, J.C. (2018). Political power and renewable energy futures: a critical review. *Energy Research and Social Science* 35: 78–93. <https://doi.org/10.1016/j.erss.2017.10.018>
- Castells, M. & Himanen, P. (2014). *Reconceptualizing development in the global information age*. Oxford: Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780198716082.001.0001>
- Chang, H.J. (2007). *Bad Samaritans: Rich nations, poor policies and the threat to the developing world*. London: Random House.
- Chibber, V. (2002). Bureaucratic rationality and the developmental state. *American Journal of Sociology* 107(4): 951–989. <https://doi.org/10.1086/341010>
- Chipkin, I. & Swilling, M. (2018). *Shadow state: The politics of betrayal*. Johannesburg: Wits University Press. <https://doi.org/10.18772/22018062125>
- Collier, P. (2010). The political economy of natural resources. *Social Research* 77(4): 1105–1132.
- D'Alisa, G., Demaria, F. & Kallis, G. (2015). *Degrowth: A vocabulary for a new era*. New York: Routledge. <https://doi.org/10.4324/9780203796146>
- Death, C. (2014). The green economy in South Africa: global discourses and local politics. *Politikon*, 41(1): 1–22. <https://doi.org/10.1080/02589346.2014.885668>
- Debor, S. (2018). *Multiplying mighty Davids? The influence of energy cooperatives on Germany's energy transition*. New York: Springer. <https://doi.org/10.1007/978-3-319-77628-6>

- Edigheji, O. (Ed.). (2010). *Constructing a democratic developmental state in South Africa: Potentials and challenges*. Cape Town: HSRC Press. Ernst & Young, (2011). *It's time for Africa: Ernst & Young's 2011 Africa attractiveness survey*. London: Ernst & Young.
- Escobar, A. (2015). Degrowth, postdevelopment, and transitions: A preliminary conversation. *Sustainability Science* 10(3): 451–462. <https://doi.org/10.1007/s11625-015-0297-5>
- Evans, P. (1995). *Embedded autonomy: States and industrial transformation*. Princeton, NJ: Princeton University Press. <https://doi.org/10.1515/9781400821723>
- Evans, P. (2010). Constructing the 21st century developmental state: Potentialities and pitfalls. In: O. Edighej (Ed.), *Constructing a democratic developmental state in South Africa: Potentials and challenges*. Cape Town: HSRC Press.
- Evans, P. (2012). What will the 21st century developmental state look like? Implications of contemporary development theory for the state's role. In: W-k Chiu & S-I Wong, *Repositioning the Hong Kong government: Social foundations and political challenges*. Hong Kong: Hong Kong University Press. <https://doi.org/10.5790/hongkong/9789888083497.003.0002>
- Fanon, F. (1963). *The wretched of the earth*. New York: Presence Africaine.
- Geels, F. (2013). The impact of the financial-economic crisis on sustainability transitions: Financial investment, governance and public discourse. *Environmental Innovation and Societal Transitions* 6: 67–95. <https://doi.org/10.1016/j.eist.2012.11.004>
- Geels, F. (2014). Regime resistance against low-carbon transitions: Introducing politics into the multi-level perspective. *Theory, Culture and Society* 31(5): 21–40. <https://doi.org/10.1177/0263276414531627>
- Grin, J., Rotmans, J. & Schot. (2010). *Transitions to sustainable development: New directions in the study of long term transformative change*. New York: Routledge. <https://doi.org/10.4324/9780203856598>
- Hajer, M. (2009). *Authoritative governance*. Oxford: Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199281671.001.0001>
- Hess, D. (2014). Sustainability transitions: A political coalition perspective. *Research Policy* 43(2): 278–283. <https://doi.org/10.1016/j.respol.2013.10.008>
- Hoornweg, D. & Freire, M. (2013). *Building sustainability in an urbanizing world*. Washington, DC: World Bank.
- International Monetary Fund. (2011). *World economic and financial surveys: Regional economic outlook: Sub-Saharan Africa*. Washington, DC: International Monetary Fund.
- Jaglin, S. & Dubresson, A. (2016). *Eskom: Electricity and technopolitics in South Africa*. Cape Town: University of Cape Town Press.
- Jayasuriya, K. (2001). Globalization and the changing architecture of the state: The regulatory state and the politics of negative co-ordination. *Journal of European Public Policy* 8(1): 101–123. <https://doi.org/10.1080/1350176001001859>
- Jessop, B. (2003). *The governance of complexity and the complexity of governance: Preliminary remarks on some problems and limits of economic guidance*. Lancaster, UK: Department of Sociology, Lancaster University. <https://bit.ly/2VCyH1c> [Accessed 16 September 2019].
- Jessop, B. (2016). *The state: Past present future*. Cambridge: Polity Press.
- Johnstone, P. & Newell, P. (2018). Sustainability transitions and the state. *Environmental Innovation and Societal Transitions* 27 (June): 72–82. <https://doi.org/10.1016/j.eist.2017.10.006>
- Kelsall, T. (2013). *Business, politics and the state in Africa*. London: Zed Press.

- Khan, F. (2008). *Political economy of housing policy in South Africa 1994–2004*. Stellenbosch, South Africa: Stellenbosch University.
- Khan, M. (2004). State failure in developing countries and institutional reform strategies. In: B. Tungodden, N. Stern & I. Kolstad (Eds), *Toward pro-poor policies: Aid, institutions and globalization*. Washington, DC: World Bank/Oxford University Press.
- Khan, M. (2011). Governance and growth: History, ideology, and methods of proof. In: A. Noman, K. Botchwey, H. Stein & J. Stiglitz (Eds), *Good growth and governance in Africa: Rethinking development strategies*. Oxford: Oxford University Press Scholarship. <https://doi.org/10.1093/acprof:oso/9780199698561.003.0002>
- Kohli, A. (2006). State and development. In: D.A. Clark (Ed.), *The Elgar companion to development studies*. Princeton, NJ: Edward Elgar.
- Kooiman, J. (1993). *Modern governance: New government-society interactions*. London: Sage.
- Lawhon, M. & Murphy, J.T. (2011). Socio-technical regimes and sustainability transitions: Insights from political ecology. *Progress in Human Geography* 36(3):354–378. <https://doi.org/10.1177/0309132511427960>
- Leftwich, A. (1995). Bringing politics back in: Towards a model of the developmental state. *The Journal of Development Studies* 31(3): 400–427. <https://doi.org/10.1080/00220389508422370>
- Leftwich, A. (2000). *States of development: On the primacy of politics in development*. Cambridge, UK: Polity Press.
- Mazzucato, M. (2011). *The entrepreneurial state*. London: Demos.
- Mazzucato, M. (2015). The green entrepreneurial state. In: I. Scoones, M. Leach & P. Newell (Eds), *The politics of green transformations*. London and New York: Routledge Earthscan. <https://doi.org/10.3898/136266211798411183>
- McKinsey Global Institute (2010). *Lions on the move: The progress and potential of African economies*. <https://mck.co/2qGbXhZ> [Accessed 15 September 2019].
- Meadowcroft, J. (2011). Engaging with the politics of sustainability transitions. *Environmental Innovation and Societal Transitions* 1(1): 70–75. <https://doi.org/10.1016/j.eist.2011.02.003>
- Mitchell, W. & Fazi, T. (2017). *Reclaiming the state: A progressive vision of sovereignty for a post-neoliberal world*. London: Pluto Press. <https://doi.org/10.2307/j.ctt1v2xvvp>
- Mkandawire, T. (2001). Thinking about developmental states in Africa. *Cambridge Journal of Economics* 25(3): 289–313. <https://doi.org/10.1093/cje/25.3.289>
- Mkandawire, T. (2011). Institutional monocropping and monotasking in Africa. In: A. Noman, K. Botchwey, H. Stein & J. Stiglitz (Eds), *Good growth and governance in Africa: Rethinking development strategies*. Oxford: Oxford University Press Scholarship. <https://doi.org/10.1093/acprof:oso/9780199698561.003.0003>
- Monitor (2009). *Africa: From the bottom up: Cities, economic growth, and prosperity in sub-Saharan Africa*. Houghton, South Africa: Monitor Group.
- Nederveen-Pieterse, J. (2000). After post-development. *Third World Quarterly* 21(2): 175–191. <https://doi.org/10.1080/01436590050004300>
- Noman, A., Botchwey, K., Stein, H. & Stiglitz, J. (Eds). (2011). *Good growth and governance in Africa: Rethinking development strategies*. Oxford: Oxford University Press Scholarship. <https://doi.org/10.1093/acprof:oso/9780199698561.001.0001>

- Offe, C. (2009). Governance: An 'empty signifier'? *Constellations* 16(4): 551–562. <https://doi.org/10.1111/j.1467-8675.2009.00570.x>
- Pant, H.V. (2013). The BRICS fallacy. *Washington Quarterly* 36(3): 91–105. <https://doi.org/10.1080/0163660X.2013.825552>
- Pitcher, A., Moran, M.H. & Johnston, M. (2009). Rethinking patrimonialism and neopatrimonialism in Africa. *African Studies Review* 52(1): 125–156. <https://doi.org/10.1353/arw.0.0163>
- Rock, M., Murphy, J.T., Rasiah, R., van Seters, P. & Managi, S. (2009). A hard slog, not a leap frog: Globalization and sustainability transitions in developing Asia. *Technological Forecasting and Social Change* 76(2): 241–254. <https://doi.org/10.1016/j.techfore.2007.11.014>
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S. et al. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society* 14(2): Art. 32.
- Rodrik, D., Subramanian, A. & Trebbi, F. (2004). Institutions rule: The primacy of Institutions over geography and integration in economic development. *Journal of Economic Growth* 9(2): 131–165. <https://doi.org/10.1023/B:JOEG.0000031425.72248.85>
- Schot, J. & Steinmuller, W. (2016). *Framing innovation policy for transformative change: Innovation policy 3.0*. Sussex, UK: University of Sussex, Science Policy Research Unit (SPRU).
- Scoones, I., Leach, M. & Newell, P. (2015). *The politics of green transformations*. London: Routledge Earthscan. <https://doi.org/10.4324/9781315747378>
- Sen, A. (1999). *Development as freedom*. New York: Knopf.
- Smith, A., Stirling, A. & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy* 34(10): 1491–1510. <https://doi.org/10.1016/j.respol.2005.07.005>
- Strange, S. (1996). *The retreat of the state*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511559143>
- Swilling, M. (2008). Tracking South Africa's elusive developmental state. *Administratio Publico* 16(1): 1–29.
- Swilling, M. (2013). Beyond the resource curse: From resource wars to sustainable resource management in Africa. In: G. Minderman, V. Raman & F. Cloete (Eds), *Good, bad and next in public governance*. The Hague: Eleven International Publishing.
- Swilling, M. (2016a). Africa's game changers and the catalysts of social and system innovation. *Ecology and Society* 21(1): 1–37. <https://doi.org/10.5751/ES-08226-210137>
- Swilling, M. (2016b). Preparing for global transition: Implications of the work of the international resource panel. In: H.G. Brauch, U.O Spring & J. Scheffran (Eds), *Handbook on sustainability transition and sustainable peace*. London: Springer. https://doi.org/10.1007/978-3-319-43884-9_17
- Swilling, M. & Annecke, E. (2012). *Just transitions: Explorations of sustainability in an unfair world*. Tokyo: United Nations University Press.
- Swilling, M., Musango, J. & Wakeford, J. (2015). Developmental states and sustainability transitions: Prospects of a just transition in South Africa. *Journal of Environmental Policy and Planning* 5(5): 1–23. <https://doi.org/10.1080/1523908X.2015.1107716>
- Swilling, M., Musango, J. & Wakeford, J. (2016). *Greening the South African economy*. Cape Town: Juta.
- Swilling, M., Robinson, B., Marvin, S. & Hodson, M. (2013). *City-Level decoupling: Urban resource flows and the governance of infrastructure transitions*. <https://bit.ly/2ONgahr> [Accessed 18 September 2019].

- Thompson, G.F. (2003). Wither the 'Washington consensus', the 'developmental state' and the 'Seattle protests': Can 'managed free trade and investment' become an alternative development model? *Problemas del Desarrollo* 34(131): 219–238.
- United Nations Conference on Trade and Development. (2012). *Economic development in Africa report 2012: Structural transformation, decoupling and sustainable development in Africa*. Geneva: UNCTAD. <https://doi.org/10.18356/eaf6f03c-en>
- United Nations Economic Commission for Africa & African Union. (2014). *Dynamic industrial policy in Africa*. Addis Ababa: UNECA.
- United Nations Economic Commission for Africa. (2016). *Greening Africa's industrialization: Economic report on Africa*. Dar es Salaam: UNECA.
- van Agtmael, A. (2012). Think again: The BRICS. <https://bit.ly/2BbtjZj> [Accessed 18 September 2019].
- Wilson, C.A. (2000). Policy regimes and policy change. *Journal of Public Policy* 20(3): 247–274. <https://doi.org/10.1017/S0143814X00000842>
- World Bank. (2011). *Africa's future and the World Bank's support to it*. Washington, DC: World Bank.
- World Business Council for Sustainable Development. (2014). *The urban infrastructure initiative*. Geneva: World Business Council for Sustainable Development.
- Wright Mills, C. (1956). *The power elite*. Oxford: Oxford University Press. <https://doi.org/10.2307/1983710>
- Zalk, N. (2011). South African post-apartheid policies towards industrialization: Tentative implications for other African countries. In: A. Noman, K. Botchwey, H. Stein & J. Stiglitz (Eds), *Good growth and governance in Africa: Rethinking development strategies*. Oxford: Oxford University Press Scholarship. <https://doi.org/10.1093/acprof:oso/9780199698561.003.0012>
- Zenawi, M. (2011). States and markets: Neoliberal limitations and the case for the developmental state. In: A. Noman, K. Botchwey, H. Stein & J. Stiglitz (Eds), *Good growth and governance in Africa: Rethinking development strategies*. Oxford: Oxford University Press Scholarship. <https://doi.org/10.1093/acprof:oso/9780199698561.003.0005>



9

INDICATORS ON TRANSFORMATIONAL INFRASTRUCTURE FOR A WELLBEING ECONOMY

Desta Mebratu

Introduction

As the term suggests, an ‘indicator’ is an instrument that provides an indication generally used to describe and/or give an order of magnitude to a given condition. There is a significant similarity between the terms ‘indicator’ and ‘index’ and the terms are sometimes used interchangeably. However, there are important differences at the level of aggregation and representation. Indicators generally provide information on the historical and current state of a given system and are particularly useful to highlight trends that can shed light on causal relations among the elements composing the system. On the other hand, an index is a composite statistic – a measure of changes in a representative group of individual data points, or in other words, a compound measure that aggregates multiple indicators. Indices are particularly useful to summarise and rank specific observations based on aggregating multiple indicators.

Various indicators have been developed over many decades to measure economic and social development. Gross domestic product (GDP), which is used to indicate the trend in economic growth of national economies, is probably the most prominent and famous among these indicators. During the latter part of the twentieth century, economists tried to find ways to relate economic growth with social development. Arguably, the most prominent among the indicators and indices which emerged is the human development index (HDI), which was pioneered by the Nobel Laureate, Amartya Sen. The need for developing a set of indicators to measure progress towards sustainable development, covering economic social and environmental sustainability, was globally recognised at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. A different set of sustainable development indicators and indices have been developed since then.

The urgency for transformational change in national development efforts received unprecedented global consensus and support in 2015. This resulted in the adoption of Agenda 2030 on Sustainable Development Goals (SDGs) and the signing of the Paris Agreement on Climate Change. At the regional level, Africa endorsed its own Agenda 2063, which aspires to transform the region along the line of Agenda 2030. As noted in the first chapter of this book, Africa has a unique opportunity to seize this transformational moment and leapfrog to a more inclusive, low-carbon and resource-efficient economy.

The overall purpose of this chapter is to provide a framework for measuring the progress of African countries in building the transformational infrastructure that are covered in this book as a basis for the transition to a wellbeing economy. The chapter provides a review of economic development indicators with a focus on GDP as a national development indicator and the alternative indicators related to sustainable development. This is followed by a discussion on key principles and procedures pertaining to sustainable indicators and sustainability assessment. The final section provides a generic framework for a 'leapfrogging indicator to a wellbeing economy' that could be adopted and used by African countries.

Economic development indicators

Indicators are essential instruments in informing policy and decision-makers about the current state and future trends of a given system and/or process. The use of indicators for measuring organisational performance has been around for a couple of centuries. However, the use of indicators for measuring policy performance and development targets has become more significant in recent decades. A combination of different indicators might be necessary to describe complex phenomena, where different concurring causes and effects have to be measured and compared. As a

general rule, the choice and combination of indicators should be based on available data, the information needed by policymakers, and policy priorities (Pintér, Hardi, Martinuzzi & Hall, 2012).

Both quantitative and qualitative information can be used to define an indicator, depending on the issue that needs to be analysed, as well as on the availability and quality of data. Quantitative indicators provide a standardised and measurable description of a given phenomenon, thereby allowing for a more consistent and universal comparison across time and space. Qualitative indicators are often expressed quantitatively (e.g., ranks, percentages) to facilitate trend identification and comparison. According to the Organization for Economic Co-operation and Development (OECD), before being used for the analysis of trends and phenomena, indicators should be assessed against some essential features which include the following:

- **Policy relevance:** The indicator needs to address issues that are of (actual or potential) public concern relevant to policy-making. The ultimate test of any single indicator's relevance is whether it contributes to the policy process.
- **Analytical soundness:** Ensuring that the indicator is based on the best available science is an essential feature to ensure that the indicator can be trusted.
- **Measurability:** The need to reflect the reality on a timely and accurate basis, and be measurable at a reasonable cost, balancing the long-term nature of some environmental, economic and social effects and the cyclicity of others. Definitions and data need to allow meaningful comparison across time and countries or regions. (OECD, 2010)

Since the middle of the twentieth century, GDP has been the most dominant economic development indicator and served well for the promotion of free-market economy in the early twentieth century. However, alternative development indicators started to emerge during the latter part of the century as the dismal failure of the free-market economy in terms of addressing social injustices and environmental degradation became more and more evident. This section explores the main features of GDP and its limitations as a measure of economic development. This is followed by a brief review of the major indicators that have emerged as an alternative to GDP and the rationale behind it.

Gross domestic product as an economic indicator

Gross domestic product, as it was defined by its creator, is a measure of the market value of goods and services produced within an economy in a given period (Kuznets, 1934). It has, therefore, been a reasonable indicator to measure the level of economic production in a region or country. However, since its inception in

the 1930s, GDP has garnered a disproportionate amount of attention and influence from both policymakers and the general public, who have come to see it not merely as a measure of economic production, but of human wellbeing and social progress more broadly (Nahman, Mahumani & De Lange, 2016). Despite the recognition of its limitation as a measure for development by its creator, Thomas Kuznets, the unlimited use of GDP has made it the most powerful number in the world (Fioramonti, 2013). It has been a couple of decades since the limitations of conventional development indicators including GDP has been recognised. This became more pronounced as the limitation of neo-classical economics in effectively addressing environmental externalities and the failure of its 'trickle-down' theory in addressing inequality became more evident. Given the significant importance and attention given to GDP in national policy and planning processes, it is essential to understand its major limitations to be able to define appropriate interventions and corrective measures.

Besides the caution given by the economist on its use as a measure of human welfare (Kuznets, 1934), the limitations of GDP as an indicator of human wellbeing have been well documented by different experts and institutions (Commission of the European Communities, 2009; Fioramonti, 2013, Nahman et al., 2016; Pepper, Jackson & Uzzell, 2009; Stiglitz, Sen & Fitoussi, 2009; Van Den Bergh, 2009). This is because human wellbeing is, in the first place, determined by a wide range of factors, such as health, education, governance and political voice, social connections and relationships, social equity, environmental quality, meaningful work, leisure time, and spirituality, that are not adequately captured by GDP (Bartelmus, 2009; Costanza et al., 2007; Sen, 1985; Stiglitz et al., 2009). While GDP does tend to correlate with some of these factors (e.g., health and education), in other cases the relationship is weak, if not harmful (Nahman et al., 2016).

GDP also fails to account for the depletion of natural capital used in the production of economic goods and services, as well as the negative impacts of economic activity on human and environmental wellbeing (Arrow, Dasgupta & Maler, 2003; Fioramonti, 2013; Hamilton, 1994, 1998; Harris, 2007; Van den Bergh, 2009). Indeed, because GDP only accounts for market transactions, social and environmental costs (such as crime and pollution) tend to be counted as 'benefits' in the calculation of GDP. On the other hand, socially beneficial activities occurring outside of formal markets, such as volunteer work and caregiving, are not counted in GDP (Fioramonti, 2013). As a result, the relationship between GDP and subjective measures of 'happiness' or 'quality of life' has been increasingly called into question. There is also mounting evidence that a narrow focus on GDP is at odds with the broader outcomes of sustainable development, particularly those relating to environmental wellbeing and social equity (Arrow et al., 2003;

Ayres, 1995; Carson, 2010; Daly, 1996; Kallis, 2011; Latouche, 2010; Nahman & Antrobus, 2005; Panayotou, 2000; Van den Bergh, 2011; Van den Bergh & De Mooij, 2002).

Gross domestic product is measured on a seemingly infinite scale. This led to almost blind faith in economic growth that fuelled unlimited and unsustainable consumption and resulted in different forms of environmental degradation and social destruction. In the absence of a specified maximum threshold and of a more balanced set of indicators that are given the same prominence in policy discussions, the goal of modern societies has become to simply maximise GDP, irrespective of whether doing so actually improves wellbeing, and with little attention paid to the negative social and environmental consequences (Nahman et al., 2016). According to Fioramonti (2016), the growth ideology, which is reinforced by the neoliberal economists, was instrumental in building an idea of success that boosted markets and political conservative forces while producing massive inequalities, ecological mayhems and social conflicts.

In a recent report in the *Finance and Development* magazine, 'Neoliberalism: Oversold?', a group of IMF economists questioned the very foundations of the neoliberal approach to growth, arguing that the free-market reforms enforced since the 1980s have not generated development but simply increased inequalities (Fioramonti, 2013; Ostry, Loungani & Furceri, 2016). An assessment of the specific policies related to the promotion of market competition through deregulation and limiting of state intervention as the two major planks of neoliberalism led the authors to three disquieting conclusions. Firstly, the benefits in terms of increased growth seem relatively difficult to establish when looking at a broad group of countries. Secondly, the costs in terms of increased inequality are prominent and such costs epitomise the trade-off between the growth and equity effects of some aspects of the neoliberal agenda. And thirdly, increased inequality, in turn, hurts the level and sustainability of growth and advocates of the neoliberal agenda need to pay attention to the distributional effects (Ostry et al., 2016).

Many attempts have been made to address the limitations of GDP as an economic and social development indicator by introducing additional indicators that cover economic and social costs. This includes the efforts made to develop an index of sustainable and economic welfare, a measure of economic welfare, and a genuine progress indicator. However, while these efforts represent some level of improvement on GDP, the primacy to economic outcomes over social and environmental outcomes is still dominant in the framing of these indicators. The HDI, which was spearheaded by the United Nations Development Programme (UNDP), has attempted to incorporate the social dimension in a more integrative way. However, this effort is based only on indicators relating to life expectancy,

education (two indicators) and income – the environmental dimension is entirely neglected (Nahman et al., 2016). Other indicators, such as the ecological footprint and the environmental performance index (EPI), focus only on the environmental dimension and are, therefore, useful only as complements to social and economic indicators. Finally, the System of Environmental-Economic Accounting (SEEA) provides a rigorous and standardised methodology for integrating the economic and environmental dimensions but ignores the social dimension. The gross national happiness index is another emerging indicator that has been applied in a specific country context such as in the Kingdom of Bhutan.

Sustainable development indicators

The global effort on developing sustainable development indicators that address the economic, social and environmental dimension of sustainable development has received a new push since the 1990s. While some earlier initiatives could be considered as precursors, the importance of developing indicators for sustainable development received global recognition by the United Nations Conference on Environment and Development (UNCED) that was held in 1992. As was outlined in Chapter 40 of Agenda 21 endorsed during the conference, the critical need for quantitative indicators to drive policy formulation and implementation was recognised from the early stage of development of the concept of sustainable development (United Nations, 1992:347). In the 1990s, many indicator sets, dashboards and composite and aggregated indicators or indices have been developed by different institutions and research groups resulting in a plethora of indicators on sustainable development.

According to Eurostat (2014), the approaches and methods potentially applied to developing sustainable development indicator frameworks can be classified into two groups: policy-based approaches and conceptual approaches. The former uses existing policy and strategy documents as a frame of reference and are typically organised according to strategic issues and targets highlighted in the documents, while the latter includes a frame of reference independent from political priorities. Both approaches function differently with each having its own processes and objectives. However, they both have their place in supporting the different stages of a policy cycle that covers policy formulation, policy legitimisation, policy implementation, policy evaluation and policy change (Hak, Janoušková & Moldan, 2016).

The United Nations Department of Economic and Social Affairs (UNDESA) stipulated that indicators for sustainable development have to be relevant, methodological sound, measurable, easy to communicate and access, limited in numbers and outcome-focused. The criterion for relevance is further comprised

of links to the target, policy-relevance, and applicability at the appropriate level (UNDESA, 2007). Despite different concepts of policy cycles and diverse processes in the development of indicator frameworks, it seems clear that a rigorous indicator framework can be neither a purely conceptual framework nor only a policy-oriented frame of reference defined basically by specific development goals (Hak et al., 2016). This is because policy relevance and applicability at the appropriate level fall into the policy framework, while the link to the target is secured within the conceptual framework.

Lester King (2016) argues that in seeking to develop indicators with a maximised impact, one has to recognise that the function of selected indicators should be a significant determining factor. According to Melkers and Willoughby (2005), consistent top-level support, increased knowledge, and organisational capacity are the three primary drivers for an effective measurement system. Top-level support can be considered a political function of indicators since this is the basis for setting work programmes and focus. Hezri and Dovers (2006) call the knowledge function as the conceptual use of indicators, and the organisational capacity function as the instrumental use of indicators. Based on this, King provides the functional classification of sustainability indicators shown in Table 9.1.

Table 9.1 Functional classification table of sustainability indicators

Value	Leadership functions	Knowledge increase functions	Capacity assessment functions
Intrinsic (governance)	Political and operational	Problem recognition and awareness	Justificatory
Extrinsic (general public)	Normative guidance	Communication and opinion forming	Monitoring, control and reporting

(Source: Adapted from King, 2016:23)

Intrinsic and extrinsic functions are described as the importance of sustainability indicators to the internal interests of governance groups versus public needs and wants. This difference is critical to recognise in developing indicator programs since different actors maintain different interests in the realm of public policy (Sommer, 2000). The important distinction here between this extrinsic dimension and the intrinsic dimension of the leadership function is that the former is meant to recognise the function of empowering the general public through normative guidance, while the latter is intended to recognise the integration of internal political directives from the leading governance units (King, 2016). On the other hand, indicators for the extrinsic dimension of the capacity function should be defined by the active participation and involvement of local citizens to provide an effective monitoring and control function.

Bringing separate systems, represented by the balance between the economic, social and environmental considerations into a holistic framework for policy evaluation is the ideal intrinsic dimension of the knowledge function (Brugmann, 1997). Consideration of developing more robust indicators that fulfil the extrinsic dimension of the knowledge function of indicators include fostering communication and plurality of information and understanding the social and cognitive processes that affect public choices (Yli-Viikari, 2009). The administrative feature of the intrinsic dimension of the capacity assessment function focuses on justifying the governance position which includes resource needs, organisational improvements, employee motivation and operational control (Holzer & Yang, 2004).

Experience from the last couple of decades has clearly shown that the development of sustainability indicators involves the most complex types of appraisal methodologies. This is particularly true in the absence of a systems-based approach and methodology. When one considers the issue of sustainability, fundamental uncertainties arise from the unpredictability of natural and social systems and the interactions between them. The very nature of complex adaptive systems involves at least two non-reducible sources of uncertainty (Garnåsjordet, Aslaksen, Giampietro, Funtowicz & Ericson, 2012). Firstly, any quantitative representation based on a given set of measurable attributes sooner or later will become obsolete because of systems-evolutionary changes introducing new definitions of relevant attributes and issues (Georgescu-Roegen, 1976). Secondly, their organization of multiple hierarchical levels requires the adoption of different scales for their perception and representation (Allen & Starr, 1982; Simon, 1962) and makes it impossible to adopt just a single mathematical model, no matter how complicated it might be (Giampietro, Allen & Mayumi, 2006; Rosen, 2000).

The Stiglitz Commission recognises that uncertainty is normative, as they question how measures established today may be used to predict the valuations of future generations in situations that may have become very different (Stiglitz et al., 2009). Despite the uncertainty involved, there are numerous sets of sustainable development indicators that have been developed both through scientific research groups and the inter-governmental process. Some argue that there is a significant obsession with numbers that led to an indicators explosion while others call for new and better indicators (Hak et al., 2016; Morse, 2013; Riley, 2001). Neither the scientific community nor the users know whether this remarkable worldwide effort should be more coordinated and regulated or if the 'survival of the fittest' principle is still the most efficient one (Dahl, 2012). The United Nations Statistics Division (UNSD) sees an explicit need to structure the indicators for Sustainable Development Goals (SDGs) into a coherent framework to secure the completeness of the indicator sets and emphasise linkages among the indicators thereby avoiding arbitrariness in the selection process (UNSD, 2015).

Sustainability assessment and composite indicators

This section discusses composite indicators related to sustainable development. It also considers green economy indicators and describes some of the initiatives currently underway aimed at developing green economy indicator sets.

Sustainability assessment as a basis

Concepts such as integrated assessment and sustainability assessment are introduced to offer new perspectives to impact assessment and indicators development geared towards planning and decision-making on sustainable development (Sala, Ciuffo & Nijkamp, 2015). Devuyt (2001) defined sustainability assessment as a methodology that can help decision-makers and policymakers decide what actions they should take and should not take in an attempt to make society more sustainable. Verheem (2002) on the other hand states that the goal of sustainability assessment is to pursue that plans and activities make an optimal contribution towards sustainable development. According to Sala, Farioli and Zamagni (2013), performing a coherent sustainability assessment research calls for:

- adopting a holistic approach for understanding the dynamic interaction between nature and society and assessing vulnerability and resilience of complex social-ecological systems;
- moving from multi-disciplinarity via interdisciplinarity towards trans-disciplinarity as characterised by functional integration of different methodologies and epistemologies, co-production of knowledge, strong links with specific social context and institutional settings, and the inclusion of relevant values and common goods perceptions (Lang et al., 2012);
- having a normative function by addressing the strategic and operational questions of what viable transition pathways could be identified for coupled human-environment systems and strategies for finding solutions to sustainability problems (Wiek, Ness, Schweizer-Ries, Brand & Fariolli, 2012);
- promoting social learning and mutual feedback leading to co-production of knowledge with other stakeholder groups in a collective process of problem identification and resolution; and
- dealing with uncertainties by adopting a probabilistic approach for the assessment of scenarios is essential to achieve robust decision-making (Funtowicz & Ravetz, 1993).

There are different sets of principles employed by different research groups and institutions in carrying out sustainability assessments. Out of the available alternatives, the Bellagio Sustainability Assessment and Measurement Principles

(STAMP), is considered to represent harmonisation of the major principles used by experts in the field. These principles were initially developed by a group of measurement practitioners who met at the Bellagio Centre in 1996 and was later updated by Pintér et al. in 2012. The following are the main elements of the Bellagio STAMP:

- **Guiding vision:** Progress towards sustainable development should be guided by the goal of delivering wellbeing within the carrying capacity of the biosphere and ensuring it for future generations.
- **Essential considerations:** Underlying social, economic, and environmental components of the system as a whole should be taken into account as well as the interactions thereof and their implications for decision-making, including trade-offs and synergies.
- **Adequate scope:** The assessment of progress towards sustainable development should adopt an appropriate time horizon and geographical scope to capture both the short- and long-term effects and their local and global effects, respectively.
- **Framework and indicators:** Sustainability assessment should be based on a conceptual framework as a basis for identifying core indicators and related reliable data, projections and models.
- **Transparency:** Transparency of data and data sources, models, indicators and results are crucial as well as public access to the results.
- **Effective communication:** It is necessary to use clear and understandable language to ensure effective communication and to attract the broadest possible audience as well as minimise the risk of misuse.
- **Continuity and capacity:** Sustainability assessment needs to be complemented by a continuous monitoring phase that includes repeated measurement as well as responsiveness to change as a basis for continuous learning and improvement.
- **Broad participation:** Sustainability assessment needs to find appropriate ways to strengthen legitimacy and relevance, engaging early on with users of the assessment, reflecting the views of the public while providing active leadership. (Pintér et al., 2012)

In general, as was noted by Rametsteiner, Pülzl, Alkan-Olsson and Frederiksen (2011), the development of sustainability indicators is a process of both scientific ‘knowledge production’ and of political ‘norm creation’, and both components need to be appropriately acknowledged. Studies conducted across different sets of indicators have shown that both groups were present in all sustainability

indicator processes, albeit in varying degrees, both in design and in practical implementations). The challenging question is to determine what is better from having a slightly more accurate but politically less relevant set or a slightly less accurate but politically more relevant set. From practical expediency perspective, going for the latter option, with a built-in adjustment and improvement mechanism, could be more beneficial, particularly for developing countries.

Composite indicators

The use of composite indicators received much attention in the early decades of indicators formulation for sustainable development (Moldan, Janoušková & Hak, 2012). Wilson, Tyedmars and Pelot (2007) identified the following as some of the main composite indicators related to sustainable development that developed in the 1990s and the subsequent decade:

- **Ecological footprint (EF):** The EF provides a quantitative assessment of the biologically productive area (the amount of nature) required to produce the necessary resources (food energy and materials) and to absorb the wastes of a given population (Rees & Wackernagel, 1996). The ecological footprint, therefore, ultimately measures the sustainability of human consumption patterns.
- **Environmental sustainability index (ESI):** The ESI is a composite index targeting environmental, socio-economic and institutional indicators as a means to assess sustainability. An ESI incorporates 20 indicators, each of which has two to eight variables, for a total of 68 underlying datasets. The core components of an ESI include environmental systems, reducing stresses, reducing human vulnerability, social and institutional capacity, and global stewardship (World Economic Forum, Yale University & Columbia University, 2002).
- **Wellbeing Index (WI):** A WI is a composite index that evaluates human and ecosystem wellbeing. It is an equally-weighted average of the human wellbeing index (HWI) and the ecosystem wellbeing index (EWI). Both consist of five dimensions. The former comprising health and population, knowledge and culture, community and equity; the latter consists of land, water, air, species and genes, and resource use (Prescott-Allen, 2001).
- **Human development index (HDI):** The HDI is one of the most widely recognised measures of development. It measures three dimensions of human development: a long and healthy life, knowledge, and decent standard of living (UNDP, 2004). HDI is used as a proxy of sustainability based on the rationale that high human development facilitates sustainable development.

In recent years, a new metrics called gross happiness index (GHI) has been added to this group. The foundation for this index was laid by the United Nations High-Level Meeting called Wellbeing and Happiness: Defining a New Economic Paradigm, which was hosted by the Kingdom of Bhutan in 2012. The Kingdom of Bhutan is the first country that adopted gross national happiness as its primary development indicator instead of GDP. This has provided the basis for producing the World Happiness Report¹ by the UN Sustainable Development Solutions Network.

As much as composite indicators may be useful in highlighting interesting differences between countries in ways that may contribute to improved knowledge, they can seldom be used as a basis for implementing specific policy measures (Garnåsjordet et al., 2012). Furthermore, different authors (OECD, 2008; Paruolo, Saisana & Saltelli, 2011; Saisana, Saltelli & Tarantola, 2005; Saltelli, 2007; Stiglitz et al., 2009) indicated that besides leading to severe normative questions, aggregation of incommensurable value dimensions might conceal differences in underlying indicators rather than clarifying them. Table 9.2 highlights some pros and cons of composite indicators as described by Saisana and Tarantola (2005).

Table 9.2 The pros and cons of composite indicators

Composite indicators	
Pros	Cons
<ul style="list-style-type: none"> ▪ Can summarise complex or multi-dimensional issues in view of supporting decision-makers 	<ul style="list-style-type: none"> ▪ May send misleading policy messages if they are poorly constructed or misinterpreted
<ul style="list-style-type: none"> ▪ More straightforward to interpret than trying to find a trend in many separate indicators 	<ul style="list-style-type: none"> ▪ May invite simplistic policy conclusions
<ul style="list-style-type: none"> ▪ Can facilitate the task of ranking countries on complex issues in a benchmarking exercise 	<ul style="list-style-type: none"> ▪ May be misused, e.g., to support a desired policy even if it lacks sound statistical or conceptual principles
<ul style="list-style-type: none"> ▪ Can assess the progress of countries over time on complex issues 	<ul style="list-style-type: none"> ▪ The selection of indicators and weights could be the target of political challenge
<ul style="list-style-type: none"> ▪ Can reduce the size of a set of indicators or include more information within the existing size limits 	<ul style="list-style-type: none"> ▪ May disguise severe failings in some dimensions and increase the difficulty of identifying proper remedial action
<ul style="list-style-type: none"> ▪ Can facilitate communications with the general public and promote accountability 	<ul style="list-style-type: none"> ▪ May lead to inappropriate policies if dimensions of performance that are difficult to measure are ignored

(Source: Adapted from Saisana and Tarantola, 2002, as cited in Garnåsjordet et al., 2012:330)

Even if there are some limitations related to the use of composite indicators, it is believed that they can provide valuable insight into policy and decision-making, particularly in assessing progress towards agreed goals and targets. Hence, most organisations and governments use one or another form of composite indicators keeping in mind the possible limitations they may have.

Green economy indicators

The recent global trend towards a ‘green economy’ has added renewed impetus to initiatives aimed at going ‘beyond GDP’. The United Nations Environment Programme (UNEP) defines a green economy as one that results in ‘improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities’; that is, an economy which is ‘low carbon, resource efficient, and socially inclusive’ (UNEP, 2011:16). Given the multiple economic, social and environmental objectives of a green economy, and the inherent limitations of GDP, an alternative (or at least expanded) set of indicators is required for measuring progress towards a green economy. Several initiatives are currently underway aimed at developing green economy indicator sets or frameworks. These include:

- work on a green economy index (Nahman et al., 2016);
- a green growth measurement framework (OECD, 2011);
- work on measuring progress toward a green economy (UNEP, 2014);
- the ‘iGrowgreen’² indicator-based assessment framework to identify country-specific challenges in promoting greener growth (Eurostat, 2012);
- the Wealth Accounting and Valuation of Ecosystem Services (WAVES)³ global partnership, which provides technical support for countries implementing the System of Environmental-Economic Accounting (SEEA); and
- the Global Green Growth Institute (GGGI) indicators for green growth strategy and planning and the Green Growth Knowledge Platform, a global partnership between the GGGI, OECD, World Bank and UNEP, which is working towards a common framework of green growth indicators (Benson & Greenfield, 2012).

The green economy indicators framework that was developed by UNEP provides a set of indicators that focus on measuring progress and trends at the different stage of the policy cycle with a particular focus on factors that facilitate the transition to a green economy. The framework identifies the following as the main stages of the policy cycle covered under the green economy indicators (UNEP, 2014):

- **Issue identification:** These are instruments that help decision-makers to identify and prioritise problems that might undermine the path towards sustainable development. Four steps are proposed for the use of indicators in the issue

2 For more information on iGrowgreen: http://ec.europa.eu/environment/archives/greenweek2011/sites/default/files/1-8_Bucher.pdf

3 More information can be found at: <https://www.wavespartnership.org/>

identification phase, namely: (i) identification of potentially worrying trends, (ii) assessing the issue and its relation to the natural environment, (iii) analysing more fully the underlying causes of the issue of concern, and (iv) analysing more fully how the issue impacts society, the economy and the environment.

- **Definition of policy goals and formulation:** While indicators for issue identification help to frame the problem, indicators for policy formulation help to design solutions. The two key steps that constitute policy formulation are the identification of policy objectives and the identification of intervention options. A multi-stakeholder approach is required to ensure that different perspectives are considered and incorporated in the definition of policy objectives and targeted interventions.
- **Policy assessment phase:** In this phase, expected economic, social and environmental effects of different policy options need to be measured with the help of impact indicators. Also, the advantages and disadvantages of each policy option need to be analysed to provide robust evidence in support of decision-making. Three steps that are suggested for this phase are (i) estimate policy impacts across sectors, (ii) analyse impacts on the overall wellbeing of the population, and (iii) analyse advantages and disadvantages and inform decision-making.
- **Policy monitoring and evaluation:** Indicators for policy monitoring and evaluation support the assessment of the performance of the intervention implemented and allow decision-makers to design timely corrective measures when needed. The analysis should include an estimation of co-benefits and ancillary benefits for the economy as a whole, as well as the improvement of the wellbeing of the entire population.

This approach is consistent with the use of the DPSIR framework through the identification of Drivers (D), Pressures (P), State (S), Impacts (I) and Responses (R) (UNEP, 2008). While indicators for problem identification help to frame the issue, and indicators for policy formulation help to design solutions, impact indicators support the assessment of the cross-sectoral impacts of the interventions chosen. Finally, the use of monetary and financial indicators enables the evaluation of the feasibility of each intervention, comparing investment and avoided costs, or added benefits, depending on the issue to be solved.

Despite the numerous efforts on developing indicators related to a green economy, there has been little progress in developing a green economy dashboard or composite index that provides the same level of usability and simplicity offered by GDP. In addition, existing initiatives are primarily based on issues identified in the context of developed economies and as such tend to emphasise the economic and environmental dimensions of the green economy and to neglect social and broader

developmental issues of relevance to many developing countries. Furthermore, the emphasis in existing green economy indicator frameworks tends to be on indicators of relative decoupling, that is, indicators of reduced resource use or environmental impact per unit GDP (e.g., CO₂ emissions per \$ GDP). Indicators of absolute decoupling (reduced impact of the economy as a whole) are generally missing from these frameworks.

Indicators of relative decoupling, while necessary in terms of measuring the resource or emissions intensity of an economy, can be misleading. Total emissions, for example, can still be increasing, as long as they are rising at a slower rate than GDP. Furthermore, such indicators are susceptible to hiding the pollution that is shipped to developing countries if they are not designed from a life-cycle perspective. Indicators of relative decoupling, therefore, fail to reflect the urgency of the need for a transition toward a green economy. Given recent evidence suggesting that four out of the nine ‘planetary boundaries’ have already been exceeded (Steffen et al., 2015) and considering the need for urgent action on issues such as climate change, the focus should arguably be on indicators of absolute (rather than relative) decoupling. This may necessarily have to be on a per-capita basis (to reflect the difference in population size between countries) and over a specified period (e.g., CO₂ emissions per capita per year).

The proposed framework for leapfrogging indicators

While many lessons could be drawn from existing literature and practical experience in developing and utilising sustainability-related indicators, the framework proposed in this chapter focuses explicitly on assessing the leapfrogging possibilities from transformative infrastructure. The first subsection of this section concentrates on presenting the most relevant considerations and criteria for selecting the relevant indicators. This is followed by a presentation of the proposed framework for developing and utilising indicators that can assist countries to assess their progress in laying the foundation for their transition to a wellbeing economy.

Selection criteria for indicators

As was noted by Stiglitz et al. (2009), measuring sustainability differs from standard statistical practice in a fundamental way as what is needed are projections of not only technological or environmental trends but also projections of how they will interact with socio-economic or even political processes. A fundamental property of any sustainability indicator is its ability to show changes over time. An indicator-based sustainability assessment needs to address its historical development as well as its possible continuation into the future or provide early warnings of emerging threats to sustainability (Garnåsjordet et al., 2012).

One of the major challenges faced by most developing countries is to identify and select the most relevant and practical set of indicators out of the hundreds of indicators proposed by different institutions and processes. There are a different set of criteria proposed for use by countries and governments in selecting the most relevant indicators. This chapter considers the criteria recommended by Cook, Saviolidis, Daviosdottir and Johannsdottir (2017). These criteria were developed through a two-stage approach, which involved focus group research that represents a bottom-up approach and indicator selection by a team of experts as a top-down approach. The criteria used by Cook et al. are as follows:

- **Policy relevance:** Could the indicator be closely related to an existing or future policy target?
- **Utility:** Did the indicator meet the needs of decision and policymakers and the public in being fundamentally understandable?
- **Soundness:** Did the indicator appear to be aligned with a consistent methodology for capturing the multiple components of environmental sustainability without presenting a risk of duplicating aspects?
- **Interpretability:** Was the indicator able to communicate meaningful information concerning performance relative to environmentally sustainable outcomes?
- **Data availability and quality:** Was the indicator based on sufficiently high-quality data with adequate coverage over time?

Proposed framework for transformative leapfrogging indicators

The overall objective of the indicator framework for leapfrogging to a wellbeing economy is to assist African countries to develop the infrastructural foundations for building a wellbeing economy that is inclusive, low-carbon and resource-efficient. Such an economy ensures sustainable livelihood and wellbeing to its people and contributes to the global sustainability effort. In this section, we propose the preliminary skeleton structure of the framework for the leading indicators with a focus on the critical infrastructural elements that will determine the leapfrogging possibility of a country towards an inclusive, low-carbon and resource-efficient economy. As a framework, it needs to be adapted to the specific policy and operational context of each country for its effective implementation and use. To measure progress on building a transformative development trajectory towards a wellbeing economy, it focuses on the fundamental transformational foundations that provide the basis for the transition. It also looks at the most appropriate

institutional context for effective operationalisation and implementation of the transformational process.

The fundamental building blocks of the framework for the leapfrogging indicators are defined on the combined consideration of the key principles of the Bellagio Sustainability Assessment and Measurement Principles (STAMP), as updated by Pintér et al. (2012), and the set of criteria proposed by Cook et al. (2017). The framework is also informed by the key issues and conceptual frameworks that have been highlighted in the preceding chapters of this book. The following are the major elements and features of the proposed framework for the leapfrogging indicators:

- **Guiding vision:** African countries can transition to a wellbeing economy which will enable them to fulfil the basic needs and aspirations of their people while sustaining the wellbeing of the natural ecosystem as a foundation for their development.
- **Essential consideration:** An internally driven and context-relevant transformative leapfrogging, as opposed to externally-driven incidental leapfrogging, is key in avoiding decisions that will lock African countries in unsustainable consumption and production patterns.
- **Adequate scope:** The investment decisions to be made on essential infrastructure development within the coming five to ten years will determine African countries' leapfrogging opportunities to a wellbeing economy both in the medium and long term.
- **Framework and indicators:** An African country's ability to effectively integrate the above consideration in their policy, planning and budgeting process is a crucial factor in determining its leapfrogging potential towards a wellbeing economy.
- **Selection criteria:** The selection of the specific indicators needs to be based on their potential utility function, methodological soundness, ability for meaningful and effective communication, and data availability and quality.

Figure 9.1 shows the wellbeing economy development framework. As depicted, the framework for transformative leapfrogging indicators is structured under the three major components taking the above criteria and the related conceptual frameworks into consideration, namely transformative governance, transformative policy formulation and transformative policy formulation.

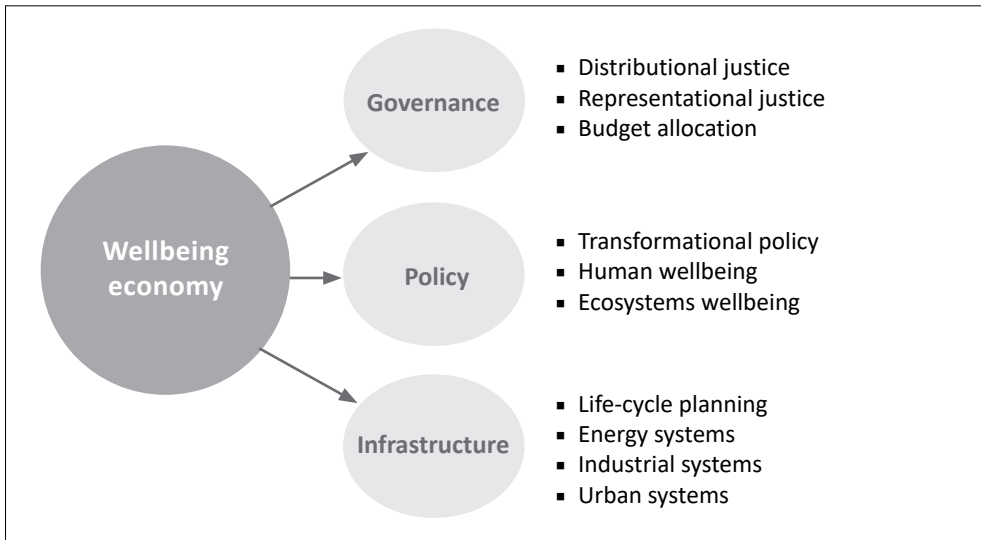


Figure 9.1 Wellbeing economy development framework

- **Transformative governance:** Realising an effective governance system that fulfils both distributional and representational justice for communities is one of the primary prerequisites for achieving transformational development in the twenty-first century. This is mainly dependent on both the policy formulation and infrastructure development component, which may create practical constraints or act as facilitators for achieving distributional and representational justice. It is further reflected on the level of equitable allocation and effective utilisation of national budget allocation.
- **Transformative policy formulation:** High-level political commitment expressed in the form of national policy and strategy document is critical for any country's progress towards a wellbeing economy that ensures both human and ecosystem wellbeing. This could range from incremental policy measures in specific sectors to a more comprehensive policy commitment that influences the national development trajectory. This can be assessed through the level of commitment for transformational development to wellbeing economy that promotes integrated consideration of human and ecosystem wellbeing and the policy preference given to transformative infrastructure development.
- **Transformative infrastructure development:** Decisions that are made on types of economic development infrastructure will determine the distributional effect of the whole economy besides determining the overall socio-economic and socio-ecological efficiency. It also determines the country's lock-in pitfalls and leapfrogging potential. The most critical factor in this process is the level of life-cycle consideration in the design and development of key

economic infrastructure and the ability of countries to utilise existing and emerging knowledge, technology and systems that enhance the efficiency and effectiveness of their energy, industry and urban infrastructure.

Table 9.3 summarises the indicator framework for transformative leapfrogging.

Table 9.3 Indicator framework for transformative leapfrogging

Foundations	Building blocks	Transformational indicators
Transformative policy formulation	Macro-economic policy and strategy formulation	<ol style="list-style-type: none"> 1. Level of integration of human and ecosystems wellbeing dimensions in national policies and strategies (1–10) 2. Fiscal policy preference and priority for transformative infrastructure that promotes inclusive, low-carbon, and resource-efficient development 3. Policy level recognition for adaptive planning that combines top-down with the bottom-up planning process
	Human wellbeing improvement	<ol style="list-style-type: none"> 4. Percentage increase in productive employment 5. Percentage increase in basic service provisions (food health, education, water, energy, etc.) 6. Percentage improvement in gross happiness and wellbeing index
	Ecosystems wellbeing improvement	<ol style="list-style-type: none"> 7. Percentage improvement in basic ecosystems services from forests, wetlands, etc. 8. Percentage reduction in CO₂ emission and improvement in air quality 9. Percentage increase in investment in nature-based Infrastructure
Transformative infrastructure development	Infrastructure planning and development process	<ol style="list-style-type: none"> 10. Scope of life cycle considerations in planning, development, and management of infrastructure (1–10) 11. Level of cross-sectoral synergy and integration in infrastructure planning and development (1–10) 12. Reduction in the percentage of stranded assets in unsustainable infrastructure (1–10)
	Transitioning to sustainable energy systems	<ol style="list-style-type: none"> 13. Percentage of the total population with energy access 14. Percentage increase in renewable energy share of total energy generation 15. Percentage increase in GDP per unit energy consumption as a measure of energy efficiency
	Development of an inclusive and resource-efficient industrial infrastructure	<ol style="list-style-type: none"> 16. Level of horizontal and vertical integration of industries to the local and national economy (1–10) 17. Percentage of local value addition to the overall industrial output and productivity 18. Number of jobs created per unit of industrial investment 19. Reduction in material energy and pollution intensity per unit manufacturing output
	Development of urban infrastructure	<ol style="list-style-type: none"> 20. The multi-modality and functional synergy of urban infrastructure 21. Percentage improvement in job creation and value addition of the urban economy 22. The decline in the percentage of the population living in urban slums

Foundations	Building blocks	Transformational indicators
Transformative governance	Ensuring distributional justice	23. Presence of conducive polity for a sustainable developmental state 24. Level of fair and equitable distribution of resources across regions and communities 25. Level of consideration for intra-generational justice in natural resource management
	Ensuring representational justice	26. Level of representational participation in planning and management of development programmes 27. Level of empowerment of women and youth groups in the decision-making process
	Budget allocation and utilisation	28. Percentage of the budget allocated for transformational projects 29. Level of decentralised and equitable allocation and management of the budget 30. The ratio of the additional leveraged resource with the allocated budget

The indicators listed in Table 9.3 are a combination of quantitative and qualitative indicators. The non-quantifiable indicators listed can be assessed through proxy values, which can be converted to an aggregated value of 1–10. Each country can measure its progress against the indicators either through an internal benchmarking that compares its performance with the previous years or through external benchmarking that compares its performance with a regional average value or any other country’s performance.

Conclusions

Systemic transitions always involve complex dynamics that need to be understood and managed from the systems perspective. This task is even more complicated when it comes to social transformations. Fortunately, such moments of social transformations always come with some fundamental drivers that will essentially determine the most probable trajectory. The challenge for development practitioners and policymakers is to understand the dynamics between these primary drivers and manage their interactions for broader societal benefits.

Indicators are one of the most useful tools that help us to understand these dynamics and guide our policy and planning actions to steer the development process to the most desirable outcome. The significant volume of literature that is available on sustainability assessment and sustainable development indicators provides a useful foundation to make an informed decision on the best use of indicators.

As was noted in the previous chapters, the twenty-first century is a century in which humanity is faced with a historic moment of social transformation of a global proportion. In this context, African countries are faced with two important

and historic choices. These are either being locked in the conventional ‘growth economies’ that are exclusive, inefficient and unsustainable or leapfrog into the ‘wellbeing economy’ that is inclusive, climate-resilient and resource-efficient economies of the twenty-first century.

The main objective of this book was to underline the critical importance of the path to be followed in developing a given country’s socio-economic infrastructure in determining a country’s economic future in this century. It also provided some of the major technical and decision-making tools that African countries could deploy in making the transition to a wellbeing economy. This final chapter of the book attempted to provide a framework of indicators that could be used as a basis for countries to assess their progress towards a more inclusive, low-carbon and resource-efficient economy. Needless to say, the framework needs to be adapted to the specific contexts of application to ensure its effective utility.

References

- Allen, T.F.H. & Starr, T. (1982). *Hierarchy: Perspectives for ecological complexity*. Chicago: University of Chicago.
- Arrow, K.J., Dasgupta, P. & Maler, K.G. (2003). Evaluating projects and assessing sustainable development in imperfect economies. *Environmental and Resource Economics* 26(4): 647–685. <https://doi.org/10.1023/B:EARE.0000007353.78828.98>
- Ayres, R.U. (1995). Economic growth: Politically necessary but not environmentally friendly. *Ecological Economics* 15(2): 97–99. [https://doi.org/10.1016/0921-8009\(95\)00073-9](https://doi.org/10.1016/0921-8009(95)00073-9)
- Bartelmus, P. (2009). The cost of natural capital consumption: Accounting for a sustainable world economy. *Ecological Economics* 68(6): 1850–1857. <https://doi.org/10.1016/j.ecolecon.2008.12.011>
- Benson, E. & Greenfield, O. (2012). *Surveying the 'green economy' and 'green growth' landscape*. Working Draft for consultation. London: Green Economy Coalition.
- Brugmann, J. (1997). Sustainability indicators revisited: getting from political objectives to performance outcomes. *Local Environment* 2(3): 299–302. <https://doi.org/10.1080/13549839708725534>
- Carson, R.T. (2010). The environmental Kuznets curve: Seeking empirical regularity and theoretical structure. *Review of Environmental Economics and Policy* 4(1): 3–23. <https://doi.org/10.1093/rep/rep021>
- Commission of the European Communities. (2009). *GDP and beyond: Measuring progress in a changing world*. Brussels: Commission of the European Communities.
- Cook, D., Saviolidis, N.M., Daviosdottir, B. & Johannsdottir, L. (2017). Measuring countries' environmental sustainability performance – The development of a nation-specific indicator set. *Ecological Indicators* 74: 463–478. <https://doi.org/10.1016/j.ecolind.2016.12.009>
- Costanza, R., Fisher, B., Ali, S., Beer, C., Bond, L. et al. (2007). Quality of life: An approach integrating opportunities, human needs, and subjective wellbeing. *Ecological Economics* 61: 267–276. <https://doi.org/10.1016/j.ecolecon.2006.02.023>
- Dahl, A.L. (2012). Achievements and gaps in indicators for sustainability. *Ecological Indicators* 17, June: 14–19. <https://doi.org/10.1016/j.ecolind.2011.04.032>
- Daly, H. (1996). *Beyond growth: The economics of sustainable development*. Boston, MA: Beacon Press.
- Eurostat. (2014). *Getting messages across using indicators*. Luxembourg: Eurostat.
- Fioramonti, L. (2013). *Gross domestic problem*. London: Zed Books Ltd.
- Funtowicz, S.O. & Ravetz, J.R. (1993). Science for the post-normal age. *Futures* 25(7): 739–755. [https://doi.org/10.1016/0016-3287\(93\)90022-L](https://doi.org/10.1016/0016-3287(93)90022-L)
- Garnåsjordet, P.A., Aslaksen, L., Giampietro, M., Funtowicz, S. & Ericson, T. (2012). Sustainable development indicators: From statistics to policy. *Environmental Policy Governance* 22(5): 322–336. <https://doi.org/10.1002/eet.1597>
- Georgescu-Roegen, N. (1976). *Energy and economic myth*. New York: Pergamon Press.
- Giampietro, M., Allen, T.F.H. & Mayumi, K. (2006). The epistemological predicament associated with purposive quantitative analysis. *Ecological Complexity* 3(4): 307–327. <https://doi.org/10.1016/j.ecocom.2007.02.005>
- Hak, T., Janoušková, S. & Moldan, B. (2016). Sustainable development goals: A need for relevant indicators. *Ecological Indicators* 60: 565–573. <https://doi.org/10.1016/j.ecolind.2015.08.003>
- Hamilton, K. (1994). Green adjustments to GDP. *Resources Policy* 20: 155–168. [https://doi.org/10.1016/0301-4207\(94\)90048-5](https://doi.org/10.1016/0301-4207(94)90048-5)

- Harris, M. (2007). *Towards genuine progress on the genuine progress indicator*. Sydney: University of Sydney. <https://doi.org/10.1504/IJWE.2008.022259>
- Hezri, A. & Dovers, S. (2006). Sustainability indicators, policy and governance: issues for ecological economics. *Ecological Economics* 60(1): 86–99. <https://doi.org/10.1016/j.ecolecon.2005.11.019>
- Holzer, M. & Yang, K. (2004). Performance measurement and improvement: an assessment of the state of art. *International Review on Administrative Science* 70(1): 15–31. <https://doi.org/10.1177/0020852304041228>
- Kallis, G. (2011). In defence of degrowth. *Ecological Economics* 70(5): 873–880. <https://doi.org/10.1016/j.ecolecon.2010.12.007>
- King, L.O. (2016). Functional sustainability indicators. *Ecological Indicators* 66: 121–131. <https://doi.org/10.1016/j.ecolind.2016.01.027>
- Kuznets, S. (1934). *National Income, 1929–32*. 73rd US Congress, 2nd session, Senate document no. 124. Washington, DC, United States Congress. <https://fraser.stlouisfed.org/title/971> [Accessed 15 September 2019].
- Lang, D.J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P. et al. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science* 7(1): 25–43. <https://doi.org/10.1007/s11625-011-0149-x>
- Latouche, S. (2010). Degrowth. *Journal of Cleaner Production* 18: 519–522. <https://doi.org/10.1016/j.jclepro.2010.02.003>
- Melkers, J. & Willoughby, K. (2005). Models of performance – measurement use in local governments: Understanding budgeting, communication and lasting effects. *Public Administration Review* 65(2): 180–190. <https://doi.org/10.1111/j.1540-6210.2005.00443.x>
- Morse, S. (2013). *Indices and indicators in development: An unhealthy obsession with numbers*. London: Routledge.
- Moldan, B. Janoušková, S. & Hak, T. (2012). How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators*, 17(1): 4–13. <https://doi.org/10.1016/j.ecolind.2011.04.033>
- Nahman, A. & Antrobus, G. (2005). The environmental Kuznets curve: A literature survey. *South African Journal of Economics* 73(1): 105–120. <https://doi.org/10.1111/j.1813-6982.2005.00008.x>
- Nahman, A., Mahumani, B.K. & de Lange, W.J. (2016). Beyond GDP: Towards a green economy index. *Development Southern Africa* 33(2): 215–233. <https://doi.org/10.1080/0376835X.2015.1120649>
- Organization for Economic Co-operation and Development. (2008). *Handbook on constructing composite indicators. Methodology and user guide*. Paris: OECD.
- Organization for Economic Co-operation and Development. (2010). *A framework to measure the progress of societies*. OECD Statistics Working Papers No. 2010/05, OECD Publishing, Paris.
- Organization for Economic Co-operation and Development. (2011). *Towards green growth: Monitoring progress: OECD indicators*. Paris: OECD.
- Ostry, J.D., Loungani, P. & Furceri, D. (2016). Neoliberalism: Oversold? *Finance and Development* 52(2): 38–41. <https://bit.ly/2PASiOL> [Accessed 10 January 2019].
- Panayotou, T. (2000). *Economic growth and the environment*. CID Working Papers 56A, Center for International Development at Harvard University, Cambridge, MA.
- Paruolo, P., Saisana, M. & Saltelli, A. (2011). Ratings and ranking: Voodoo or science? *Journal of the Royal Statistical Society Series A* 176(3): 609–634. doi: 10.1111/j.1467-985X.2012.01059

- Pepper, M., Jackson, T. & Uzzell, D. (2009). An examination of the values that motivate socially conscious and frugal consumer behaviours. *International Journal of Consumer Studies* 33(2): 126–136. <https://doi.org/10.1111/j.1470-6431.2009.00753.x>
- Pintér, L., Hardi, P., Martinuzzi, A. & Hall, J. (2012). Bellagio STAMP: Principles for sustainability assessment and measurement. *Ecological Indicators* 17: 20–28. <https://doi.org/10.1016/j.ecolind.2011.07.001>
- Prescott-Allen, R. (2001). *The wellbeing of nation: A country-by-country index of quality of life and the environment*. Washington, DC: Island Press.
- Rametsteiner, E., Pülzl, H., Alkan-Olsson, J. & Frederiksen, P. (2011). Sustainability indicator development – Science or political negotiation? *Ecological Indicators* 11(1): 61–70. <https://doi.org/10.1016/j.ecolind.2009.06.009>
- Rees, W. & Wackernagel, M. (1996). *Our ecological footprint: Reducing human impact on earth*. Gabriola Island, BC: New Society Publishers.
- Riley, J. (2001). The indicator explosion: Local needs and international challenges. *Agriculture, Ecosystems & Environment* 87(2): 119–120. [https://doi.org/10.1016/S0167-8809\(01\)00271-7](https://doi.org/10.1016/S0167-8809(01)00271-7)
- Rosen, R. (2000). *Essays on life itself*. New York: Columbia University Press.
- Saisana, M., Saltelli, A. & Tarantola, S. (2005). Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators. *Journal of the Royal Statistical Society Series A* 168(2): 1–17. <https://doi.org/10.1111/j.1467-985X.2005.00350.x>
- Sala, S., Ciuffo, B. & Nijkamp, P. (2015). A systemic framework for sustainability assessment. *Ecological Economics* 119: 314–325. <https://doi.org/10.1016/j.ecolecon.2015.09.015>
- Sala, S., Farioli, F. & Zamagni, A. (2013). Progress in sustainability science: lessons learnt from current methodologies for sustainability assessment. *International Life Cycle Assessment* 18: 1653–1672. <https://doi.org/10.1007/s11367-012-0508-6>
- Saltelli, A. (2007). Composite indicators between analysis and advocacy. *Social Indicators Research* 81: 65–77. <https://doi.org/10.1007/s11205-006-0024-9>
- Sen, A.K. (1985). *Commodities and capabilities*. Amsterdam. North Holland Publishing Company.
- Simon, H.A. (1962). The architecture of complexity. *Proceedings of the American Philosophical Society* 106(6): 467–482.
- Sommer, F. (2000). Monitoring and evaluating outcomes of community involvement – the LITMUS experience. *Local Environment* 5(4): 483–491. <https://doi.org/10.1080/713684888>
- Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I. et al. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science* 347(6223) 1259855. <https://doi.org/10.1126/science>
- Stiglitz, J., Sen, A. & Fitoussi, J.P. (2009). *Report by the Commission on Measurement of Economic performance and social progress*. <https://bit.ly/2CK9E6C> [Accessed 20 September 2019].
- United Nations Development Programme. (2004). *Human development report 2004*. New York: UNDP. <https://doi.org/10.18356/68b83600-en>
- United Nations. (1992). *United Nations sustainable development: Agenda 21*. New York: United Nations.
- United Nations Department of Economic and Social Affairs. (2007). *Indicators of sustainable development: Guidelines and methodologies* (3rd edition). New York: United Nations.
- United Nations Environment Programme. (2008). *SCP indicators for developing countries. A guidance framework*. Paris: UNEP.

- United Nations Environment Programme. (2011). *Towards a green economy: Pathways to sustainable development and poverty eradication*. Nairobi, Kenya: UNEP.
- United Nations Environment Programme. (2014). *A guidance manual for green economy indicators*. Nairobi, Kenya: UNEP.
- United Nations Statistics Division. (2015). *Discussion paper on principles of using quantification to operationalise the SDGs and criteria for indicator selection*. ESA/STAT/4412/2/58A/14. New York: UNSTAT.
- van den Bergh, J.C. (2009). The GDP paradox. *Journal of Economic Psychology* 30(2): 117–135. <https://doi.org/10.1016/j.joep.2008.12.001>
- van den Bergh, J.C. (2011). Environment versus growth – A criticism of ‘degrowth’ and a plea for ‘a-growth’. *Ecological Economics* 70(5): 881–890. <https://doi.org/10.1016/j.ecolecon.2010.09.035>
- van den Bergh, J.C. & de Mooij, R.A. (2002). An assessment of the growth debate. In: J.C. van den Bergh (Ed.), *Handbook of environmental and resource economics*, Cheltenham, UK: Edward Elgar.
- Wiek, A., Ness, B., Schweizer-Ries, A.W., Brand, F. & Fariolli, F. (2012). From complex systems thinking to transformational change: A comparative study on the epistemological and methodological challenges in sustainability sciences projects. *Sustainability Science* 7: 5–24. <https://doi.org/10.1007/s11625-011-0148-y>
- Wilson, J., Tyedmers, P. & Pelot, R. (2007). Contrasting and comparing sustainable development indicators metrics. *Ecological Indicators* 7(2): 299–314. <https://doi.org/10.1016/j.ecolind.2006.02.009>
- World Economic Forum, Yale University & Columbia University. (2002). *The environmental sustainability index (ESI)*. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <https://doi.org/10.7927/H4SB43P8>
- Yli-Viikari, A. (2009). Confusing messages of sustainability indicators. *Local Environment* 14(10): 891–903. <https://doi.org/10.1080/13549830903255405>



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